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Capturing Value in International Manufacturing and Supply Networks

New models for a changing world

20 and 21 September 2012, Møller Centre, Cambridge

Symposium proceedings

The 16th Cambridge International Manufacturing Symposium
20 and 21 September 2012, Møller Centre, Cambridge

Capturing Value in International Manufacturing and Supply Networks: New models for a changing world

Organisers

The Symposium is organised and hosted by the Centre for International Manufacturing (CIM), one of several research centres within the University of Cambridge's Institute for Manufacturing (IfM). CIM focuses on applied research in close collaboration with industrial partners. The centre has developed a strong academic-industrial community and provides expertise and a range of industrial services in the areas of international manufacturing and supply networks, particularly capability development, network configuration and design, and key trends and implications for industry.

Editors

Dr Jagjit Singh, Dr Tomas Harrington, Dr Mukesh Kumar, Dr Yongjiang Shi
Institute for Manufacturing, Department of Engineering, University of Cambridge

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Institute for Manufacturing
Department of Engineering
17 Charles Babbage Road
Cambridge CB2 3FS
UK

IfM Centre for International Manufacturing

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Capturing Value in International Manufacturing and Supply Networks: New models for a changing world

AGENDA

Thursday 20 September

09.00 *Registration and refreshments*

09:30 **Welcome and Introduction**
Dr Jagjit Singh Srai, Head, Centre for International Manufacturing, Institute for Manufacturing, University of Cambridge, UK

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Steve Churchhouse, Executive Vice President, Supply Chain Development, Rolls-Royce plc, UK

Operational and service leadership
Richard van Delden, Executive Director, Wavin, The Netherlands

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The development and future challenges for Huawei's supply network
Yuanfeng Gao, Senior Strategy Specialist, Huawei Technologies Co Ltd, PR China

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Bali Padda, Chief Operating Officer, The LEGO Group, Denmark

13:00 *Lunch*

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David Manson, Director, Previously COO of Findus Foods and Senior Vice President, Supply Chain, Unilever, UK

Value creation in pharmaceutical supply chain
Clive Badman, VP Investigational Materials Supply, GlaxoSmithKline, UK

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15.30 Research paper presentations – continued

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Supply Network Risk

Leveraging ERP systems capabilities and collaborative enterprise governance for agile manufacturing: a new dynamic enterprise reference grid

Yi Wan and Ben Clegg
Operations & Information Management Group, Aston Business School,
Aston University, Aston Triangle, Birmingham, B4 7ET, UK
wany@aston.ac.uk, b.t.clegg@aston.ac.uk

Abstract
Manufacturing companies are increasingly dependent on external resources and are endeavoring to develop and manage the Enterprise Resource Planning (ERP) information systems capabilities and strategic inter-firm relationships concurrently and dynamically to leverage external resources for competitive advantage. This paper investigates and theorizes about the correlation between different types of ERP systems and different Collaborative Enterprise Governance (CEG) strategies, where an enterprise is considered to be made up of parts of different companies engaging in very close collaboration. Empirical case studies have been conducted based on six successful manufacturing companies in the UK and China. It specifically proposes a new conceptual model – the Dynamic Enterprise Reference Grid for ERP (DERG-ERP) – as a management contingency framework. The purpose of this is to improve the concomitance between strategic thinking, agile manufacturing and ERP information systems development and implementation in response to the changing business and operational requirements.

Keywords: Enterprise Resource Planning (ERP), Collaborative Enterprise Governance (CEG), New Conceptual Framework, Manufacturing, IT Network.

1. Introduction
Over the last few decades, collaboration has risen in importance with the push to develop core competence and strategic capabilities within the company, while outsourcing peripheral activities from the member-company (Gottfredson *et al.*, 2005; Binder and Clegg, 2007). Dynamic manufacturing environment compels firms to move beyond their walls and get involved in a “virtual value chain” (Rayport and Sviokla, 1995) and inter-organizational processes by taking objective-driven and process-wide approach, agile manufacturing strategies, and the ERP information systems capabilities.

The existing research on ERP capabilities, however, is typically focusing on improving core ERP systems by extending their functionality to form bigger and better internal systems (Michel, 2000; He, 2004) for single manufacturing companies to increase their competitive advantage (Chen, 2001). Although some recent studies try to advocate the inter-organizational information systems (IOIS) (Bala and Venkatesh, 2007) and e-business enabled manufacturing operations (Rosenzweig, 2009); they always build upon the unilateral perspectives such as IOIS implementation (Rodon *et al.*, 2011), process-based IOIS (Vathanophas, 2007), information systems (IS) integration in mergers and acquisitions (M&As) (Henningsson and Carlsson, 2011). Less emphasis has been placed on investigating how ERP systems can become more supportive of dynamic change in collaborative enterprises grounding on the well-comprehensive constructs and strategic thinking. Additionally, it is argued that only if supported by the *enterprise* paradigms, ERP's inner integrating potentialities could be fully unleashed instead of being merely hidden in the functional information silos.

The European Commission defines an *enterprise* as, "… an entity including partnerships or associations that can be made up of parts of different companies" (European Commission, 2003). In light of the EC's definition researchers should no longer consider manufacturing operations to be single legal entities operating in isolation but instead should try to embody enterprise management concept which is the new superior frontier of collaboration with tighter integrated partnerships against the antecedent "manufacturing supply chain integration". Specific research in this area recognizes that critical interdependencies exist among manufacturing firms, suppliers, customer and even competitors are inclining to rely on the concomitancy between information technology (IT) and new manufacturing concepts (Banker *et al.*, 2010). However, despite an emerging body of literature about inter-firm forms (Binder and Clegg, 2007; Zhang and Dhaliwal, 2008) and new manufacturing structures (Shridhar and Ravi, 2002; Cheng *et al.*, 2011), manufacturing enterprise management and its relationships to ERP types remains theoretically under-developed; and it is imperative to link ERP with enterprise structure in order to handle the new and emerging manufacturing strategies including the agile manufacturing (Vazquez-Bustelo and Avella, 2006), niche manufacturing firms (Olsen and Sætre, 2007), and manufacturing servitization (Baines *et al.*, 2011).

In response to the above need, the objectives of this paper are (i) propose a new management contingency framework known as the DERG-ERP based on extant literature and case studies (ii) explain the correlations between ERP systems types and manufacturing enterprise structures by demonstrating the principles of DERG-ERP using the inductive empirical research (iii) illustrate the contingent dynamic transitions between each trend by using the inductive empirical research.

2. Conceptual foundation

2.1 From incipient traditional ERP to ERPII and on towards ERPIII

Traditional ERP is described as an internally integrated information system (IS) used to support internal manufacturing functional areas (Davenport, 1998; Al-Mudimigh *et al.*, 2001). Although coordination of inter-functional divisions is made easier by ERP systems, ERP has its roots in manufacturing and does not always readily support the e-business requirements (Bond *et al.*, 2000; Moller, 2005). In response, further functional modules have been developed as 'add-ons' to form ERPII which is recognized as an integral part of business strategy to enable inter-organizational collaboration (Bagchi *et al.*, 2003). One might say that the first generation of ERP primarily supported and enhanced single organizational manufacturing operations (Akkermans *et al.*, 2003), whilst ERPII supports "…value chain resource planning co-operation between different organizations at a meta-level" (Daniel and White, 2005).

Although ERPII system is currently the dominant type to support modern manufacturing enterprises, many manufacturing firms still endeavour to re-design their operations to become more dynamic in order to anticipate change. Implementing ERP systems in dynamic environments presents many challenges due to temporary existence of organizational structures and will tend to use predominantly web-compatible IS infrastructures and technologies (Xu *et al.*, 2002) such as Service Orientated Architectures (SOA), Software as a Service (SaaS), Utility Computing (Maurizio *et al.*, 2007) and open source applications. They all potentially offer increased flexibility, agility and re-configurability as well as better integrated connection with external firms (Torbacki, 2008) and as a result are now considered necessary to make more dynamic manufacturing enterprise structures a reality.

In this paper we tentatively refer to future generation enterprise resource planning systems as ERPIII. The authors define ERPIII as *a flexible, powerful information system incorporating web-based technology, which enables dynamic (virtual) enterprises to offer increasing degrees of collaborative dynamic responsiveness through increased functional scope and scalability*. Presently academic literature inadequately covers ERPIII, which should be researched further as it can be a source of sustainable competitive advantage.

2.2 Collaborative enterprise strategy

This paper specifically focuses on the three main types of manufacturing enterprise strategy known as Vertically Integrated Enterprises (VIEs), Extended Enterprises (EEs), and the Virtual Enterprises (VEs) for achieving the agile manufacturing.

Vertically integrated enterprises (VIEs) operate as single multi-functional firms striving for large scale of economy which have conventional hierarchies (Lynch, 2003) and are recognised as “a response to pre-existing market power problems or as a strategic move to create or enhance market power in upstream and downstream markets” (Joskow, 2003, p. 25). There is a downside to VIEs because VIE’s boundaries are mediated by firm structure and engage-abilities (Argyres, 1996), which restricts quick and easy IS re-development to address all types of market changes, and develop new core competences swiftly. To mitigate the downside of VIEs, *extended enterprise* structures and strategies should be used.

‘Extended enterprises’ (EEs) are defined by Davis and Spekman (2004) as “… the entire set of collaborating companies…which bring value to the marketplace…” and by Lyman *et al.*, (2009) as “… a business value network where multiple firms own and manage parts of an integrated enterprise”. Thus extended enterprises are deemed to be far more agile than vertically integrated enterprises. But even EEs cannot manage to follow highly turbulent and unpredictable market behavior in which the *virtual enterprise* (VE) structures and strategies must be used (Byrne and Brandt, 1993).

Generally, VEs are described as fluid, flexible combination of components of one or more business entities assigned by decomposed specific objectives to deliver value to a market (Davenport, 1998) or can be thought of as innovative IT networked structures in which temporary alignments are delivered. Thus, this kind of inter-firm relationship can more easily facilitate innovative agile operations (Cho *et al.*, 1996) and deal with dynamic market needs (Madu and Kuei, 2004) by heavily utilising new web-based information and communication technologies (ICT) tools.

2.3 Agile manufacturing

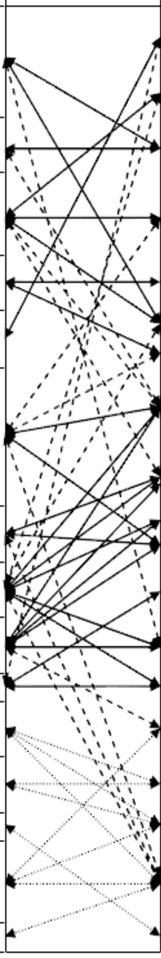
Manufacturing industry is on the verge of a major paradigm shift, which will take traditional firms away from mass production, way beyond lean manufacturing, into a world of agile manufacturing (Kidd, 1994). As new manufacturing enterprises are characterized by abilities to effect flexible reconfiguration of resources, shorter cycle times and quick responses to customer demands, agile manufacturing (AM) has been spontaneously evolving from lean manufacturing. This paradigm envisages that the organization, people and technology can be combined into an integrated and coordinated whole without compromising the cost and profitability (Vinodh *et al.*, 2010). In contrast, Krishnamurthy and Yauch (2007) and Goldman *et al.* (1995) hold the view that agile manufacturing firm is an organization that displays the ability to thrive and reconfigure itself in a dynamic, aggressively change embracing, and growth oriented environment. Accordingly, AM can be considered as *enterprise* structures and strategies supported by three essential elements: innovative enterprise management patterns, skill based knowledgeable people, and flexible and intelligent IT/IS platform. As a result, managing and developing ERP systems and enterprise forms (i.e. VIE, EE, and VE) concurrently and appropriately could assist manufacturing companies to achieve agility via merging above three resources into a coordinated and interdependent system.

2.4 ERP and CEG: contingency approach

The above literature covers ERP, ERPII, and potential ERPIII capabilities, as well as VIEs, EEs, and VEs characteristics. This paper now proposes some provisional causal links between these two disciplines. Specifically, strong correlations are identified between ERP and VIE, ERPII and EE; therefore, this paper proposes that traditional ERP and ERPII are best for VIE and EE respectively. Emerging literature on post-ERPII systems (i.e. ERPIII) are fewer but suggest ERPIII is most appropriate for VEs (see the potential strong links). Weak links are also identified between ERP and EE, ERPII and VIE, as well as between ERPII and VE and can be used to guide transitional managerial decisions in dynamic business environments.

Contingency theory (Van De Ven and Drazin, 1985) argues that no theory or method can be applied in all instances, in other words, that there is no one best approach to design the collaborative enterprise strategy with corresponding ERP information systems to achieve the best organizational performance by fitting different manufacturing environment. For this reason, the authors use two *a priori* frameworks, namely the Dynamic Enterprise Reference Grid (DERG) (Binder and Clegg, 2007) and IS Strategy Formulation (Galliers, 1994) to help explain these strong, weak and potential strong correlations further. These *a priori* frameworks are taken as two points of departure from established concepts in the field as they illustrate the changing perceptions of organizational capability and IS strategy respectively which are both underpinned by the contingency approach. For brevity, the model details are not given in this paper.

Table 1. Proposed correlations between ERP systems and Collaborative Enterprise Governance

ERP types		Key capabilities (extant literature)	Correlations found in literature	Key characteristics and requirements (extant literature)	CEG types
1st Generation ERP systems	Op	▪ Promise internal business processes integration with seamless information (Park and Kusiak, 2005; Al-Mashari *et al.*, 2003) ▪ Productivity improvement (Palaniswamy and Frank, 2000) ▪ Cost and cycle time reduction (McAfee, 2002; Esteves, 2009)		Conventional hierarchies with multi-functional units and inflexible environment (Lynch, 2003) Decision regarding business coordination and resource allocation is made by chief strategists (Harrigan, 1984)	VIEs
	S	▪ Automate internal data transfer and sharing (Chen, 2001) ▪ Enable sales and production forecasts (Davenport, 1998)		Focus on large scale of economics rather than extended and virtual collaboration (Clegg *et al.*, 2012)	
	M	▪ Facilitate speedy decision-making with real-time operating information (Nah *et al.*, 2001; Wallace and Kremzar, 2001) ▪ Better internal resource management (Scott and Vessey, 2000)		Require quick response to the market demands to enhance market power; lean strategy (Richardson, 1996; Joskow, 2002; HUallachain and Wasserman, 1999)	
	IT	▪ Unify disparate functional systems (Hicks and Stecke, 1995) ▪ Streamline internal data flows (Markus and Tanis, 2000)		In-house development of proprietary systems (Binder and Clegg, 2007; Clegg *et al.*, 2012)	
	Org	▪ Improve internal communication and cooperation (Alsene, 2007) ▪ Empowerment (lower bureaucracy) (Shang and Seddon, 2000)		Emphasis on transaction costs (Harrigan, 1985) Strong product quality control (Rothaermel *et al.*, 2006)	
ERPII systems	Op	▪ Enable tight integration between core supply chain components (Tapscott *et al.*, 2000; Bendoly *et al.*, 2004) ▪ Provide consistent real-time information across inter-firm operations with greater flexibility (Bond *et al.*, 2000; Weston, 2002) ▪ Customer service improvement (Sharif and Irani, 2005)		Entire set of collaborating firms through value network (Dyer, 1996; Childe, 1998; Doz and Hamel, 1998; Davis and Spekman, 2003; Lyman *et al.*, 2009) Strategically outsource external resource and core functions (Jagdev and Browne, 1998; Sutton, 2006; Thun, 2010)	EEs
	S	▪ Optimize inter-firm operational processes (Bond *et al.*, 2000) ▪ Support global business processing requirements (Zrimsek, 2003)		Require advanced IT/IS (Jaiswal and Kaushik, 2005) Medium-long term collaboration (Binder and Clegg, 2006)	
	M	▪ Manage external linkages via digital technology solutions (Li, 1999) ▪ More accurate and cost-efficient decision making (Weston Jr., 2003)		Weak power and authority due to flat and geographically distributed structure (O'Neil and Sackett, 1994)	
	IT	▪ Adaptable and collaborative IS infrastructure (Ericson, 2001) ▪ BPM, SCM, CRM, APS, e-business (Callaway, 2000; Moller, 2005)		Reductions in costs and lead-times from interoperability (Clegg, 2003; Triantafillakis *et al.*, 2004)	
	Org	▪ Facilitate organizational change and learning (Eckartz *et al.*, 2009)		Relatively stable; potential risks (Binder and Clegg, 2007)	
ERPIII systems	Op	▪ Enable dynamic, agile and event-driven operation (Hauser *et al.*, 2010) ▪ Support reconfigurable virtual integration (Ponis and Spanos, 2009)		Heavily utilise web-based ICT tools (Hye and Joel, 1999; Martinez *et al.*, 2001; Hyvonen *et al.*, 2008)	VEs
	S	▪ Manage and integrate strategic alliances (Muscatello *et al.*, 2003) ▪ Create synergy between innovation and customer-focus (Wood, 2010)		Facilitate innovative agile operation (Cho *et al.*, 1996; Sharp *et al.*, 1999; Cao and Dowlatshahi, 2005)	
	M	▪ Information security governance (Khoo *et al.*, 2010)		Short-term collaboration (Binder and Clegg, 2007)	
	IT	▪ Web-service, SOA (Hofmann, 2008; Ponis and Spanos, 2009) ▪ Cloud computing with unhampered data transfer (Maria *et al.*, 2011) ▪ SaaS, PaaS, Utility, SLA mgt. (Buco *et al.*, 2004; Torbacki, 2008)		Flexible infrastructure combing multiple business entities with temporary alignments (Lipnack and Stamps, 1997; Daniels, 1998; Camarinha-Matos and Pantoja-Lima, 2001)	
	Org	▪ Foster borderless organizational structure (Wood, 2010)		Low trust; high risk (Kasper-Fuehrer and Ashkanasy, 2001)	

* Op – Operational; S – strategic; M – Managerial; IT – IT infrastructure; Org – Organizational.

⟷ Strong links; ⇠---⇢ Weak links; ◂⋯▸ Potential strong links.

3. Research methodology

Considering the nature of the subject an exploratory and qualitative empirical research approach was used based on inductive grounded theory (GT) (Glaser and Strauss, 1967; Strauss and Corbin, 1990) and interpretive case study methods. This paper only presents some early findings, initial observations, and the established evidence (e.g. coding with data analysis and verbatim record) to support the proposed relationships between ERP systems and manufacturing enterprise structure types, which also helps to further develop the DERG-ERP framework. The complete GT analysis processes are not demonstrated in this paper.

The research methodology was deployed by conducting 32 semi-structured interviews from the manufacturing industry covering 6 companies in the UK and China. Key characteristics of the interview and background information on each of the case study sites are given in Table 2.

Table 2. Overview of the case companies and interviews

Industry sector	Company identifier	ERP systems	Role of interviewee
Printing manufacturer	Print-on-demand Co. UK Company A	Content Management System Oracle (PeopleSoft)	Managing Director
			Operations Director
			Manufacturing Manager
			Client Service Manager
			IT System Manager
			Supply Chain Manager
	Printing Co. UK Company B	Print-Pack MIS systems	Managing Director
			Client Service Manager
			Account Director & Sales Manager
			Production & Administration Manager
			Studio Manager
Electronic manufacturer	Electronic Co. UK Company C	SAP systems	Supply Chain Programme
			Supply Chain Tech.
			Finance Manager
			Logistics & Manufacturing
			B2B Tech.
			Supply Planning & Customer Management
Crane manufacturer	Zoomlion Chinese Company D	SAP systems	Executive Manager
			Chief Information Officer
			Logistics Manager
			(Regional) Marketing Director
			Credit manager
			Business (Sales) Assistant
Concrete and mixer manufacturer	Lanye Chinese Company E	Alutex (GPS) systems	General Manager
			Chief Information Officer
			Logistics Director
			Production Manager
			Chief Executive Officer
	Wanghai Chinese Company F	Three-Prosper Technology	Chief Executive Officer
			Human Resource Manager
			Inventory Manager
			Chief Information Officer

4. The new proposed dynamic enterprise reference grid for ERP (DERG-ERP)

Figure 1 is the newly founded conceptual model showing a new contingency framework known as the Dynamic Enterprise Reference Grid for ERP (DERG-ERP) which demonstrates how Binder and Clegg's (2007) CEG and Galliers's (1994) IS Strategy Formulation Model has been combined to guide enterprise resource planning and enterprise management decision making (*cf.* objective i); it is also partly founded on the wider literature review given above, and preliminary pilot case studies (for brevity, details of the pilot case studies are not given in this paper).

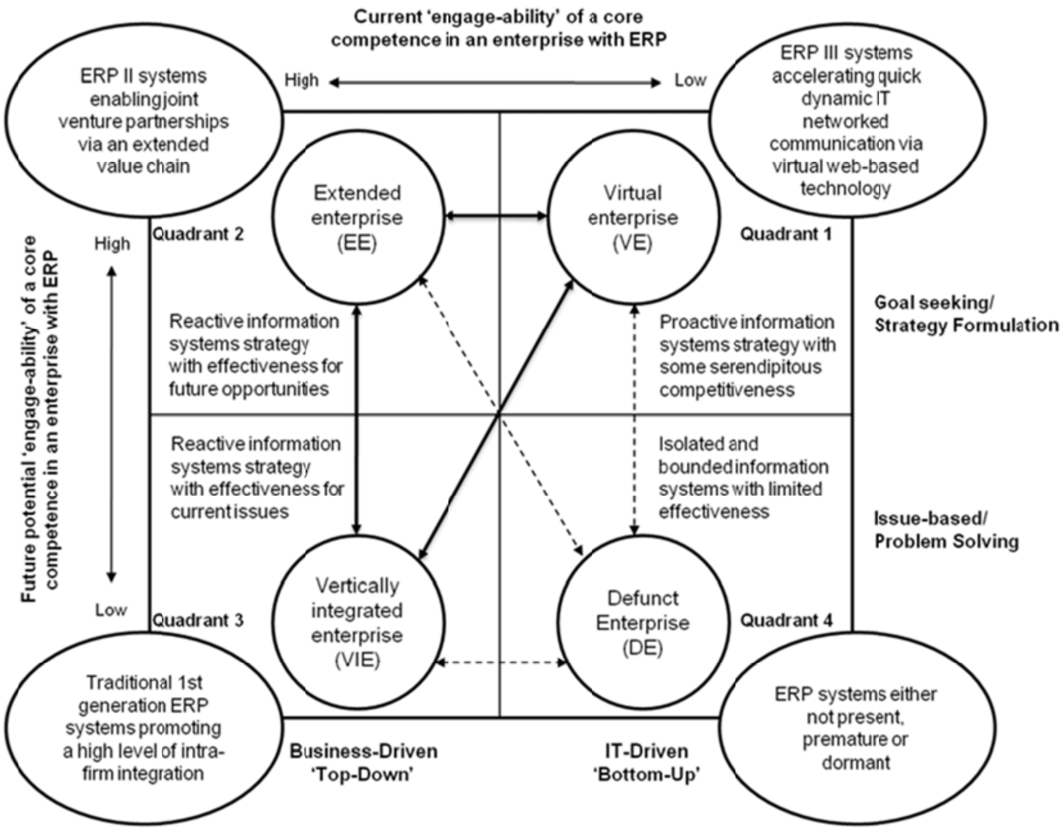


Figure 1. Dynamic enterprise reference grid for ERP (DERG-ERP)

Firstly, in Figure 1 (the DERG-ERP), it is important to note that proposed enterprise and ERP types do not result from different strategies, but are best considered part of a strategic continuum for inter-company cooperation. Therefore, under different circumstances manufacturing enterprises may change structures and use correspondingly different ERP types to suit business requirements.

The key components and characteristics of each trend in DERG-ERP are illustrated based on early findings and new observable by empirical research (*cf.* objective ii). Contingent dynamic transitions between each trend are also explained (*cf.* objective iii).

4.1 ERPIII systems use in virtual enterprise (Quadrant 1)

In Quadrant 1 of the DERG-ERP (*cf.* Figure 1) the VE-ERPIII is shown. As manufacturing industry is characterized by increasing e-marketplace with 'demand driven', establishing short-term inter-firm relationships is important to increase the company's flexibility, agility and innovative capability while shortening turnaround cycle (lead time) of product (service) and decreasing the cost to cope with the dynamic change, uncertain customer demands as well as creating new business opportunities; especially for small-and-medium sized manufacturing enterprises (SMEs).

"… if you go to Amazon to ask for a copy of that book they would say we do not actually stock it in our warehouse but one of our partner is LS … you will pay them (Amazon) the money and they place the order with us. We print it and we deliver it to you – their customer the next day. There is no risk … we have a good relationship … but if it is of short turnaround time it has to be a very efficient strong relationship. That is very important.” (Manufacturing Manager, UK Company A, 24th March 2011)

So the VE presently best serves SMEs which have aspirations for rapid growth and see themselves as innovative and likely to be serial and parallel collaborators. Collaborative partners within VEs always implement the same (similar) business strategy but the responsibilities are clearly defined for achieving better integrated collaboration. They normally take various functional roles (e.g. publisher, supplier, wholesaler, channel distributor, etc.) and make contributions into the entire virtual value stream. However, different trading partners are interdependent and trust to one another within the VEs. Also, the core competitive advantage and product volume are often driven by ‘cost-effective’ and the speed of manufacturing and delivery.

“… I might send the books out to the customer [use] our third-party carrier … It is our responsibility to make sure those books arrive … we would have customer send the books off arrive damage, can you re-print them … So in order to give customer a very fast turnaround, we have to limit the amount of product that is available to them.” (Operations Director, UK Company A, 24th March 2011)

“Amazon is our competitors and customers. We selling to Amazon but they are also competitor because they have a printer similar towards [ours] in their own building … the quicker we make things, the more books again you get the order.” (Managing Director, UK Company A, 24th March 2011)

From the IS perspective, VEs require the corresponding ERP systems to be more efficient and flexible at lower cost, which can support timey communication and transparency through the virtual network. ERPIII systems are considered to be able to facilitate temporary and highly agile operations using non-proprietary web-based technology for computer integrated manufacturing systems with decentralized control on a global scale and scope. ERPIII systems can therefore be used strategically to achieve high level goals whilst still incorporating incremental IT driven changes required by bottom-up idiosyncrasies.

“Well, I would say our systems have to be flexible …” (Manufacturing Manager, UK Company A, 24th March 2011)

“… our customer … will place the order into our systems by our Electronic Data Interchange (EDI) or Web interface…” (Operations Director, UK Company A, 24th March 2011)

Although ERPIII is proposed as the most appropriate information system for VEs, it is argued that not all the manufacturing firms who use the virtual enterprise strategy would simultaneously adopt ERP systems – even the ERPIII systems/concept as a result of company size, systems implementation cost, the purpose and extent of demand, and so forth.

“No, we have not [used ERP systems yet]; we do not use anything like that … it is really because of the company size of PS … Now why I have not changed that is because we need something more sophisticated … because it works – it works and they (all the staffs) like it … sophisticate is enough to actually going … I put in new (ERP) system, would we gain any major benefit from it – probably not; not too may … we actually perhaps use the similar type of system but we cannot afford the sort of thing (i.e. ERP system) that they (i.e. trading partners) pay." (Managing Director, UK Company B, 28th March 2011)

Nevertheless, these kinds of manufacturing firms might implement some other types of information systems with similar capabilities to ERP which are critical to support their enterprise structure. Alternatively, virtual manufacturing enterprises could use cloud based solution (e.g. SAP's Business ByDesign offers) and select required customized functional modules to support each small entity's core competence (i.e. strategic capabilities) and achieve real decentralized business efficiencies.

"… it is very important to have a good information technology structure in practice with the MIS system – Management Information System; that is critical …" (Account and Sale Manager, UK Company B, 28th March 2011)

"Our main platforms are Oracle. Most of our financial modeling and all the management is provided to the Oracle environment. We also use other database for our content management." (IT System Manager, UK Company A, 25th March 2011)

"… when we bringing those books into our database, they (CM information system) stretch content management … to hold all of our books." (Managing Director, UK Company A, 24th March 2011)

By considering the above issues, it is necessary to explore the ERPIII's feasibility and make its strategic advantages to be more convincing. From the ERP user's perspective, ERPIII for VEs could be facilitated by SOA, SaaS, and (cloud) computing tools in order to reduce IS investment and enhance dynamic responsiveness through increased ERP integrating capabilities and agile manufacturing strategy.

"Yes, you are sharing it (ERP systems). You seeing 'cloud' there and what you are doing is you are accessing it and you are sharing it …" (Managing Director, UK Company B, 28th March 2011)

From the ERP vendor's perspective, the advanced technologies required for realizing ERPIII are already there but the organizational behavior of each small legal entity within the VEs is the key challenge as those companies might not get ready or would not like to go through with such new IS strategy based on ERPIII concept. Another problem is who should be responsible for handling the ERPIII systems. Commonly the third-party consulting companies such as IBM and Accenture ought to be the actor. But the original ERP vendors (e.g. SAP) who design and develop ERPIII idea would worry this approach as they think it could make them lose the influence on their customer side (i.e. the end users). (Interview Memo with Industry Principal Manufacturing Discrete and Process Manager, SAP UK, 8th March 2012)

4.2 ERPII systems use in extended enterprise (Quadrant 2)

In Quadrant 2 of the DERG-ERP (*cf.* Figure 1) the EE is shown. As market keeps moving and changing, business strategy and collaboration design are not only based on the consumer demand but also influenced by the industry-specific and new entrants. Manufacturing firms should therefore extend the scope of their strategic partnerships into upstream (suppliers) and downstream (customers) across the entire product/service value chain, in order to strategically forecast the marketing demand, manage and control the supply, get more flexible and more responsive to customer, and adapt different consumer requests.

"Well, it (i.e. the business strategy) is based on customer demand … we have spent a lot of time … to increase our response of flexibility to customers while still providing our customers with the surety of supply that they desire." (Supply Chain Programme, UK Company C, 23rd May 2011)

"I think we changed our business model based on the way (that) the industry was changing … the major players in the industry [are] suppliers, customers, partners, competitors … As different competitors came into the marketplace, we had to adapt [different business customer demands]." (Supply Chain Tech., UK Company C, 23rd May 2011)

"… manage good at have a look at customer account so like the OEMs (Original Equipment Manufacturers) and disties … manage their supply … analyzed their forecast (and) make sure … having their supply to meet the manufacturing needs … the goal was really to be more responsive to customers … we have put a lot of processes and places … to be more flexible and more agile." (B2B Tech., UK Company C, 24th May 2011)

Therefore the EEs best serve medium-to-large sized operations that have aspirations to form close partnerships within an extended value chain. However, the cooperation within EEs would sometimes pursue a 'self-centered' approach which is differing from the virtual intercommunication within the VEs. With the purpose of having a clear market-driven foresight, partnerships are normally led and supervised by the most strategically influential member (e.g. manufacturer or prime contractor).

"… But our customers themselves do not have a clear picture of what is coming in the future … In fact quite often they rely on us to tell them what we think is coming in the future." (Supply Chain Programme, UK Company C, 23rd May 2011)

Once the competencies get matured, EEs need to design and develop a completely 'end-to-end' solution or a package rather than merely simple product/service for the customers, in order to create their own ecosystem or even compete in some new markets by sharing the company resources and outsourcing complementary/peripheral activities. Simultaneously the partners seek to eliminate any non-critical or unsuccessful members and the remaining ones try to establish a more stable, connected and long-term venture in order to lower transaction costs.

"… developed their own ecosystem … they have done well at … design completely end-to-end solution for customers …" (B2B Tech., UK Company C, 24th May 2011)

"We are going to compete in those new markets … We need to figure out who we are going to work with … we will work closely with Nokia … on new mobile phone device …" (Supply Chain Programme, UK Company C, 23rd May 2011)

From the IS perspective, EEs require the corresponding ERP systems to be able to support the more agile and more responsive manufacturing operations; set up the connections between firms, customers, suppliers and third-parties relying on real time information against manual intervention and data entry by linking different ERP systems. Additionally, ad hoc modules such as Supply Chain Management (SCM), Customer Relationship Management, Enterprise Data Warehouse (EDW) and Decision Support System (DSS) are expected to be implemented for managing the extended relationships whilst supporting internal decision making and business process re-engineering.

Thus, ERPII systems which extend traditional ERP capabilities are considered to be the most appropriate one for EEs as it cover the supply chain management and customer relationship functions that may involve active participation from other legal entities. ERPII systems can be business driven top down tasks that can be directly used for achieving goals and formulating strategy across company boundaries (e.g. supply chain policies and collaborative forecasting with suppliers). ERPII is best used when core competencies of strategic partners in an enterprise are currently, and in the near future, highly engaging and therefore highly likely to be needed in new collaborations, with new modus operandi.

"… we change our [business] process be more flexible … be more responsive as well external to customers …We need to get the information from them and be able to respond automatically [and] we need remove this manual data entry … So really business-to-business most of the job is how can we set up connections between customers, suppliers, third-party's ERP systems and link them to our ERP system. So we get real time information that reduces the time line but also reduces manual intervention (and) manual work …" (B2B Tech., UK Company C, 24th May 2011)

"… I would say this is an increasing need from our customers for more B2B … A few years ago, we worked with several of our customers to implement RosettaNet net connections. And then more recently, we have got a lot of requests for EDI which is more machine specific – machine to machine connections … for our SAP systems … I think we call it the 'next generation B2B hub' … you have got CRM module, SCM module, various modules … We still have many different packages … DSS … which we have built that relies on data. So our structure is you got SAP … all the data from that is stored into something called "EDW" … all of our data get stored. Then we use tools like DSS to search through that data to create reports and data information which enable us to take decisions on what to do." (Supply Chain Programme, UK Company C, 23rd May 2011)

"… We have created a customer service management systems (which is own CRM) … There is some data interchange between CRM systems and SAP systems … besides of our 'three core systems' we have 'two core portals' … the other one (portal) is called 'supplier portal' which is used to manage our suppliers … we have realized a good information sharing between internal and external via this portal …" (Chief Information Officer, Zoomlion, 12th August 2011)

4.3 Traditional ERP systems use in vertically integrated enterprise (Quadrant 3)

In Quadrant 3 of the DERG-ERP (*cf.* Figure 1) the VIE is used. Marketing saturation and product/service maturity requires the manufacturing enterprise to well establish a market viability while the business strategy mainly aiming for high profit margins, lower cost and large economic scale. Value members may seek whole ownership of assets that they have become interdependent upon to achieve competitive advantage around the industrial environment.

Mergers and Acquisitions (M&A) and outsourcing strategies are often taken on board for VIEs structure. At the same time, quality of product/service needs to be standardized, specified and checked. Functional processes from different areas are integrated for achieving high efficiency of manufacturing operations instead of agile manufacturing strategy. Companies that go through with VIEs also try to stretch their product/service portfolio as well as establishing long-term stable collaboration to reinforce the competitive competences and industrial position.

"… we have become the best one and leader in this industry after we have acquired some concrete factories, quarrying firms and electronic power station … We always go through with the standardized manufacturing … which concrete type the customers require; how many cubic concrete do they need … the benefit of merging and acquiring the quarrying firms is that we have solved our resource problem – especially for some non-renewable resources; also the quality can be better controlled …" (General Manager, Lanye, 19th July 2011)

The VIE serves large single manufacturing operations well, as they require ERP systems to support all core processes and provide a high level of intra-firm integration. Such systems are relatively good at long term issue based (or problem solving) tasks and help accomplish business driven top down goals, although do not directly contribute towards strategic decisions, and so therefore are relatively reactive to strategic and environmental business changes. They are best used when core competencies of strategic partners in an enterprise are currently highly engaged but may decline in attractiveness in the future; hence allowing for transaction costs and scale of economies to be achieved.

"… the current ERP systems that we use are mainly support our core operational business processes including the procurement, manufacturing, sales and marketing, finance and human resource management … with the upstream of our supply chain, some of the peripheral activities like quarrying can be outsourced to strategic cooperator and we would have a good communication via our Web interface … However, most of the functional modules that we have got are 'off-the-shelf' which lack of the customization that can specifically support our manufacturing business processes; on the other hand, the customized ERP systems are much too expensive …" (Chief Executive Officer, Wanghai, 20th July 2011)

4.4 Defunct enterprises and information systems misuse (Quadrant 4)

In Quadrant 4 of the DERG-ERP (*cf.* Figure 1) the defunct enterprise (DE) is shown. DE's occur when strategy, structurization or IS policy have gone wrong or are premature – no plans are made to have joint ventures; the challenge for managers is to move to any other type of enterprise quickly. In DEs ERP is typically not widely used, used inappropriately or without any great effectiveness. Tasks are normally driven by bottom up information technology purposes lacking strategic congruency.

4.5 Dynamic transformational routes of six manufacturing firms: holistic observations

As illustrated above, the principles of each paradigm of DERG-ERP are interpreted along with initial observations and part of verbatim transcripts. It is important to note that each case is not only applied to one type in DERG-ERP contingency framework; but are strategically shifting from one trend into another as shown by Figure 2 which also indicates the potential transitions between each trend (quadrant) in DERG-ERP.

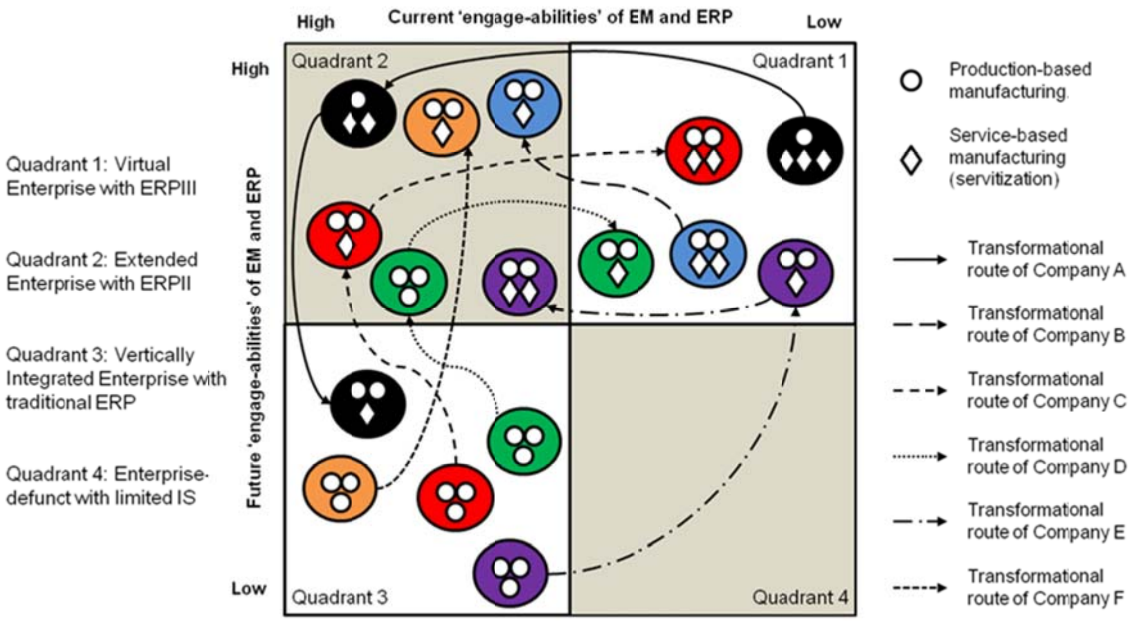


Figure 2. Transformational routes of six cases

Figure 2 generally summarises the transformational routes experienced by six manufacturing companies in the UK and China, which also demonstrates the correlations between ERP systems capabilities and Collaborative Enterprise Governance. Specifically, it points out that VIEs could directly shift into EEs by developing ERP to ERPII (e.g. Company C, D, F) and *vice versa* (e.g. Company A); EEs could directly shift into VEs by developing ERPII to ERPIII (e.g. Company C, D) and *vice versa* (e.g. Company A, B, E); and VIEs could directly transform into VEs by developing ERP to ERPIII (e.g. Company E) and *vice versa* (N/A in this paper).

From a holistic view there are three emerging interesting observations based on Figure 2 and above discussion, which currently have still not been fully tested, and need more evidence and supportive data:

- Most of the manufacturing companies which apply VIEs strategy are traditional large sized and production-based firms. They normally use traditional ERP systems or may use ERPII.
- Most of the manufacturing companies which apply EEs strategy are relatively innovative medium-to-large sized firms with hybrid production-based and service-based strategies. They normally use ERPII systems or may still use traditional ERP or try to embrace the ERPIII concept.
- Most of the manufacturing companies which apply VEs strategy could be the innovative small-to-medium sized and production-based or service-oriented firms; and they might be relatively innovative medium-to-large sized firms with a hybrid production-based and

service-based strategies; if they are large sized firms but still want to go through with VEs, the corresponding manufacturing strategy is suggested to be purely focus on the servitization. These firms normally use ERPIII systems or do not implement any ERP systems and may adopt other types of information systems.

4.6 An illustration of the new DERG-ERP (*cf.* Figure 1)

Figure 1 gives a simple consolidated conceptual framework for static and dynamic views of *ERP-CEG* design and management. Table 3 illustrates Figure 6 in small bite-sized chunks to explain such 'static' and 'dynamic' components of the new DERG-ERP observable in six manufacturing companies.

Table 3. The DERG-ERP illustrated using transitions from the cross-case studies

DERG-ERP component			
Static	**Dynamic**	**Provenance from literature**	**Illustration from empirical research**
Quadrant 1 Virtual enterprise (VE) with ERPIII		• Quick and dynamic inter-firm collaboration through business process management • Psychological issues such as trust and conflict are critical success factors • Flexible, agility, loose, temporary and dynamic project based collaborative venture • ERPIII systems accelerate quicker and more dynamic business network communication • ERPIII contains a flexible, agent-based ICT architecture • Assisted by SOA, cloud computing, PaaS, SaaS and other web-based tools. • Potential high risk with fragmented resource base	The printCo. (Company A and B) is setting up on a small venture embracing large amount of collaboration This is the future enterprise management (EM) and IS strategy for Zoomlion (Company D) Lanye (Company E) applies the VE strategy for integrating different plants in different locations assisted by VPN (Virtual Private Network) and ERP systems
Quadrant 2 Extended enterprise (EE) with ERPII		• Medium transaction cost with relatively lean resource base • BPR for medium degree of inter-organizational integration • ERPII can enable high level integration of internal and potentially external operational processes • Moderate supplier-customer relationships and collaborative alliances are managed by SCM, CRM, etc. systems approaching the virtual value chain concept • More stable, strategic, close and permanent collaborative venture focused	The electronic Co. (Company C) is trying to integrate with upstream and downstream partners by connecting different ERP systems Zoomlion (Company D) carried out new business strategy for re-locating its value members: joint partners, suppliers, customers, and even competitors.
Quadrant 3 Vertically integrated enterprise (VIE) with traditional ERP		• High degree of functional units integration involving predominantly production processes • Potentially permanent with high degree of intra-integration • Promotes business process re-engineering • Extensive internal resource and low transaction cost • Proprietary ERP supposedly built upon real-time information	After ERP systems launch Zoomlion (Company D) had high level of intra-integration Wanghai (Company F) has achieved a real internal resource integration by adopting a full ERP system package
Quadrant 4 Defunct		• No profits achievable • Rare IT/IS implementation or no ERP	Zoomlion (Company D) is initially founded on a high-tech academic institution without any explicit profitable

enterprise with limited IT/IS efficiency		• Fixed single company configuration • No active engagement in a current collaborative activity • IT driven strategy via 'bottom-up' approach • Company focuses on solving 'issues-based' problems	purposes Wanghai (Company F) was a scrap recovery plant without any enterprise management and IS strategy
	Q 3 to Q 2 From VIEs to EEs by developing ERP to ERPII	• Business processes re-engineering and lean thinking must be adopted in parallel • The most valuable members who engaged in the entire value chain have transferred from outside company boundary to inside enterprise boundary • A new strategic partnership has revived an existing and proven enterprise module by deploying it in extended enterprises context • ERPII replaces ERP with SCM and CRM tools to gain medium inter-integration rather than merely intra-integration	By re-classifying the value members and re-designing business processes, Zoomlion's (Company D) new production line is based on collaborative alliances with ERPII systems. The electronic Co. (Company C) has developed its ERP systems by extending the functional modules involving SCM, CRM and EDW to address the real business-to-business integration
	Q 2 to Q 3 From EEs to VIEs by changing ERPII to ERP	• The enterprise with predominantly medium asset specific content and information systems move to adopt 'lock-in' tactics to gain industrial dominance and market share • For the purpose of achieve economies of large scale; known as the 'shake-out' stage • Shifting ERPII systems into ERP but still keep the intelligent ICT applications such as SCM, CRM, etc.	The print-on-demand Co. (Company A) has gained a large scale of economies by integrating and cooperating with different functional entities such as logistics, publishers, etc. in a whole
	Q 2 to Q 1 From EEs to VEs by developing ERPII into ERPIII	• Successful stable ventures trigger the creation of new temporary, agile, and dynamic ventures • Requires open minded management with proactive IT/IS strategies • Focus on temporary market opportunity through short-term collaboration • Enterprise strategies shift from company centric into "borderless enterprises" • Upgrading from ERPII to ERPIII would maximize the companies' flexibility and adaptability for coping with a quick response to the business environment • ERPIII , SCM, CRM, applications merged with SOA, SaaS, cloud computing, etc. can optimize global supply chain integration	The electronic Co. (Company C) plans to design and implement the SOA-based ERP systems to become more agile, flexible and responsive to the customers In the future Zoomlion (Company D) would test its partial development from EE into VE to address cost-effectiveness, product uniqueness, business network optimization, and short-temporary seamless issues with industrial third parties
	Q 1 to Q 2 From VEs to EEs by changing ERPIII into ERPII	• Strategic move for successful ventures depending on existing mutual relationships and experiences • Existing partnership with expertises and knowledge management are critical to establish common strategies regarding culture, trust, preferable IS issues • Changing ERPIII to ERPII for better governing medium-long term relationships with suppliers and predicting customers' demands	The printCo. (Company B) has moved from VE to EE based on its existing mature and successful business partnerships Lanye (Company E) may apply EE to achieve a more stable organizational structure with medium-long term relationships. In this case, ERPII would be used based on strategic alliances instead of web-based technology
	Q 1 to Q 3	• In the case of highly asset specific can be controlled or	As soon as completing virtual business network around

	From VEs to VIEs by changing ERPIII into ERP	influenced by former partners internally • Try to extend business portfolio and product/service differentiation to cover whole supply chain cycle via 'forward-VI' or 'back-VI' strategies • Changing ERPIII to ERP aiming at in-house IT/IS development, in order to reduce the transaction cost	both intra and inter-company scope, Lanye (Company E) gradually changes its *enterprise* structure from VE into VIE to gain more market profits and bargain power against its competitors within the same industry
	Q 3 to Q 1 From VIEs to VEs by developing ERP into ERPIII	• Traditional VIE or M&A strategies try to seek new innovative ventures to sustain their competitive • ERPIII replaces ERP towards a more flexible and agile information systems. Web-based technologies and other ICT tools will assist such newly enterprise management (EM) patterns	After re-assigning the value member classification, Lanye (Company E) has transformed from VIE into VE by setting up its own 'Virtual Private Network' (VPN) and ERP-GPS for achieving agile and quick or even the leagile manufacturing in response to the dynamic complex marketing demands

5. Conclusion

This paper summarises recent trends in ERP systems development and enterprise management; develop and induct a new contingency framework, the Dynamic Enterprise Reference Grid for Enterprise Resource Planning (DERG-ERP) to explain correlations between ERP system types and enterprise structures, particularly from the manufacturing perspective. This new model is illustrated using empirical research based on six manufacturing companies in the UK and China. Principles and key components of each trend as well as the transitions between them in the DERG-ERP are clearly presented and explained.

In all cases it was observed that traditional ERP was associated with VIEs, ERPII with EEs, ERPIII with VE and limited IS and IT was observed in DEs – the 'best fit' between the two disciplines (i.e. ERP and CEG); therefore the authors claim that there is also a correlation between each of these pairings. The DERG-ERP contingency framework is limited by being based on only six manufacturing companies; and so is currently being tested on other service and manufacturing companies in the UK and China. This work contributes to a gap in extant literature about the correlation between ERP systems and manufacturing enterprise strategies; and gives some practical decision support to guide IS and enterprise managers.

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Postponement Strategies in the International Clothing Industry: An Empirical Study

B. L. MacCarthy
Nottingham University Business School
bart.maccarthy@nottingham.ac.uk

P.G.S. Amila Jayarathne
Nottingham University Business School
lixpgj@nottingham.ac.uk

Abstract

Although the clothing industry is one of the oldest industries in the world it continues to contribute significantly to the world economy and to global trade. It is a major export industry for a number of countries, particularly for some developing economies. It is also globally distributed, with most countries producing some types of clothing products. The abolition of trade barriers, the fast pace of globalization, and the emergence of global retailers and global markets for clothing products, have combined to accelerate the mobility of clothing supply networks. Many firms in the clothing industry seek to develop and enhance their responsiveness capabilities in order to engage and compete successfully in international clothing supply networks. As demonstrated by studies in a number of sectors, postponement strategies have the potential to improve responsiveness. However, postponement has been defined and interpreted in different ways. Here we examine the relevance of different types of postponement and different postponement strategies in the context of the clothing sector and highlight the relevance and importance of postponement in planning phases. In particular the concept of staged planning postponement is introduced, defined and examined with regard to different types of clothing supply networks. Evidence is presented from a study carried out at the supply network level to examine planning postponement in different types of clothing supply network. The results show that postponement strategies differ across different types of clothing supply network. The managerial implications for the different entities involved in clothing supply networks are discussed and potential avenues for further studies in the clothing sector and other sectors are noted.

Key words: Clothing industry, Postponement, Planning cycle

1. Introduction

The international clothing industry contributes significantly to the world economy, being one of the largest international export industries. It is also one of the most globally prevalent as most countries produce some types of clothing products (Gereffi and Frederick 2010). Clothing supply networks continue to change and develop due to changes in consumer demand and in retailer sourcing strategies, and the removal of barriers to international trade in textiles and clothing (Martin 2007).

Clothing supply networks are ‘retailer-driven’ (Gereffi 1999, and Tyler et al 2006). Retailers significantly influence network structures, relationships and management in order to develop and maintain responsiveness (Forza and Vinelli 2000, Masson et al 2007, Bhardwaj and Fairhurst 2010, Yi et al 2011).

Responsiveness can be enhanced through postponement strategies (Yang et al 2004). Although several types of postponement strategies are discussed in the literature, their application in the clothing industry is limited owing to the characteristics of garment design and production processes. Form postponement, the most commonly referred to postponement type, is difficult to apply in the garment production process. Managing the planning cycle well is crucial in the clothing industry (Forza and Vinelli 2000, Xiao and Jin 2011). Although postponement in planning has been noted in passing in the literature, the concept has not been clearly defined, described or analysed using empirical evidence to date. Addressing this gap, the first objective of this study is to introduce and clearly define the concept of postponement in planning. The second objective is to examine planning postponement in different types of supply networks in the clothing industry, a topic not addressed to date in the literature.

The paper first reviews relevant literature on postponement, highlighting research gaps and justifying the objectives of the current study. The methodology adopted for the study

is then described. Using data collected in the field, a new version of postponement – planning postponement- is presented and the degree of planning postponement practiced in different types of clothing supply networks is examined. The results and findings are discussed in detail and their implications highlighted. The limitations of the study and potential avenues for further work are noted in the concluding section.

2. Literature Review

Clothing supply network members include designers, textile suppliers, apparel manufacturers, distributors, embellishment suppliers, and retailers. The latter are the most powerful players (Gereffi 1999, Tyler et al 2006). Different types of retailer operate with different goals, objectives and motivations to serve different market segments (Barnes and Lea-Greenwood 2006, Gereffi and Frederick 2010, Sen 2008).

Zara is well-known in the fashion market and is differentiated by its high level of vertical integration compared to many of the major clothing retailers. 60% of its production is carried out in-house in Europe and in neighboring countries, 40% of its fabric is sourced from its parent, the Inditex company. It has its own design resources and embellishment facilities (Tokatli 2007, Gallaugher 2008). In contrast, Primark, a leading UK retailer in Fast Fashion (MacCarthy & Jayarathne 2010), does not own production facilities but uses large scale and long term contracting and sub-contracting with over 400 suppliers in countries such as India and Bangladesh (www.sdlgreenstone.com, 2008). Benetton has utilized both franchising and sub-contracting in maintaining relationships with downstream and upstream network partners, respectively (Camuffo et al. 2001). Lewis et al (2008) discuss the differences between Zara and the international trading company, Li and Fung, with respect to global network structure, global resource leverage and digital enablement capability.

The diversity in retailers' goals, motivations and sourcing strategies, along with the other market dynamics has resulted in differences in clothing supply networks. No classification scheme exists that focuses on supply networks in the clothing sector, notwithstanding the importance of the sector globally in terms of economics and employment (Gereffi and Frederick 2010). In the initial part of this study MacCarthy and Jayarathne (2012) have identified six main types of clothing supply network structures. They are described briefly in the appendix.

Clothing supply networks need to develop and maintain responsiveness strategies in the international context to be competitive in supplying major retailers (eg. - Storey et al 2005, Lee 2002, Cravens et al 1996, Ernest and Kamrad 2000). Responsiveness can be enhanced through postponement strategies (Yang et al 2004b, Yang et al 2007). Graman and Magazine (2006) note that low forecasting accuracy increases the need for postponement in the clothing industry.

Postponement is a concept that has been applied in the business world extensively since its origins in 1920s (Boone at al 2007). The term was originally used in the marketing literature to describe an approach to reduce the risk and uncertainty costs in the differentiation of goods. Increased environmental uncertainty, increases in product variety and the need for quick response to market demands has increased the attention on postponement (Yang et al 2005).

Several definitions have been given for the postponement, only few are noted here. Van Hoek (2001) defines postponement as a concept whereby activities in the supply chain are delayed until a demand is realized. Postponement involves redesigning the product or the production process so that the point of differentiation is delayed as much as possible before a customer order is received (Yeh and Yang 2003). Bucklin (1965) defined postponement as a dimension of sequence and timing based on the concept of substitutability (Yang et al 2007). A feature of these different definitions is that postponement has been used two views - delaying activities (timing of performing certain activities) and/or changing the sequence of activities.

Different versions of postponement have been discussed in the literature. Form postponement – delaying commitment to the final product form until some late point in the production process - is the most common version discussed. Time postponement delays the product differentiation point until customer orders have been placed. Deferral of the pricing decision until demand uncertainty is resolved is known as price postponement (Van Mieghem and Dada 1999). In purchasing postponement the purchase of raw material is delayed up to the point of production. In product development postponement, initially focusing on product specification decisions that are likely to remain stable, design decisions about less stable portions of the product can be postponed until better information is available (Yang et al 2004a). Products may also be designed so that specific functionality is not set until the customer or end-user receives it (Brown et al 2000). Place postponement occurs when the final destination of a finished product is left undecided until clear demand signals are received. Upstream postponement, downstream postponement and distribution postponement are also types of postponement strategies noted in the literature (Waller et al 2000).

A number of these types of postponement strategies are infeasible or have limited application in the clothing industry. For instance, form postponement, the most commonly used one, is difficult to apply in garment production as all the key product attributes – fabric, style, colour, size – are committed at the cutting process, which is the first value adding operation in the garment production process (MacCarthy & Jayaratne , 2010). Place postponement is applicable and used to some extent as finished garments are mostly pooled in the central warehouse of the retailer and distributed to different locations depending on actual or predicted demand locally.

Postponement has been used in the clothing industry in colouring processes. Uncoloured garments are imported and dyed locally when demand is visible (Bergvall-Forsberg and Towers 2007). Yeh and Yang (2003) note that instead of dying fabric, dying the garments increases responsiveness while bringing cost advantages. The well known example of Benetton illustrates the concept of dying postponement (Dapiran 1992). However, there are significant limitations on the types of garment that can be produced by restricting garments to a single shade.

Importantly, the discussion of the postponement in the clothing industry is mostly limited to this kind of ‘dyeing postponement’, which is a significant gap. These phenomena show that typical postponement strategies are less feasible in the contemporary clothing industry as the characteristics of existing postponement strategies do not strongly match with the characteristics of the clothing industry. A different perspective on postponement is necessary in the context of clothing supply networks.

Managing the planning process is crucial in uncertain environments in order to increase the responsiveness (De Toni and Meneghetti 2000, Brun et al 2008). According to Xiao and Jin (2011) in the contemporary clothing industry new products are launched rapidly resulting in a short product life cycle and a large number of selling seasons within a year. In these circumstances, if a retailer ordered more than the actual demand, it has to reduce its prices to sell the remaining inventories at the end of the selling season (the markdown problem). Hence, effective order management including production planning process is critical. Forza and Vinelli (2000) illustrated the traditional production system in the clothing industry and emphasize the significance of the planning cycle for time compression in terms of reducing fabric production, and garment throughput time..

Some elements of postponement in planning have been mentioned in the literature (Fisher et al 1994, Yang et al 200)) However, the potential for applying postponement principles in the planning cycle has not been developed and the concept has not been defined or articulated in any detail or with any precision. This is one of the gaps in the literature addressed in this study under the first objective.

Some studies have discussed the interrelationship between the typical speculation/postponement strategies and supply networks. For instance, Yeung et al (2007) explain that balanced structures, in which entities enjoy equal power and without customer information, need speculation strategies. A customer dominated network needs purchasing postponement while production postponement is needed for manufacturer dominated network. Product development postponement strategy is appropriate for virtual supply chains in which many suppliers and many customers operate with full information and process integration utilizing advance technology. Lee (2002) notes that although efficient supply networks are not suitable for postponement strategies, purchasing postponement and logistic postponement are suitable for risk-hedging supply chain, while product design, production, logistics, price and product postponements are applicable in responsive supply chain. All types of postponement strategies – product design, purchasing, production, logistics, price, and product postponement - are applicable in agile supply chains.

Yang and Burns (2003) and Boone et al (2007) claim that the implementation of postponement strategies leads to supply chain re-configuration. Van Hoek (1999) develops a framework linking degree of outsourcing, level of postponement and spatial network configuration. Importantly, Yang and Burns (2003) advocate that postponement should be studied in association with various supply chain configurations according to the market demands. However, this has not been addressed to date. This motivates the second objective of the study – to examine the planning postponement in different types of supply networks in the clothing industry.

The literature indicates that postponement strategies may be influenced by several factors such as product characteristics (Pagh and Cooper 1998, van Hoek et al 1998, Waller et al 2000, Olhager 2003, Appelqvist and Gubi 2005, Yang et al 2005, Mason-Jones and Towill 1999), market and demand characteristics (Pagh and Cooper 1998, Cvsa and Gilbert 2002, Olhager 2003, Yang et al 2004a, Yang et al 2004b, van Hoek 1998, and van Hoek et al 1998), manufacturing practices (Pagh and Cooper 1998, Olhager 2003, Yang et al 2005), information and communication technology (van Hoek 1998), operating characteristics (van Hoek 1998), technology and process characteristics (van Hoek 1998), supply chain strategy (Mason-Jones and Towill 1999), supply chain integration and control (Yang and Burns 2003), and relationship between buyer-supplier (Mikkola and Skjott-Larson 2004).

These factors also influence the structure of the supply networks. For instance, product characteristics (eg. Fisher 1997, Caniato et al 2011), market and demand characteristics (eg. Naylor et al 1999, Lee 2002), integration (eg. Nassimbeni 1998, Stock et al 2000), buyer-supplier relationship (eg. Gereffi et al 2005, and operational activities (eg. Miles and Snow 1992 Nassimbeni 1998), have been used as dimensions on which to classify and identity different network structures. Thus, it is reasonable to assume as a starting point for the second research objective that the planning postponement strategies are likely to be different across different clothing supply networks (Hypothesis 1).

3. Methodology

The unit of analysis defined for this study is a clothing supply network that includes a retailer sourcing from a prime manufacturer. This is an exploratory study that investigates clothing supply networks where the prime manufacturing partner is located in Sri Lanka. It is an extensive study comprising twenty six clothing manufacturers serving thirty nine international retailers, and generating seventy three different supply networks in total. It addresses a further gap in the literature as it looks at postponement at a network level.

Sri Lanka is one of the top 15 clothing supplying countries that supply 87% of the world's clothing market (Gereffi and Frederick 2010). The country maintains a strong reputation as a preferred supplier for major retailers in the EU and in US (Kelegama 2005, Wijayasiri and Dissanayaka 2008). As Sri Lanka supplies a wide range of garment types for a diverse set of retailers, the study exhibits diversity in network structures, and operational strategies including postponement.

The Selection of the prime manufacturer as a proxy for a supply network is supported by Humphrey and Schmitz (2001). Prime manufacturers can provide key insights on supply networks on both upstream and downstream aspects in the clothing industry. However, this study also includes the retailers' perspective in addition to the manufacturers' perspective.

Both qualitative and quantitative research methods have been used. In-depth interviews and survey are the main research methods of qualitative and quantitative approaches, respectively. A large number of in-depth interviews were carried out with strategic and operational level personnel of twenty six clothing manufacturers and eight retail agents (either independent agents or regional offices of retailers). Observations made by one of the researchers also provide another source of qualitative data. A survey method has been used to collect specific data on the timing of commitments made at different planning stages (explained below). Data collection was carried out in three phases throughout three calendar years - 2009, 2010, 2011. In addition, secondary data sources such as reports, and publications of government authority, clothing retailers and retail agents complement the primary data sources. The multiple methods and sources used have sought to enable triangulation of research findings to increase validity and reliability.

4. Analysis and Results

4.1 Staged Planning Postponement Strategies

We define a postponement strategy in planning as one that delays the timing of specific commitments across planning decisions related to sourcing, capacity and production. We call this a 'staged planning postponement strategy'.

Figure 1 illustrates this in the context of a clothing network, which operates over a rolling planning horizon.

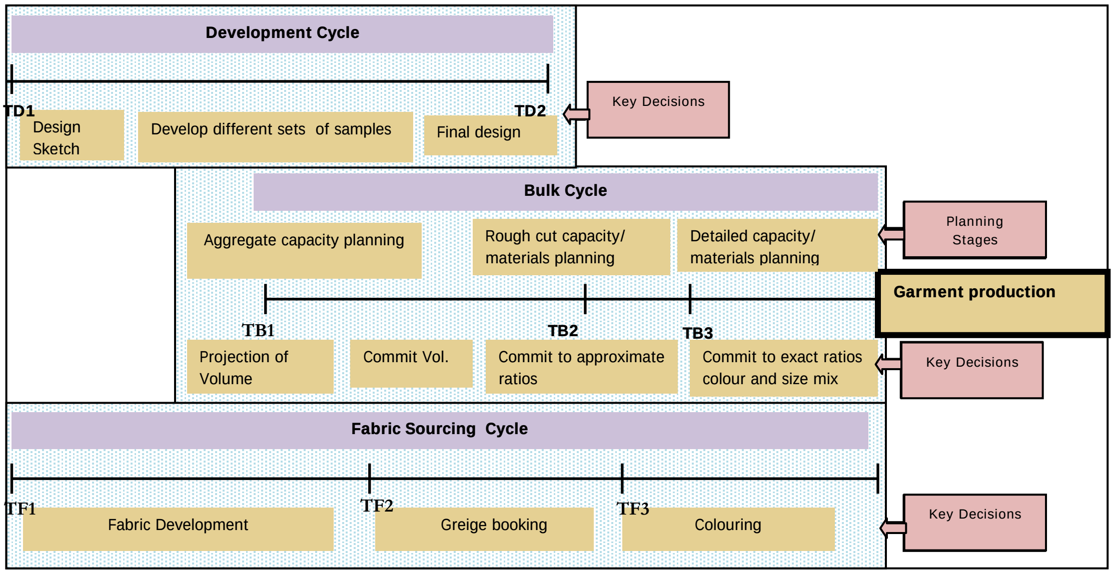

Figure 1: Staged Planning Postponement Strategy in the Clothing Industry

Three planning cycles are identified in Figure 1, namely the development cycle, bulk cycle and fabric sourcing cycle. The garment design and development cycle is complex with several stages. For the current study the two major operational planning cycles are considered, namely bulk operation cycle and fabric sourcing cycle. Studying the development cycle is advocated as a separate research area.

The process commences with aggregate capacity planning and moves through key stages for fabric procurement, rough-cut capacity planning and detailed capacity and materials planning. Precision and detail in order commitment increase at each stage in the process. Regardless of the type of retailer, manufacturer, or style of the garment, five main planning decisions made prior to production are identified: planning the aggregate capacity volume; booking fabrics in greige (undyed) form; commitment to approximate ratios in terms of style; colour and size (rough cut capacity planning); the colouring of fabrics; and the commitment to exact ratios of colours and sizes (detailed capacity planning). The nature of these commitments in different network structures provides an interesting line of research (MacCarthy and Jayarathne 2010). This study investigates it under the second research objective staged above.

4.2 Staged Planning Postponement Strategies in different Clothing Supply Networks

Staged planning postponement strategies are examined here in different types of clothing supply network structures. In order to do so the types of clothing supply network structures that operate in the industry need first to be identified. As noted, MacCarthy and Jayarathne (2012) have identified six main types of clothing supply network structures (denoted by FI, US, DS, AG, TC, and TN, and briefly described in the appendix). Planning postponement strategies have been examined across these six types clothing supply networks configurations in the empirical study in order to test Hypothesis 1 noted earlier in the Literature Review.

The lead times observed for the five main planning decisions discussed in section 4.1 above are compared across the six different types of supply network. Figure 2 shows a bar chart, which compares these five decisions across the six major types of clothing supply networks. The respective descriptive statistics are given in Table 1. Diversity in the timing of commitment decisions at different stages in the planning cycle is evident across the different supply network types.

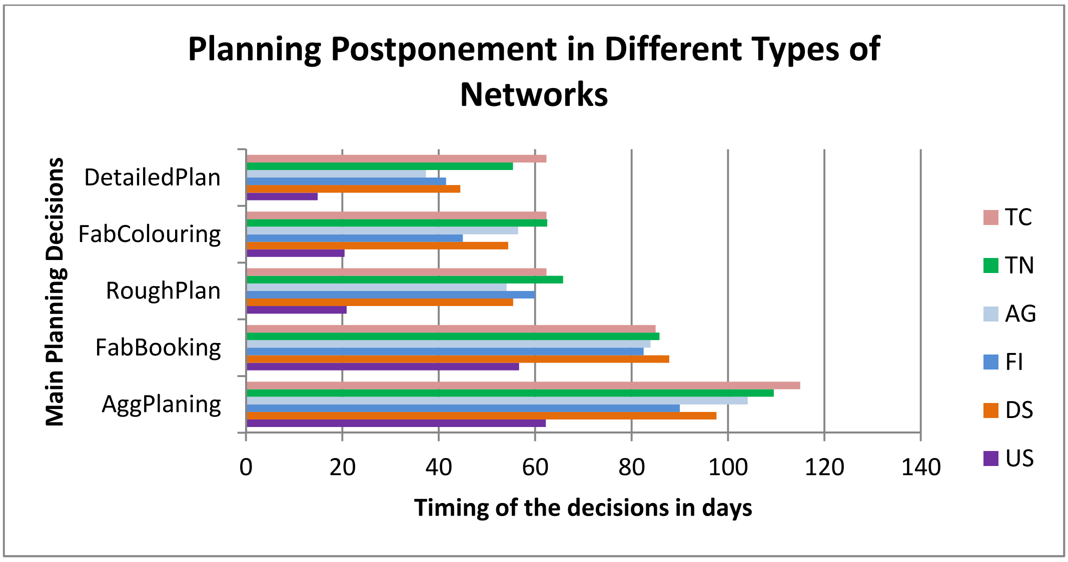

Figure 2: Comparison of planning decisions across types of supply networks

Table 1: Descriptive Statistics of the planning postponement in different types of supply networks

Planning decisions		Types of supply networks					
		US	DS	FI	AG	TN	TC
Aggregate Capacity Planning	Mean	62.22	97.61	90.00	104.12	109.5	115.0
	Std.Dev	6.67	31.58	0.00	24.67	18.77	37.75
Fabric Booking	Mean	56.67	87.83	82.50	83.92	85.8	85.0
	Std.Dev	11.18	19.53	10.61	17.67	15.97	8.67
Rough Cut Capacity Planning	Mean	20.89	55.44	60.00	54.08	65.80	62.33
	Std.Dev	9.79	12.92	0.00	10.78	12.98	4.04
Fabric Colouring	Mean	20.44	54.39	45.00	56.46	62.50	62.33
	Std.Dev	10.12	12.82	0.00	13.12	9.66	4.04
Detailed Capacity Planning	Mean	14.89	44.48	41.50	37.35	55.40	62.33
	Std.Dev	2.15	17.08	2.12	13.85	17.69	4.04

The diversity evident in the descriptive statistics in Figure 2 and Table 1 has been further verified through a One-way Analysis of Variance (ANOVA), an inferential statistical tool (Hair et al 2006), to examine whether or not such diversity is statistically significant, enhancing the rigor of the study. The results of the ANOVA tests are not included here for brevity. In summary, the results provide enough evidence to accept Hypothesis 1 that staged planning postponement strategies are diverse across different types of supply networks.

The results further demonstrate that integrated network structures, represented by US, DS, and FI, delay all the main planning decisions more than that of non-integrated network structures – AG, TN, TC. However, the results show that among these differences US networks significantly outperform all the other network structures with respect to all the main planning decisions in terms of postponement of the main planning stages.

5. Discussion

The study has introduced and defined the concept of 'Staged Planning Postponement' and provided empirical evidence from the international clothing industry to support it. Then, it has examined and compared the staged planning postponement strategies of different clothing network types, considering five main planning decisions - capacity planning, booking fabrics in 'un-dyed' form, commitment to approximate ratios, colouring of fabrics, and commitment to exact ratios. Given the objectives and the current state of knowledge on clothing supply networks, the study qualifies principally as theory building research (Wacker 2008, Stock 2009); because it introduces a new type of postponement strategy and investigates it in different network types, which is an acknowledged limitation in existing postponement studies.

The investigation extends the preliminary arguments on the applicability of postponement theory in the planning process (Fisher et al 1994, Yang et al 2007, Masson et al 2007). They mainly explore the potential and the need to delay some capacity decisions, i.e. that commitment to aggregate capacity (speculative/non-reactive product capacity) can be made in advance while postponing specific commitments (reactive product capacity) until a later date closer to the selling season. This work goes beyond these very general ideas. By formalising and making precise the concepts of staged planning postponement it enriches the preliminary ideas presented in the literature.

Presenting and analysing empirical evidence on practice in the international clothing industry further develops these concepts. Rather than simply maintaining two kinds of capacity - non-reactive and reactive - the study shows the existence of a more developed approach to planning postponement with five main planning stages. In particular, decisions on aggregate capacity planning and fabric booking in 'un-dyed' form are finalized in advance and commitment to exact ratios in terms of colours and sizes are made closer to the selling season. Evidence is also presented on postponement at the network level in the examination of staged planning postponement in different types of clothing supply networks, which addresses a knowledge gap noted in the literature (Stock 2009, Yang and Burns 2003, Yang et al 2005, Boone et al 2007).

The study uncovers that the timing of all the main planning decisions varies across the six different types of supply network. Networks with strong backward integration (US networks) outperform in terms of postponement in all the critical planning decisions. Such networks facilitate commitments later in the planning cycle than other types of supply network. This provides empirical evidence to support how responsiveness can be enhanced through backward integration, as fabric sourcing and processing time have been identified previously as a major bottleneck in the garment production process, hindering responsiveness (e.g., Forza and Vinelli 2000, Tyler et al 2006, Barnes and Lea-Greenwood 2006). Networks with strong backward integration and with close relationships between retailer and prime manufacturers can delay the main planning decisions more than other types of networks.

Interrelationships between the postponement strategy and supply network configurations have been noted by several researchers (van Hoek 1999, Lee 2002, Yang and Burns 2003), Yeung et al (2007) and Boone et al 2007). This study discloses statistically significant differences across the different network configurations with respect to the degree of planning postponement strategy in the clothing industry based on empirical evidence. It demonstrates that three variants of integrated networks – US, DS, FI – delay the commitment to planning stages more than that of three versions of non-integrated networks – AG, TN, TCs. This reflects the higher degree of planning postponement capabilities of vertical-integrated networks, supporting the argument of Yang and Burns (2003), that a gradual increase in vertical integration increases the potential applicability of postponement.

The six types of supply network analysed here were derived based on four factors - the nature of the product, the level of vertical integration, retailer-supplier relationship and functional authority in carrying out main operational activities such as garment design, sample development, sourcing, manufacturing, and final quality assurance activities. The diversity of planning postponement strategies are explored among such network configurations. It reflects that these determinant factors influence the planning postponement strategies indirectly via the network configuration. The results complement and add to some of the claims made in the literature on these influences, specifically product characteristics (Pagh and Cooper, van Hoek et al 1998, Waller et al 2000, Olhager 2003, Appelqvist and Gubi 2005, Yang et al 2005, Mason-Jones and Towill 1999), supply chain integration (Yang and Burns 2003), and buyer-supplier relationship (Mikkola and Skjott-Larson 2004). The study adds rich empirical evidence on these relationships.

6. Managerial Implications

Knowledge and insights on planning postponement strategies at the supply network level are important for both clothing retailers and prime manufacturers.

Greater understanding of planning postponement may enable retailers to operate their networks in an optimum way for their market segments. Retailers may be able to influence or in some cases dictate how their network operate such that they enable the commitment in the planning stages to be delayed as much as possible by identifying planning decisions which can be postponed and decisions which need early commitments. Also retailers can explore the supply network configurations in which planning postponement strategies can be implemented successfully and those that do not facilitate or restrict the utilization of planning postponement strategies.

It also indicates to prime manufacturers and their network partners the response capabilities needed in their networks to compete in global markets led by different retailers and brand owners. In particular, prime manufacturers and their network partners are able to understand the delays happening in the planning process. Accordingly they are able to plan and manage their limited resources while enhancing the competency to absorb such postponements.

Insights on the planning postponement patterns of different supply networks help embellishment service providers, for instance embroidery or washing and printing service providers, to understand their critical role in different network configurations. Because such service providers engage mostly at the latter stages in the planning process in which they make the capacity commitment with different manufacturers who serve several retailers in several network configurations. It is worth noting that this kind of service provider possesses special competencies and hence the availability of the service is comparatively limited due to the need for high investment. Such expertise serves for several manufacturers directly and subsequently fulfil several retailers' diverse requirements while operating in numerous network configurations on a temporary basis. Thus, effective utilization of such special competencies and limited capacities is crucial. The knowledge gained from this study helps such service providers to understand the diverse patterns of need coming from different manufacturers based on each retailer's unique requirements.

7. Conclusion

The work reported is part of a large scale study of retailer-driven clothing supply networks. It introduces a new type of postponement and has examined its use in different types of clothing supply networks. New evidence, understanding and insights have been presented on the diversity in planning postponement in international retailer-driven clothing supply networks. The insights gained are relevant to clothing retailers generally and to prime manufacturers in the sector in clothing producing regions. It also has implications for smaller producers and specialist service providers operating in such networks.

Clearly, any study of this type has limitations. Sri Lanka is a large and important clothing producing region serving many of the most prominent global retailers and brand owners. Conducting a similar type of study in other clothing producing regions would be of value and could generate interesting comparisons with the work here. Analyses can also be carried out on the different types of clothing supply networks to examine whether or not different retailers practice different planning postponement strategies at their supply network level. The current study is being extended to examine this question.

The findings described in this paper may also be relevant to supply networks in other globally dispersed industries for particular product categories. Extending the research into such industries could complement the study here.

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Appendix : Six types of clothing supply network structures

FULLY INTEGRATED (FI)

This is a network in which the prime manufacturer and fabric suppliers are all strongly integrated in terms of strategic alliances and joint ventures. The retailer deals with the prime manufacturer through the prime manufacturer’s regional office located in the country where retailer operates. This type of network is used by some retailers to source garments that need highly specialized operational competencies and strict control on materials procurement and garment specification (special fabrics and accessories), particularly for intimate apparel and lingerie.

UPSTREAM (US)

This network shares similarities with the FI network above but downstream integration is less prominent. The retailer and prime manufacturer operate independently, but the manufacturer has strong integration with fabric suppliers, either through ownership, strategic alliances or joint ventures. The retailer sources from the prime manufacturer through the retailer’s regional office in SL. As with the FI network, this supply network is utilized by retailers to source garments that need high quality materials and special operational competencies, mainly, though not exclusively, for lingerie and intimate apparel.

DOWNSTREAM (DS)

In this network, the prime manufacturer and fabric suppliers operate independently. However, the retailer maintains strong integration with the prime manufacturer, typically through long-term partnerships, strategic alliances, joint ventures, full ownership. Typically this type of network is used by retailers to source complex fashion garments that need special garment production competencies with significant work context, such as complex casual wear, leisure wear and some sportswear.

AGENTS (AG)

All the main entities – the retailer, the prime manufacturer and fabric suppliers – operate independently but collaborate temporarily. The retailer maintains the relationship with the prime manufacturer(s) through an agent, an independent company located in SL that works on behalf of the retailer. This type of network is typically used to source garments such as simple casual wear, t-shirts and essentials, sleepwear, and school wear, that need neither special operational competencies nor special materials.

TRADING COs (TC)

This network uses international Trading Companies as intermediaries between the retailer and manufacturers. Trading Companies can be clearly distinguished from agents. An agent typically represents one retailer, whereas a Trading Company typically has international standing and may represent and facilitate several retailers. Trading companies often provide more services than a retail agent (e.g., credit facilities for manufacturers). In this type of network. the retailer, the prime manufacturer and fabric suppliers operate independently. This type of network is typically used by retailers to source garments that do not need special operational competency such as simple casual wear.

TEMPNET (TN)

This is a network in which the retailer, prime manufacturer and fabric suppliers operate independently. The retailer maintains a direct relationship with the prime manufacturer. This type of supply network is used mainly by retailers to source garments that do not need special operational competency such as simple casual wear and essentials. This type of network often operates when a relatively small retailer places an initial order with a new manufacturer.

Nested patterns in large-scale automotive supply networks

Alexandra Brintrup
Said Business School, University of Oxford, OX1 1HP
Manufacturing Department, Cranfield University, MK43 0AL

Tomomi Kito
Department of Systems Innovations, School of Engineering, University of Tokyo

Abdul Alzayed
Manufacturing Department, Cranfield University, MK43 0AL

Mirja Meyer
Jacobs University, 28759 Bremen, Germany

Abstract

We draw on the network theoretic analysis of two large-scale empirical datasets describing the Toyota Motor Company and the Ford Motor Group to show that macroscopic production characteristics of supply networks are neither randomly assembled nor purely hierarchical, but are highly nested. A nested pattern means that suppliers produce proper subsets of what other suppliers produce, and niche products are produced only by those firms that already have highly diversified product portfolios. Preliminary examination hints that the pattern may be caused by large, older firms choosing to add new, unique products into their portfolio along a growth process, whilst small, young specialists produce only standard technologies. Nested networks are more robust than non-nested networks as suppliers that fail can be substituted - but on a strategic level, nestedness also means that small suppliers face more competition as their production capabilities are redundant. This gives large, diversified companies the advantage of niche production as well as operational efficiency advantages resulting from their size and large breadth of operations, possibly resulting in exponential growth.

Keywords: complexity, supply networks, nestedness, niche production, diversification

1 Introduction

Starting from 1990s the chain metaphor in supply chains has been replaced by the network metaphor, after decades of focus on studies that investigated the dynamics of a linear series of interlinked firms (Gulati et al 1995, De Toni and Nassimbeni 1995, Uzzi 1997, Lamming et al 2000 , Lazzarini 2001). While several researchers debated how concepts from complex network theory could be imported to the field of supply networks, these efforts have been limited by the lack of large-scale empirical data necessary to investigate macroscopic patterns in supply networks (Borgatti and Li 2009, Kim et al 2011, Lomi 2006). Such empirical evidence is of fundamental importance, because searching for regularities leading to universal patterns would reveal common principles underlying the organization of different organizational ecosystems and help us understand how local decision-making shapes system output.

In this paper, we contribute to the study of complex supply networks by presenting large-scale empirical evidence from the Toyota Motor Company and the Ford Motor Group and show that macroscopic production characteristics of supply networks are neither randomly assembled nor purely hierarchical, but are highly nested.

The term nestedness originates from the field of ecology, and was originally used to refer to the pattern with which specialist animals eat from and pollinate proper subsets of plants that generalist animals eat from and pollinate (Bascompte et al. 2003, Jordano et al. 2006).

The pattern is important for two reasons. First, nested networks are highly cohesive, in that most generalist plant and animal species generate a dense core of interactions to which the rest of the community is attached, making it less likely for the network to disconnect into isolated clusters (Jordano et al 2006). Second, because of asymmetry in interactions, species are more likely to persist: if a plant goes extinct, only a few animals will die, and most will survive as they can eat from other plants (Atmar and Patterson 1993).

Inspired by studies in ecological networks, we search for nested patterns in the Toyota and Ford automotive supply networks. Our findings show that specialist suppliers offer proper subsets of products that diversified suppliers offer, prompting us to discuss why this is so and what it means. Our initial investigation hints that several theories from organizational theory, such as Transaction Cost Economics, could offer theoretical foundations for the formation of a nested pattern: for example asset specificity leads large suppliers to internalize production, which results that firms in the network offer subset portfolios of each other.

Emergent nestedness in supply networks result in three main systemic properties: First, a nested structure becomes more robust than random structures, because failing suppliers can be substituted. Second, there is a lack of specialized firms that only produce goods that are unique to the supply network. This gives large, diversified companies the advantage of niche production as well as operational efficiency advantages resulting from their size and large breadth of operations. Thirdly, the market for standardized generic products is more competitive, because there are many other companies supplying them. In what follows we review organizational theories that relate to generalist and specialist production, and the study of nested patterns in other networks (Section 2). We then present empirical evidence from the Ford and Toyota supply networks, analyse product diversification patterns (Section 3), and discuss why such patterns may have risen (Section 4).

2 Background

2.1 Product Diversification in Organizational Theory

According to classical organizational theory, specialist producers are those that offer products with a small range of variation a certain dimension of interest, whereas generalists are those that display a broad range of products. It has long been the view of organizational theorists that in order to grow and increase profits, firms need to diversify, because entry into new markets not only allows a firm to explore previously unused resources, but also reduces risk (e.g. Chandler 1962). Additionally, diversification generates economies of scale across similar functions of the same firm, and allows leverage (Paine and Anderson 1983).

Hannan and Freeman (1977) challenged this view by arguing that environmental conditions mattered as well. They posited that specialists have a strategic advantage as they can exploit resources more efficiently. Generalists, on the other hand, expand their competencies to a wider range of products and diversify, which usually requires them to simultaneously manage different operational activities such as several product lines. They predict that specialists will perform better in fine-grained environments as generalists will not be able to respond quickly enough to variations by operating efficiently. Thus Hannan and Freeman assert that an optimal strategy exists given different environmental characteristics.

Resource partitioning theory has built on this assertion by pointing out that market concentration will be a defining factor, because competing generalists will occupy the centre of the market, making their gains through economies of scale, and specialists will be able to use resources without engaging in direct competition with generalists (Carroll 1985; Carroll and Swaminathan 2000; Dobrev 2001). The theory was empirically validated in various markets including newspapers (Carroll 1985), American breweries (Carroll and Swaminathan 1992), rural cooperative banks in Italy (Freeman and Lomi 1994), and US wineries (Swaminathan 1995).

However, Baum and Amburgey (2000) warn against oversimplifying the dynamics of generalist/specialist competition, pointing in the direction of studies that challenge the assumption that each firm experiences competition on equal footing. For example, studies by Baum and Mezias (1992) showed that organizations similar in size, product price, and geographic locations compete more intensely with one another, and models that ignore homophily tend to overestimate dynamics such as resource partitioning (Lomi 1995).

While organizational theories on product diversification assume competitive market scenarios, both the forces of cooperation and competition simultaneously exist in supply networks, as firms depend on one another’s success to have success on their own. There is a long-standing history of theoretical build up on cooperative relationships, such as outsourcing and alliances in supply networks, which has given rise to Transaction Cost Economics (TCE) (Williamson 1975). The TCE world-view is that every dyadic relationship in the supply chain is a commercial boundary with costs and risks associated with it. When firms decide on their production portfolio, they consider the risks and costs associated by their dyadic relations, such as opportunistic behavior. The TCE interpretation is fundamentally focused on the buyer-supplier dyad (De toni and Nassimbeni 1995, Lamming et al 2000). However, there are no studies that investigate how such local decisions affect the macro system of companies over time. In this paper we examine the macro system using evidence from two large-scale supply networks, and question whether localized decisions on product portfolio diversification do indeed give rise to predictable, systemic patterns.

2.2 Nested patterns in networks

Originating in the study of ecological networks of species interaction, a nested pattern refers to a particular structure in which proper subsets of species interact with more generalist species (Bascompte et al. 2003, Jordano et al. 2006). The concept has not been formally defined through mathematical relationships, but instead by means of verbal statements about the arrangement of species among communities. Although there is relative consensus on the meaning of nestedness, there are various debates regarding how it should be measured (Atmar and Patterson 1993, Brualdi and Sanderson 1999, Hausdorf and Hennig 2003).

Consider a plant-animal bipartite network representing species of plants that animals feed on and pollinate. The network is represented by a binary matrix, where each row represents a species, and each column is a plant. The entries of the matrix indicate an interaction (1) or the lack of an interaction (0) between plants and animal species. When the matrix is ordered according to marginal rows and column sums, we observe a triangular structure. If the concentration of interacting and non-interacting entries (Fig. 1a) is significantly different than what we would expect by chance to occur (Fig. 1b), then the network is a nested network, in that species interact with proper subsets of other species. The pattern excites ecologists because nested networks are cohesive and stable as only a few species act as hubs in the network, given that they are involved in many interactions with other species, but many species simply interact with those few hub species. This provides the ecosystem with redundancy to allow alternative options to be found in case some of the interactions are disrupted (Bascompte and Jordano, 2007).

In ecology, the main hypotheses on the emergence of nestedness involve differences in abundance of interacting species (Lewinsohn et al. 2006), higher extinction rates for specialists that interact with other specialists (Ollerton et al. 2003) or the convergence of traits among a set of species (Guimaraes et al. 2006, Santamaria and Rodriguez-Girones 2007).

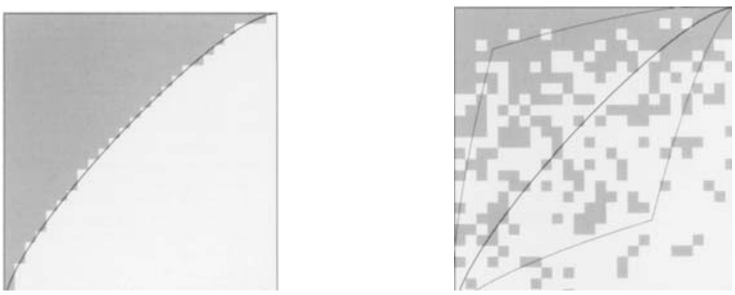

Figure 1. (a) nested, and (b) random interaction matrices

More recent studies have examined socio-economic networks. While Saveedra et al. (2008) and Koenig et al. (2012) examined networks of interactions in banking and trade, Hidalgo and Haussmann (2007) analyzed the competitiveness of countries by analyzing their production capabilities. They found that the capabilities of countries is significantly nested, which pointed the difference between “ubiquitous products” that require few capabilities, allowing most countries to be able to produce these products, and “complex products” that only diversified countries can produce. This meant that non-diversified countries are competitively disadvantaged, as they traded in ubiquitous products, which were of lower value in the market as many countries exported them.

Searching for a nested pattern in supply networks is worthy of note for two reasons. First, the existence of nestedness in a supplier-product network can give us insights into the product diversification decisions taking place in a coopetitive network. That is, supply networks do not function purely as competitive markets with one off transactions because firms depend on the products of each other, neither are they purely cooperative because they may also decide to expand their product portfolio instead of relying on others. While current studies show that nested patterns can be found in competitive (e.g. banks) and cooperative (e.g. plant-animal) networks, we do not know how coopetitive forces impact product diversification. Second, nestedness impacts systemic properties. A nested structure becomes robust, as production portfolios of disrupted suppliers can be substituted. A nested pattern would also point to a systemic lack of specialized firms that only produce unique or ubiquitous products because only generalist firms choose to produce them.

3 Research Setting and Analysis

In order to examine nestedness, we construct two large-scale supply networks. Buyer-supplier relationships differ across industrial contexts (Goffin et al 2006). In order to avoid under or overestimation of network patterns by using uniform measurement across varying contexts, we confined our analysis to a single setting, described as follows.

Our empirical context is the automotive industry because this choice allows us to use primary network data from a single database managed by an independent agency, making data collection convenient and the dataset comprehensive (Marklines Automotive Information Platform[1]). Within the automotive industry, we focus on the networks of Ford and Toyota Motor Company. The reasons behind selecting the Toyota and Ford supply networks as our empirical base are twofold: 1) both networks have historically been compared and contrasted with one another in their approach to supplier relationships. Empirically examining network patterns in both of these companies could give us insights into whether their differences reflect upon the emergent structure, and help reveal the universality of supply network patterns or lack thereof, and 2) given the scale of both companies, the corresponding data is sufficiently large to derive statistical analysis. We construct two network maps of who-supplies-to-whom, and then examine the production portfolios of suppliers in the network. In addition to the network map, we used a secondary data source (OneSource[2]) to query financial information and cross-validate data gathered from the first database.

Data were downloaded from the databases during August - October 2011 by two independent researchers, and secondary checks have been made during June - September 2012. Our construction of the Toyota network includes 2373 supplier firms, and 833 products; and the Ford network includes 1011 supplier firms and 780 products.

It should be noted that the firms within the dataset define themselves as automotive manufacturers. While their clients might or might not be members of the automotive industry, the data set is primarily automotive focused, and therefore is not exhaustive. We also decided not to aggregate data from subsidiaries of parent firms

[1] www.marklines.com
[2] www.onesource.com

as these local subsidiaries are often independent. Another advantage is that we can see with increased granularity which subsidiaries produce which products, allowing us to draw more accurate measures.

Following data collection we investigated patterns of nestedness in the network using three nestedness calculators: Nestedness Temperature Calculator (Atmar and Patterson 1993), BINMATNEST (Rodriguez-Girones and Santamaria 2006), and ANINHADO (Guimaraes, P. R. 2006).

The interactions of firms-products is given by the semipositive matrix M whose elements are such that:

$$M_{ij} = \begin{cases} 1 & \text{if Supplier } i \text{ produces Product } j \\ 0 & \text{if Supplier } i \text{ does not produce Product } j \end{cases}$$

Ordering the rows of the matrix by the number of products and the columns by the number of suppliers reveals a substantially triangular structure in both the Toyota and the Ford network (Figure 2). Table 1 shows the associated nestedness values found using the three different calculators. A value between 0-100 is considered, with 0 being a perfectly nested matrix, and 100 being a random matrix. It appears that all calculators are in agreement that the supplier-product matrix in both networks is highly nested. The nested structure results in the assertion that some companies produce a large fraction of all products (companies with diversified product portfolios), and some products appear to be produced by most suppliers (ubiquitous products). The suppliers that produce only a few products tend to produce only ubiquitous products, meaning that they produce those products that everyone else produces, and highly diversified companies are the only ones that produce products that are unique or rare in the supply network. Next we discuss reasons why such a pattern may exist in these networks.

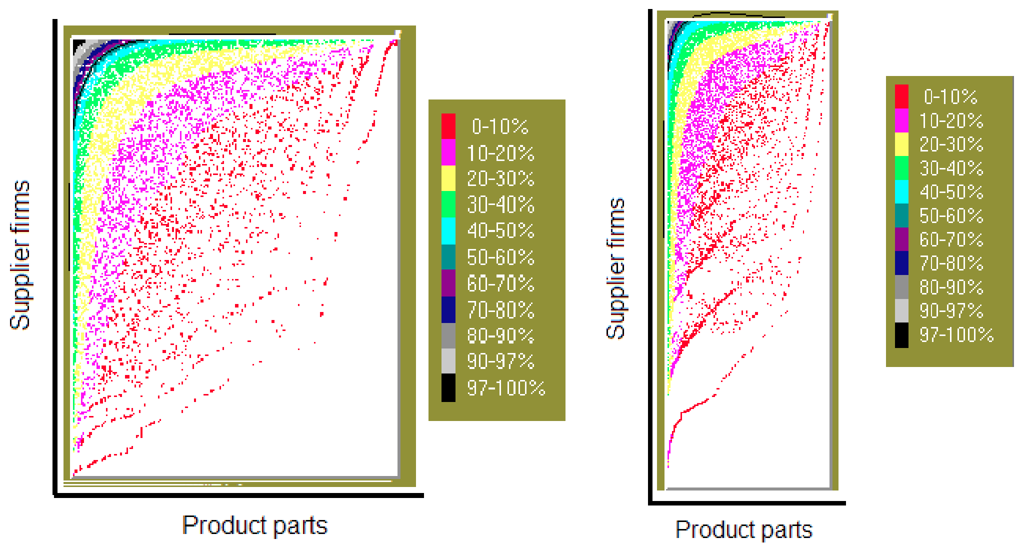

Figure 2. Probability of space occupancy in (a) Ford and (b) Toyota supplier-product networks

Table 1. Nestedness in the Ford and Toyota supply Networks

Method	Ford Supply Network		Toyota Supply Network	
	Matrix Value	Packed % Fill	Matrix Value	Packed % Fill
Atmar and Patterson 2006	1.110	1.300	0.510	0.600
Rodríguez-Gironés and Santamaria (2006)	0.836		0.316	
Guimaraes, P. R. (2006)	1.110	1.310	0.510	0.600
Number of products	780		833	
Number of suppliers	1011		2373	

4 Discussion and Conclusions

The supply networks of Ford and Toyota exhibit a nested structure that is significantly different than what we would expect to occur randomly, highlighting the fact that there is a systematic relationship between the diversification of companies in a supply network and the ubiquity of the products they make. In these networks poorly diversified companies compete almost exclusively in ubiquitous products, while diversified companies appear to be the only ones producing unique products.

A nested supplier-product structure suggests that, as companies grow, they become more diversified and add more unique products to their portfolio while keeping, at the same time, to their old productions. Our investigation of the most diversified and most specialized companies does indeed show that companies that are most diversified are, on average, bigger, older, and have higher revenues compared to specialized companies (Table 2). Although we need more statistical analysis to validate the significance of these attributes, our preliminary findings contradict classical thinking that predicts an emergence of either niche or generalist production in cooperative organizational ecosystems (e.g. Hannan and Freeman 1977). In fact, all other things being equal, conventional thinking would suggest that an idealized cooperative network would have a block-diagonal structure, with all suppliers producing specialized products, and each taking responsibility in the final assembly equally. A purely competitive market on the other hand, could aggregate in communities producing similar goods, resulting in a wider block-diagonal structure (e.g. Baum and Mezias 1992).

Since theoretical discussions do not support the evident structure, one can suspect that other agencies shape the decisions of suppliers and give rise to nested product diversification. An obvious theoretical foundation to consider is Transaction Cost Economics. The theory predicts that as the specificity of the product to be bought from a supplier increases, so does the risk of outsourcing it, as the manufacturer becomes heavily dependent on the supplier. Considering absorbable cost of in-house production and high frequency of need, the probability of integration with the supplier increases. Our anecdotal discussions with car manufacturers revealed that the most ubiquitous products in our dataset are standardized, lower value goods[3], whereas the least ubiquitous products are more complex to produce and are of higher value. If diversified companies supply products that are only supplied by other diversified companies and if non-diversified companies supply only what all other companies supply; then diversified companies have more specific assets in their product portfolios in addition to non-specific assets. We also observe that as firms get closer to the focal company (e.g. Ford or Toyota) their products tend to include more specific products (Table 2), and that they are involved in a higher number of mergers and acquisitions, which makes firm level decisions on integration one possible explanation behind the observed pattern. This in turn might mean that companies that only produce complex products are more likely to be integrated with other companies, creating larger firms with diversified portfolios. To find out, we would need to carry out longitudinal studies and consider the order in which companies add products in their portfolio.

In addition to internalizing production portfolios, we observe that diversified companies have higher revenues, and therefore higher capabilities for larger investments in production. Since it appears that the least ubiquitous products are in general more complex and higher value, we may presume that they require higher investments in production, which only large, diversified companies can afford, creating an alternative explanation of the relationship between product diversification and firm size.

Of course, the above considerations explain why diversified companies have complex products in their portfolio, but they do not explain why they do not let go of standardized, ubiquitous products that most other companies produce and focus only on niche products. A simple explanation could be that there is simply more demand for these products and producing them is still profitable. Firms may also wish to continue with their traditional identity and expertise, making only incremental changes within their core production, while adding niche products to their portfolio through integration. Again, we would need to carry out an analysis of product portfolio evolution to find out whether this is the case.

Although more analysis needs to be conducted on the possible causes of nestedness in supply networks, nestedness gives rise to important systemic properties. First of these is that nested networks are more robust to disruptions (in our case loss of certain products or disruptions at suppliers), as such losses are more likely to impact products that can be replaced in the network. Since firms that are most diversified are large multi-nationals, we might also reflect that they will be more likely to recover from disruptions, making unique, complex products safely cocooned within the network. Of course here we are bound by the assumption that firms can readjust their links, and replace lost production by buying from alternative suppliers while such decisions will inevitably be bound by cost, risk and capability constraints.

The second insight a nested network structure gives rise to, is that non-diversified suppliers compete within the ubiquitous product space, which means they face more competitors in the market, including large, diversified suppliers. While it is entirely plausible that producing ubiquitous products make financial sense, the fact that there

[3] We thank Ford UK and Mercedes Benz Turkey for their support

are more companies producing them might make it harder for these small suppliers to differentiate themselves in the market. General industrial economics view is that more capabilities bring higher returns, and the accumulation of new capabilities brings an exponential growth advantage as more capabilities give large, diversified companies the advantage of niche production as well as operational efficiency advantages resulting from their size and large breadth of operations. Additional empirical studies need to be conducted to confirm whether the same effect takes place in coopetitive supply networks.

So what can we learn from this analysis? We showed that first, there is a high chance that large-scale supply networks may have ordered, nested patterns; and second, that the pattern impacts important properties such as network robustness and competitiveness. We plan several avenues of future research. One of the limitations we have faced is that the constructed network maps are cross-sectional, and do not consider production volume. Supporting data on portfolio evolution, production volumes, and market demand could give us insights into why diversified suppliers do not let go of ubiquitous products, and why small firms choose to produce ubiquitous products. While initial research gave us important hints on the characteristics of products and suppliers that were ubiquitous or diversified, there is a need for carrying out further statistical analysis. In addition, companies in different industrial settings face varying interaction barriers and structural constraints generated by environmental differences as well as differences in the status of focal companies, which may limit the number and range of potential companies they can interact with, and products they may add to their portfolios. An expansion of our analysis into other industrial settings would therefore be valuable.

Table 2. Key attributes of 15 most diversified and most specialized companies

	Most diversified companies	**Most specialised companies**
Average number of employees	81610	3562
Average age	56.7	35.2
Average Annual Sales Revenue	$ 24173.8 mil	$ 92.67 mil
Average number of countries of production	22	5
Number of Mergers & Acquisitions since	28	2
Distance to focal company (average tier at which the company operates)	1	2.3

Table 3. Most and least ubiquitous products

Most ubiquitous products	**Least ubiquitous products**
Bush / seal	Drive train: Multiple Disc and Viscous LSD
Elemental components: spring, bearing, gear, shaft, pin, valve, etc.	Drive train: Power take off Alternate fuel system: LPG and CNG
Engine main structural part: crank shaft, piston, drive plate, con rod	Air suspension Body/ exterior: Rear end module
Brakes	Climate control: Pre-heater
Interior trims: door trim, roof trim, carpet	Electric suspension Body/ exterior: Gas spring
	Drive train system for electric and hybrid cars

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Factors influencing planning process design and their impact

Katharina Adaev
Fraunhofer Institute for Material Flow and Logistics, Enterprise Planning
Joseph-von-Fraunhofer-Str. 2-4, 44227 Dortmund, Germany,
Katharina.Adaev@iml.fraunhofer.de, +49 231 9743-459

Abstract

The acknowledged lower acceptance of centralized planning approaches by independent companies participating in networks raises the question: In which cases is it optimal to use a central planning approach, as opposed to a local planning approach, for an integrated planning process in networks? Many planning fields also require intensive information exchange. Therefore, by trying to cooperate in all fields, companies risk inefficient planning; thus, raising another question as to which fields should and should not be collaboratively planned. This context also presents the following interesting question: According to which criteria can orders be allocated to various production sites?

Addressing these questions, this paper identifies and categorizes factors influencing the design of sales, capacity and transportation planning processes, and finally suggests solutions regarding decisions on possible combinations of compatible characteristics.

Keywords: production networks, sales planning, capacity planning, transportation planning, changeability

1. Introduction

Due to dynamic requirements, lack of transparency and disorganized planning processes, changeable integrated planning processes have become more important. Integrated planning processes are known from theory and practice and corresponding planning systems are available. But there is not yet a methodology that allows expansion of these planning processes on the network level and ensures the changeability of planning processes (von Bredow, 2008). Recently, an increasing number of companies are being forced to produce in networks to be able to react to unexpected and continuous changes. Production in networks can be supported by joint integrated planning of the sales, production and transportation processes (Wiendahl *et al*., 2002). It is therefore important for all enterprises to primarily concentrate on planning processes that are at the core of all their value-adding activities. Enterprise planning is often divided into three or four planning horizons, ranging from long- to short-term planning. In this paper the changeability of annual planning and rolling medium-term planning of make-to-order production is discussed. The main function of sales planning is managing product demand. This process defines sales expectations, which are the basis for capacity planning. Capacity planning is followed by sales planning, which is the comparison of generated sales expectations and capacity expectations. In this matching process, capacity may be reduced or increased, or in the worst case, sales expectations are adjusted. Subsequently, the capacity plan will be adjusted in the rolling planning process by taking order books into account (O'Leary-Kelly *et al*., 2002). On the basis of this planning sequence, this study develops a framework of factors influencing planning processes to enable more changeable integrated sales, capacity and transportation planning in production networks. The results are developed within a project in the steel industry and are specific to the industry's characteristics. Nevertheless, this model should enable companies in various industries to adapt to volatile market requirements by changing the design of their planning processes. Therefore, the following research questions can be deduced:

- How can changeability of integrated sales, capacity and transportation planning be ensured?
- Which influencing factors require adaptation of planning processes?
    - How can a company decide when planning processes must be collaboratively managed?
    - How can a company decide whether a central or local planning approach is optimal for an integrated planning process in networks?
    - How must these planning processes be designed?

2. Theoretical background

2.1 Changeability

Manufacturing companies are exposed to significant pressures of competition. Worldwide, existing production networks and unpredictable consumer behaviour lead to increasingly dynamic production conditions. As a result, enterprises are forced to be more changeable. At present, the literature contains many different and sometimes contradictory definitions of the term changeability. In general, changeability means the ability to adapt the company to changed circumstances, a quality we must distinguish from flexibility.

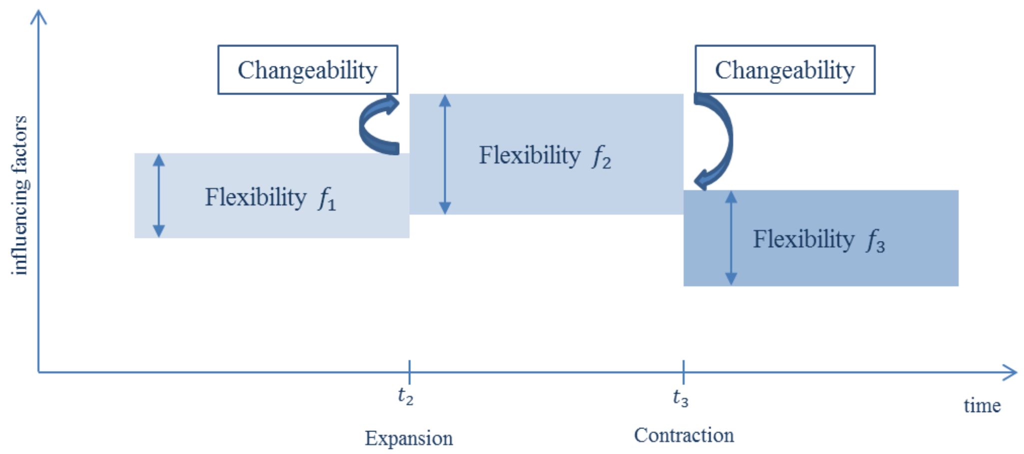

Figure 1. Difference between changeability and flexibility (Zaeh *et al*., 2005)

Flexibility is restricted by so-called flexibility corridors as shown in Figure 1. These flexibility corridors represent requirement spaces, in which a system does not exceed the limits by operative adjustments to fluctuating requirements. In other words, flexibility is defined as the potential to perform operative adjustments to fluctuating requirements, such that limits of the defined corridors are not exceeded. In contrast, changeability is the ability to adjust a system’s flexibility corridors to changing requirements through tactical or strategic actions (Zaeh *et al*., 2005).

The difference and above-mentioned definitions can be explained by the following example (Figure 2). To exemplify, a company in the steel industry can produce at its location hot strip thickness of 2–8 mm. The thickness can be varied within this range per the production system’s predetermined flexibility. The company plans to produce thicker hot strips based on new planned orders; it can potentially produce hot strips with a thickness of 9 mm at other actors' locations in the production network. This capability to make such strategic decisions makes the entire network changeable.

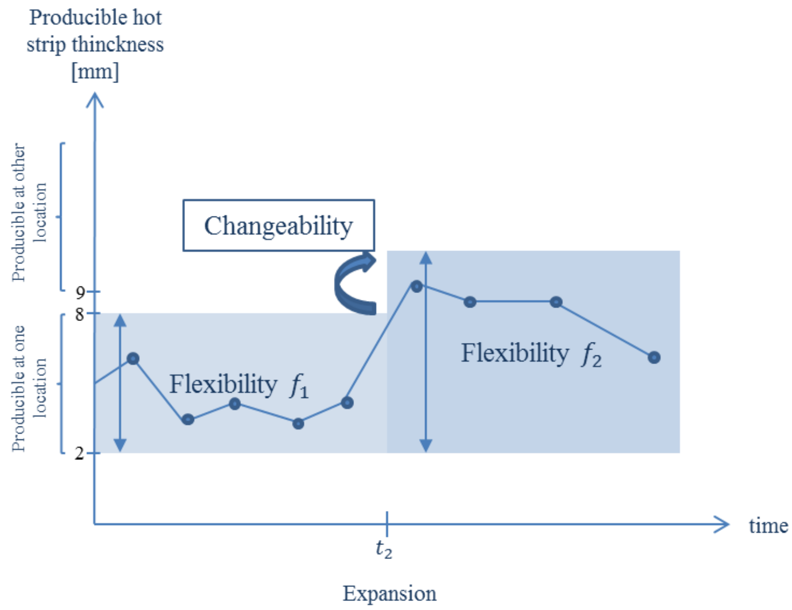

Figure 2. Changeability by example

Most authors concur that changeability must be analyzed at the network level, because most previous studies deal with changeability on the more detailed levels of a manufacturing site or even a production area (von Bredow *et al*., 2008). It is important, however, that individual companies are already changeable in their planning process, because the collaborative planning builds upon the companies' basic modules for future production in networks. An integrated planning system must have features that enable companies to be changeable to react to dynamic requirements. So-called 'change enablers' include universality, mobility, scalability, modularity and compatibility (von Bredow *et al*., 2008). The change enablers for planning processes can be described as follows. Universality describes planning models' function neutrality. The implementation of universal planning models should be possible in all forms of production networks. Mobility means the mobility or simple and rapid movement of data exchanged during the planning process. Scalability describes the planning model's ability to add new processes or process chains. Modularity is the planning model's ability to exchange standardized planning process elements. Compatibility describes networking capability, which can be achieved by, for example, standard interfaces in networks (Sauer *et al*., 2010).

2.2 Process chain model for identifying relevant influencing factors

Identifying and categorizing influencing factors requires an appropriate structure. The process chain model (PCM) with its 17 optimization potentials developed by Kuhn (1996) enables the identification of factors influencing planning process design. Potential classes help to identify relevant processes and their weaknesses (Figure 3) (Kaczmarek *et al*., 2002). The PCM enables combined analysis of a system's static (structures, resources) and dynamic (sinks, sources, control) elements. The PCM contains different process chain elements that represent individual detailed processes (e.g. reconciling of sales expectations with production capacity during production planning) or aggregated main processes (e.g. annual production planning). Sinks and sources, respectively, describe inputs and outputs of a process or process chain that represent material and information flows of logistic objects (Bockholt, 2011). This paper deals with planning processes, and therefore, process chains describe only information flows. Processes are completely described by the parameter control, structures and resources. Parameter control levels entail the rules-based coordination and monitoring of defined processes. The parameter resources determine all necessary resources for performing the processes. Parameter structures define the static composition of the entire system's processes (Uygun, 2012).

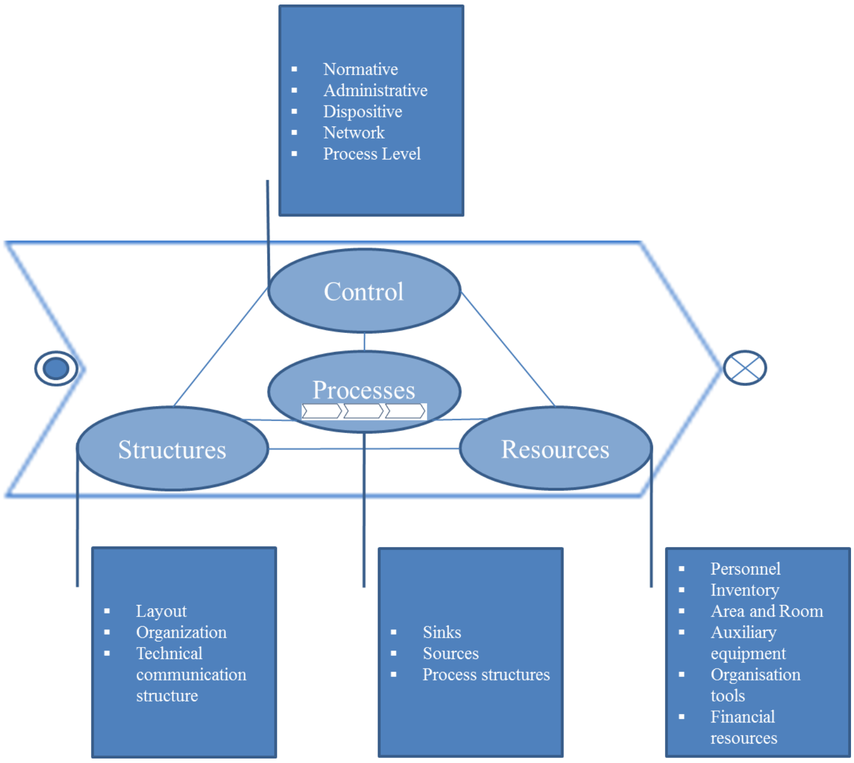

Figure 3. Process chain model with 17 optimization potentials (Klingebiel, 2006)

3. Framework of influencing factors and their impacts

The existence of room for improvement in the 17 defined optimization potentials (s. 2.2) indicates that these processes' influencing factors can be deduced from parameters. Parameters of group control are defined such that influencing factors are deduced from them because control rules in particular are the most influential upon planning processes. Parameter processes, structures and resources complete the framework of influencing factors. A process model will summarize various planning processes over which the identified influencing factors have direct influence (Figure 4).

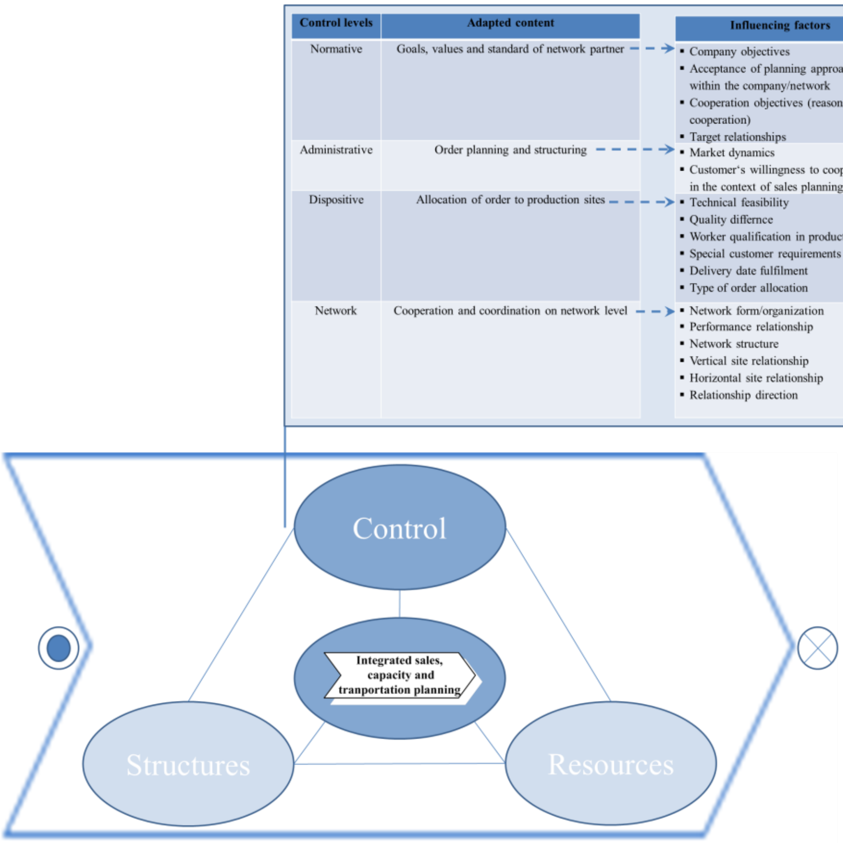

Figure 4. Derivation of influencing factors

Company and cooperation objectives are determined within the normative control level. It is also important to note that an actor's individual defined goals can differ from the network level goals. This fact and the interrelationships of goals must be taken into account in the influencing factors framework. The normative level is the highest control instance that reflects company spirit, and thus, describes acceptance of the company's methods or planning approaches. This influencing factor group closely interacts with the factors influencing group network, where the network is defined, and therefore, has considerable influence on the decision regarding centralized or decentralized cooperation control in the network planning processes.

The administration is responsible for order planning, structuring and passing to disposition. Considering planning processes, this level can be compared with sales planning tasks (Kuhn *et al.*, 2007). Market dynamics and low customer willingness to cooperate in the context of demand planning can complicate the sales planning process (Homburg *et al.*, 2008). In this group the defined influencing factors particularly support companies in reaching decisions regarding design of sales planning process.

At the dispositive level, orders are allocated to different production sites. This matching process is influenced by a number of factors, including technical feasibility, expected quality standard, worker qualification in production at a specific site, special customer requirements, delivery date fulfilment and type of order allocation. To balance varying orders, different combinations of influencing factors ensure flexible adaption of production resources. This influencing factor group has considerable influence on the decision regarding design of integrated capacity and transportation planning.

The network partners conduct the entire planning processes or process elements autonomously. The network connects these autonomous subsystems to integrate and harmonize the planning modules (Beckmann, 1998). The network organization is described at the network level. Networks can include companies belonging to affiliated groups as well as several independent, and even competitive, companies. The factor network form influences the decision regarding the planning approach. Material flow relationships between the partners are also described at the network level. The collaborative planning process requires intensive interchange of planning data among participating actors. There are many planning fields that require intensive information exchange. By trying to cooperate in all fields, companies risk inefficient planning; thus, the question arises as to which planning fields should and should not be collaboratively planned (Kaphahn *et al*., 2006). The answers to this question vary depending on a combination of the influencing factors' values that are derived from material flow relationships. The individual factors are explained in the rest of this section.

Orders in process are passed on the basis of rules defined by process levels (Figure 3). Planning processes, therefore, are described at this level, and thus cannot be a basis for the derivation of influencing factors.

During the identification and structuring of factors influencing the design of integrated sales, capacity and transportation planning three main groups can be identified. In the first group, factors influencing coordination focus in collaborative planning are described. The second group includes all factors influencing the collaborative planning approach. In the last group, factors influencing the design of integrated sales, capacity and transportation planning are summarized (Figure 5).

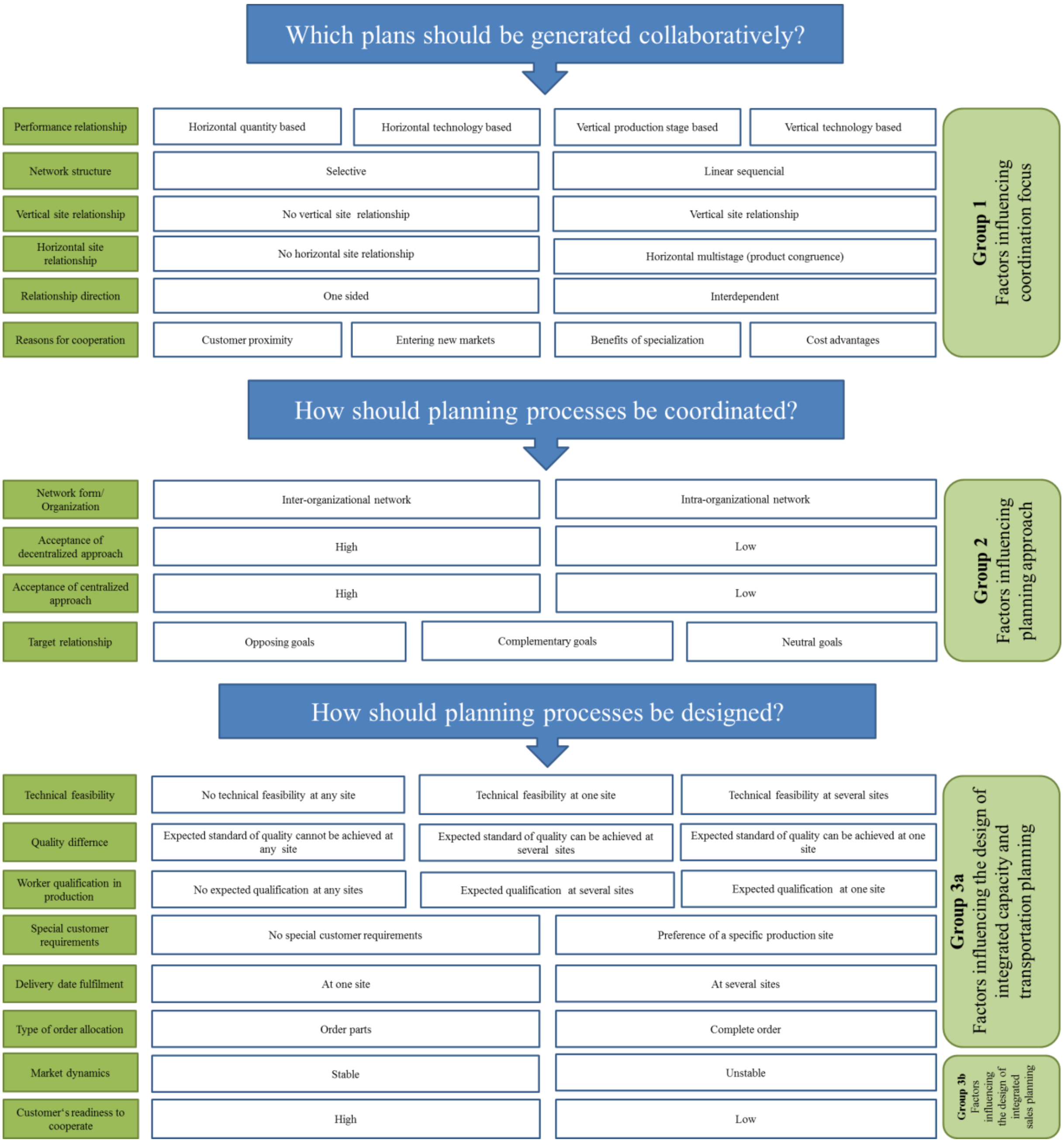

Figure 5. Framework of influencing factors

Coordination foci in networks can be identified through an analysis of material flow relationships in production networks. Kaphahn *et al.*'s (2006) scientific contribution to production planning and control coordination in internal production networks provides a basis for deriving influencing factors. Analysis defined six relevant factors. Various combinations of the values of these factors in turn describe two types of production networks, process and market oriented. The production network type determines the appropriate coordination foci'.

Performance relationships in networks can be categorized as horizontal and vertical. Companies or production sites of a company are horizontally related when their production processes are similar for branch and production stages. The horizontal relationships are divided into quantity, system and technology based. The ability to produce similar products at different production sites indicates a horizontal quantity-based production network structure. In horizontal system-based networks, the products are manufactured by adding products manufactured at different production sites to a system product. The adding process is usually performed at the customer's location. In the further analysis of influencing factors, this type will not be considered because it is atypical of the steel industry. The defining characteristic of a horizontal technology-based relationship is the ability of network actors to produce the same products in parallel due to congruent technology at several production sites. Vertical relationships can also be divided based on vertical technology and production stage. A vertical production stage-based relationship is characterized by an internal customer-supplier partnership. In vertical technology-based allocation of production sites, the required production technology is available only at one production site. The *network structure* describes enterprise-wide or company-wide alignment of production sites within the network. In the selective network structure, the production stages of all network actors are identical. In the linear sequential network, each production stage is performed by only one network actor. *Vertical site relationship* describes the complexity of relationships on the vertical level and indicates the number of different production stages for division of labour. *Horizontal site relationship* is distinguished by the fact that the same products can be manufactured by all network actors in parallel. The characteristic *relationship direction* observes material flows between participating network actors, and the material flow direction can be one-sided or interdependent. The characteristic *reasons for cooperation* includes customer proximity, entering new markets, benefits of specialization and cost advantages (Kaphahn *et al*., 2006).

The two production network types are described below (Figures 6 and 7), using the morphological box presented above. This description should enable companies to identify relevant coordination foci in the collaborative planning process.

The first type, the process-orientated network (Figure 6), is characterized by each participating actor's specialization in one element of the production process. The process-orientated network is characterized by a vertical site relationship, because such companies cannot have parallel production stages at different production sites. The participating actors have a vertical production step-based relationship. Sometimes a vertical technology-based relationship is possible when a production technology is available at only one production site. The relationship direction is one-sided because of product transfer to the next production stage. In a technology-based relationship, interdependent direction is possible, with cooperation being based on benefits of specialization and cost advantages (Kaphahn *et al*., 2006).

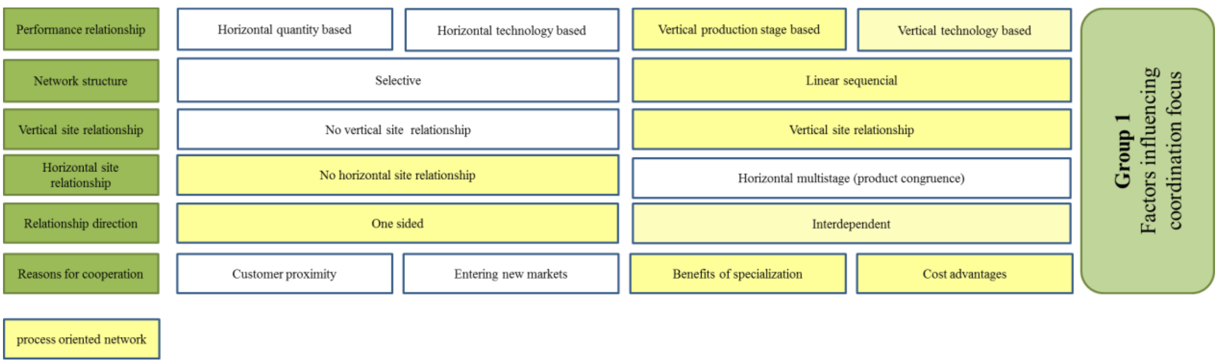

Figure 6. Process-oriented network (Kaphahn *et al*., 2006)

In the market-oriented network, the entire production process can be performed at one production site parallel to other manufacturing processes of the same product at different production sites (product congruence) (Figure 7). Thus, the market-oriented network is characterized by the horizontal quantity or technology-based relationship with selective network structure. The direction is interdependent because of the possibility of mutual external production within the network. The motivation for such cooperation may be customer proximity or potential to win new markets (Kaphahn *et al*., 2006).

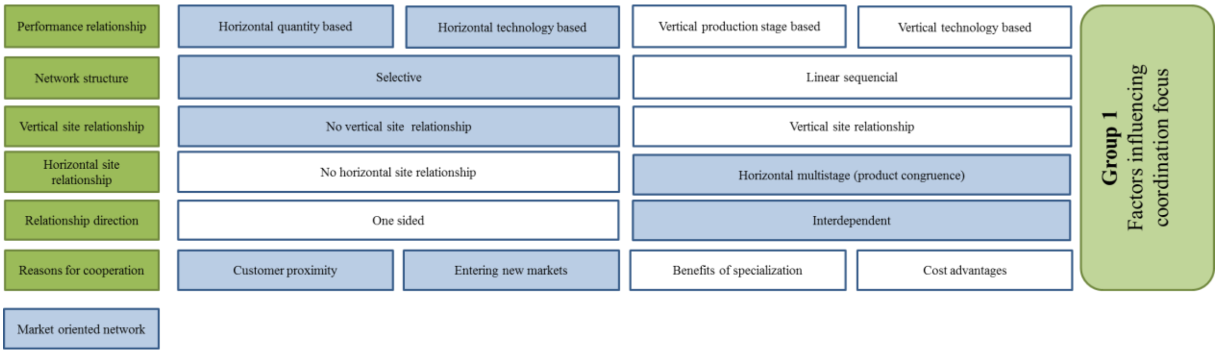

Figure 7. Market-oriented network (Kaphahn *et al*., 2006)

In the following step, the coordination foci in the sales, capacity and transportation planning for the identified production network types are described (Figure 8).

Because of the linear sequential structure of *process-oriented networks*, the *capacity planning with determined production volume allocation* must be performed collaboratively to avoid successive forwarding of demands. *Sales plans* need not be coordinated, because the finished goods do not have to arrive at the same time at the customer's location as is necessary in a horizontal system-based relationship. But this does not mean that the sales planning process need not be integrated into the capacity planning process. Further, both processes must be integrated to achieve competitive advantages in the market place (O'Leary-Kelly *et al*., 2002). In this case, the network partners do not need *a joint network production plan*, because only individual production steps occur at several production locations, and the manufactured products at these production locations are different. In the process-oriented network consisting of independent companies, the transportation process must be planned between production sites for a continuous production flow. In internal production networks, company-wide *transportation planning* is both necessary and easier to implement (Figure 8).

In the *market-oriented network*, the entire production process occurs at one production site for the manufacturing of the same products, facilitating access to all the production resources. Using shared resources makes it important to cooperate in *joint network production planning*. For this network type, it also very important to cooperate in *capacity planning with optimized production volume allocation*. Because of numerous material movements, the participating companies or production sites within a company must jointly determine a *transportation plan* (Figure 8) (Kaphahn *et al*., 2006).

	Process-orientated network		Market-orientated network	
	Independent companies	Internal production network	Independent companies	Internal production network
Coordinated sales plan	○	○	○	○
Coordinated capacity plan with optimized allocation of production volume	○	○	●	●
Coordinated capacity plan with determined allocation of production volume	●	●	○	○
Coordinated plan of joint network production	○	○	●	●
Coordinated transportation plan for production sites of an enterprise	○	●	○	●
Coordinated transportation plan for enterprises within the production network	●	○	●	○

Figure 8. Coordination foci (Kaphahn *et al*., 2006)

Because of the acknowledged lower acceptance of centralized planning approaches by independent companies participating in networks, the following question arises: In which cases is it optimal to use a decentralized planning approach, as opposed to a centralized planning approach, for an integrated planning process in networks? (Hegmanns, 2010). In general, two distinct planning approaches can be identified, on the basis of which planning in production networks can be coordinated effectively: *centralized* and *collaborative decentralized* approaches. Practice has shown that although centralized coordination of planning processes provides better results, it is harder to implement because of its lower acceptance in production networks. The first impediment that prevents the centralized approach from being implemented is the necessary alignment of individual planning decisions in the network. To provide the best planning results in the networks, an allocated planning decision has to ensure that network goals are achieved. Taking into account that each participating actor can have different individual goals, the best planning decision for the entire network may not be accepted by all actors. Further, the necessary network-wide information sharing complicates the implementation of the centralized approach. Companies can manipulate the information exchange to obtain additional profits or protect themselves by withholding relevant information (Pibernik *et al*., 2007). The second block of the framework presents factors influencing the planning approach (Figure 9). The network's *organizational structure* makes a centralized or decentralized planning approach more suitable. In general, networks can be categorized as inter-organizational and intra-organizational. An inter-organizational network has relationship fabric beyond the limits of a company. Intra-organizational networks are network-like relationship patterns within an organization (Zundel, 1999). In an intra-organizational network, control by a focal enterprise or centralized planning is more efficient, whereas inter-organizational networks should prefer a collaborative decentralized planning approach. The *acceptance* of the approaches is one of the most important factors influencing the planning approach. The *relationship of the goals* pursued by network actors also influences the decision for or against each of the planning approaches. As mentioned above, each actor's goals can be different from other actors' and the network's goals. Neutral or complementary goals of network partners can facilitate the implementation of a centralized planning approach. However, the decentralized approach is a better basis for planning in networks of companies that pursue competing goals (Hegmanns, 2010). The following morphological box summarizes all influencing factors with their values and illustrates the cases wherein a centralized or decentralized planning approach is optimum for an integrated planning process in networks (Figure 9).

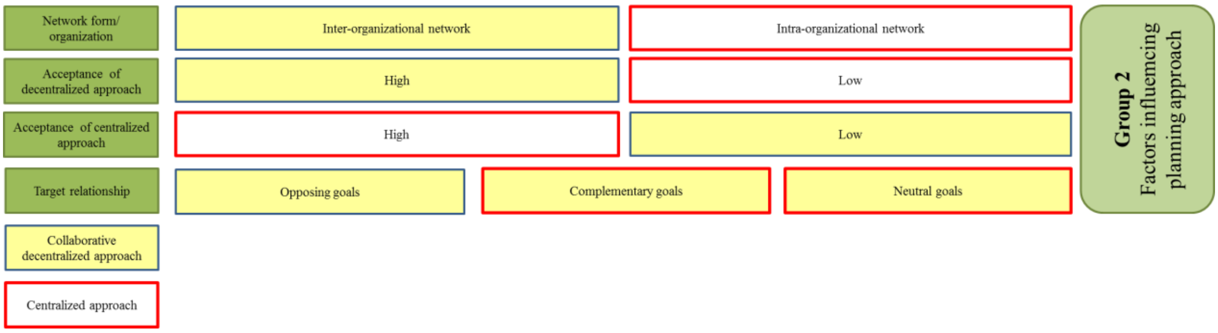

Figure 9. Centralized vs. decentralized planning approach

After determining which planning processes must be generated collaboratively and which planning approach is the best in a given case, the third framework block enables decision support for planning processes. The last framework block presents an approach for capacity planning by taking into account transportation costs to optimize transportation planning by determining the best for it. Factors influencing order allocation decisions are classified into two groups based on the types of capacity planning presented in the first framework block: design of capacity planning with (1) determined production volume allocation and (2) optimized production volume allocation. The most important factor influencing allocation decisions on capacity planning with determined production volume allocation is the *technical feasibility* of the planned order on the existing within-network equipment. Especially in the steel industry, the key criteria for the decision against production at a specific site are its failure to achieve the *expected standard of quality* and the absence of any *expected worker's qualifications*. In practice, the customers needing the products from this branch also have *special requirements* for the production site, at which their products must be manufactured. To increase customer satisfaction, the production network has no choice but to produce at this site with the given technical feasibility. If there is only one production site at which the delivery date can be fulfilled, the given site will be chosen for production. At this point, that factor alone has sufficient value to determine production at one specific site. However, when these criteria are fulfilled and the production of the planned order is possible at several sites, the network allocation process must be optimized from the perspective of costs. In allocating the production order to different sites, it is important to select the lowest-cost production option. Cost factors include production costs at every alternative production site, costs for transport between production sites, that is, if a production order is divided into several parts and costs for transporting finished goods from plants to the customer as well as every alternative production site's inventory costs (Jayaraman *et al*., 2001) (Figure10). However, it is also necessary to pursue the goal of optimal capacity utilization.

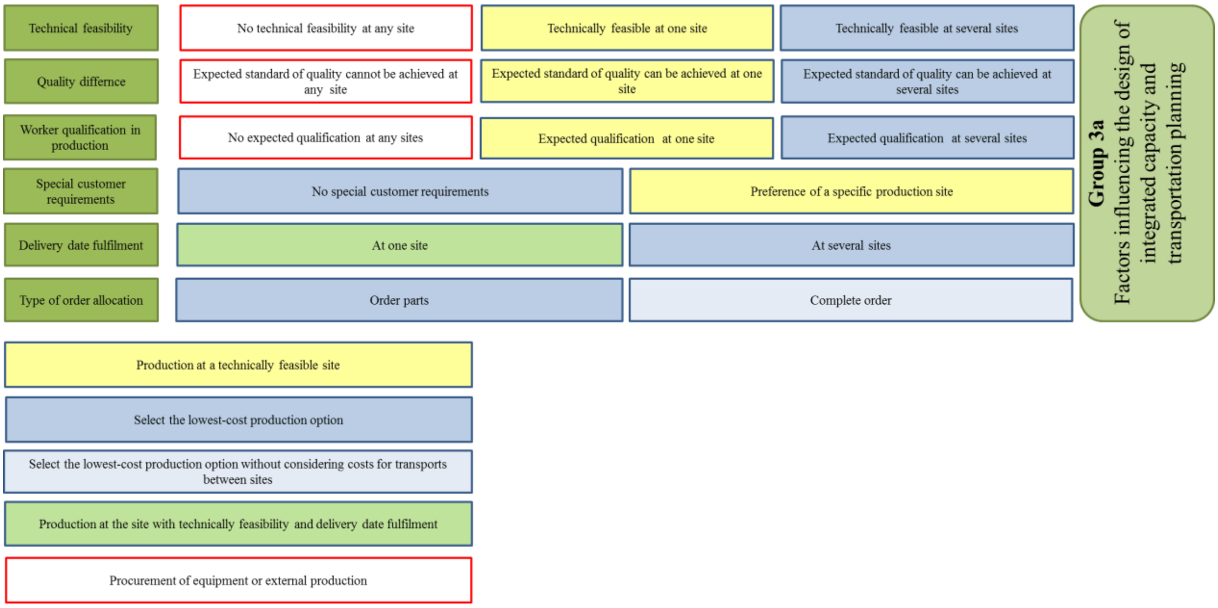

Figure 10. Integrated capacity planning considering transportation planning

In the final step, several factors influencing integrated sales planning design must be identified. Homburg *et al*. (2008) analyzed critical points of sales planning. The factors influencing sales planning can be derived from several critical points in sales planning itself. Homburg *et al*. (2008) criticized inward orientation sales planning most harshly. Many companies focus on cost items or their own production program during sales planning. To increase customer satisfaction and achieve more accurate planning results, collaborative planning with customers is necessary. Unfortunately, *customer readiness* to exchange information is often low. However, the degree of *market development stability* also influences the sales planning process (Homburg *et al*., 2008) (Figure 11).

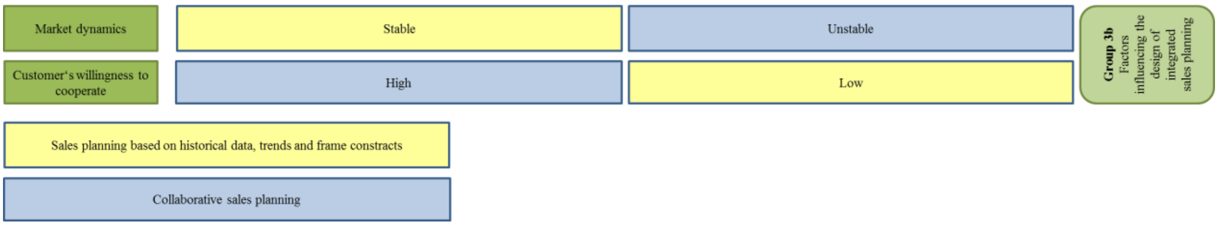

Figure 11. Integrated sales planning

In general, sales planning is conducted on the basis of historical data, trends, information from customers and frame contracts (Heidrich, 2004). With relatively stable demand development and low willingness of customers to exchange planning information, the above-mentioned basis is sufficient for planning. When customers are more willing to exchange information and market development is difficult to anticipate, planning in collaboration with customers using optimization models, such as CPFR (Collaborative Planning, Forecasting and Replenishment), is preferable (Barratt, 2001).

4. Conclusion and Outlook

The developed framework of influencing factors and their impact could answer the research questions posed at the beginning of this paper. The findings suggest that a planning process's need for coordination depends on the network's type of material flow relationship. Further, different conditions affect the choice of centralized or decentralized planning process coordination. Finally, results demonstrated how integrated capacity and transportation as well as integrated sales planning can be designed, depending on influencing factors' values. This study developed a basis for changeable processes by identifying and structuring factors that influence planning processes in production networks. This framework provides the first approach by which companies can adapt to volatile market requirements by changing the design of their planning processes relevant to influencing factors. Therefore, a variety of planning process models suitable to the diverse combinations of influencing factors' values need to be developed, such that their design fulfils the requirement defined in the portfolio of change enablers (s. 2.1).

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Mastering innovation life cycles from a supply chain perspective

A framework for aligning supply chains along maturity of technology life cycles

Matthias Parlings*, Katja Klingebiel**
*Department of Supply Chain Engineering, Fraunhofer Institute for Material Flow and Logistics,
Joseph-von-Fraunhofer-Str. 2-4, 44227 Dortmund, Germany
**Chair of Factory Organisation, Technical University Dortmund,
Leonhard-Euler-Str. 5, 44227 Dortmund, Germany

Abstract

Existing recommendations for the management of supply chains in regard to technological innovations primarily address companies in innovative sectors and are based on a snapshot classification of product and market characteristics. Yet, as technology cycles become shorter and innovations more radical, supply chains have to be realigned step by step to the developing maturity degree of a new technology. This aspect has not yet been discussed in research or practice, though technology life cycle discussions may clearly contribute here. Hence, this paper proposes an approach for dealing with technological innovations in changeable supply chains: After presenting the state of the art, technological innovation is classified and technology life cycle phases are systematised. A framework for aligning supply chains along the maturity degree and type of technological innovation is presented. The applicability and significance of this supply chain design innovation framework is demonstrated based on the example of e-mobility.

Keywords

Supply Chain Design, Supply Chain Management, Technological Innovation, Life Cycle

1. Introduction

The spread of information technology in the 1990s is one example of the impacts of technology-based innovations on Supply Chain Management (SCM) (Kuhn and Hellingrath, 2002). More recent trends, that will most presumably influence SCM as a whole, include sensor technology, autonomous systems and cloud technology (Strassner, 2005; Albrecht, 2012; Delfmann and Jaekel, 2012). In addition, branch-specific innovations arise that affect only certain supply chains: E.g. it is argued that the spread of electric and hybrid propulsion technology will radically change the automotive supply chain (acatech, 2010).

The management of supply chains in regard to technological innovations has already been widely discussed (Pfohl, 2007; Quick and Renner, 2010). Nevertheless, existing models and recommendations like Fisher’s (1997) Supply Chain Strategy Matrix or Lee’s (2002) Uncertainty Matrix primarily address companies acting in innovative sectors like high tech and computer industry (Huang et al., 2002). Furthermore, when choosing the right supply chain strategy based on a “snapshot” classification of product and market characteristics is necessary to deal with innovation in a first step, there may be a competitive advantage if the supply chain can be stepwise aligned to the respective maturity degree of a new technology. Though this maturity has been systematised in technology life cycle discussions as given by Gartner’s “hype cycle” (Fenn and Raskino, 2008) or the well-established innovation s-curve model (Spath and Renz, 2005), it has not been connected to supply chain alignment/design so far.

And even more so, in the past the required measures for dealing with technological innovation in supply chains have been mainly focused on establishing supply chain flexibility within the boundaries of the existing system (Kuhn et al., 2011). However, current discussions show that – as technology cycles become shorter and innovations themselves more radical – supply chains have to be empowered to actively and quickly adapt to changing market reactions on a new technology, i.e. supply chains are forced to become changeable in structure, processes and resources (Bertsch and Nyhuis, 2011; Klingebiel et al., 2012). In the early stages of innovation life cycles, supply chain processes are not running stable due to manifold uncertainties. In this timeframe, companies face the challenge of figuring out which phase the product or technology is in when it enters the next stage. Additionally, companies have to identify which impact being in the respective phase has on logistics and SCM. Hence, the company has to interpret the signs accurately to be able to act quickly and consequently. To respond to the challenge the use of a life cycle model which companies can use to class their innovations with different phases is proposed. Different life cycle curves have to be monitored to create an overall picture and increase the likelihood of interpreting the signs accurately.

This paper proposes an approach for dealing with change in supply chains triggered by technological innovations: After a brief discussion of the state of the art in chapter 2, technological innovation is classified and technology life cycle phases are systematised by integration of different technology life cycle concepts. Based on the classification a framework for aligning supply chains along the maturity degree is presented. The applicability and significance of this framework is demonstrated by taking the example of e-mobility.

2. State of the Art

The following fundamental approaches and models have to be considered in order to define the problem area and identify the academic void. First, technological innovation is defined to create a common state-of-the-art apprehension for the field of research. Secondly, most relevant models in the context of technological life cycles are described. The third section briefly presents the state of the art of logistics and SCM research related to technological innovation. Concluding, this chapter ends with a critical evaluation of the state of the art.

2.1. Defining Technological Innovation

The term “technological innovation” already suggests being a subtopic of innovation. Hence, before determining the scope of technological innovation, a brief discussion of innovation has to be undertaken. Although multiple definitions that have been developed for decades are present in the literature, two main attributes can be derived when defining innovation (Burr, 2004, p. 25; Mischke, 2007, p. 36; Hauschildt and Salomo, 2011, pp. 3–8):

- **Degree of novelty:** An innovation bears on a novelty. Therefore, an innovation has to differ perceptibly from a similar state. In other words, an innovation always implies an invention.
- **Commercial use:** The commercial use (e.g. through market introduction) is the crucial attribute when determining an innovation. In the words of Garcia and Calantone (2002, p. 112): “An innovation differs from an invention in that it provides economic value”. Economic utilisation is what lifts an invention to an innovation.

A homogeneous definition of technological innovation cannot be found in the literature. However, the following definitions well represent a general consensus of the understanding of technological innovation that will also be followed in this paper. Garcia and Calantone (2002,

p. 112) provide a broad view on technological innovation: “Technological innovations are those innovations that embody inventions from the industrial arts, engineering, applied sciences and/or pure sciences”. Their understanding is derived from an OECD-study in 1991 (Freeman, 1991). Zahn and Weidler (1995, pp. 362–366) describe technological innovation as being one dimension within an integrated innovation management. The other dimensions are organisational innovations and business-related innovations. Technical innovation implies products, processes and technical knowledge.

2.2. Existing Models for Technological Innovation Life Cycles

Many different models describe innovation life cycles and the development of technological innovations over time from various perspectives. The most common models include the Diffusion Process model, the Adoption Curve, the Performance S-Curve, the Maturity Curve, the Standard Life Cycle model and Gartner’s Hype Cycle. These models are briefly introduced in this section.

One highly respected work in the context of innovation evolution is Rogers’ (2003) “Diffusion of Innovation”. Rogers describes a model for the spread of innovations in a social system. The work focuses on socioeconomic aspects of innovation and its development. The key element in describing the development of innovations over time is the diffusion which is defined as “the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 2003, p. 11).

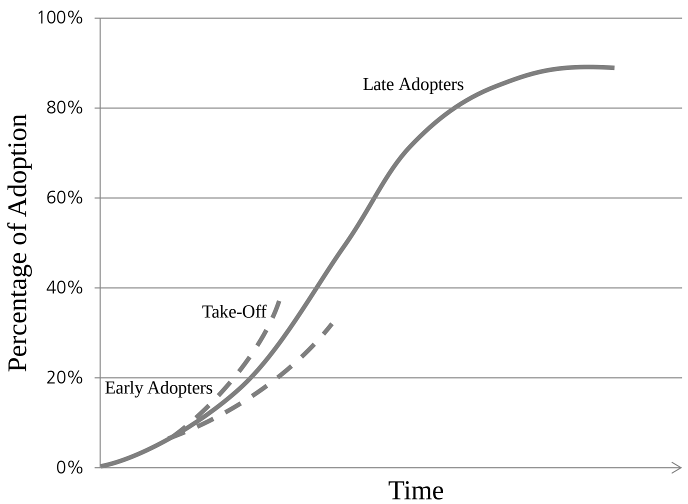

Figure 1: The Diffusion Process (Rogers, 2003, p. 11)

The diffusion process has been well established in innovation research literature as the “adoption curve” (Linden and Fenn, 2003, p. 6; Rogers et al., 2005, p. 12; Fenn and Raskino, 2008). There are two main alternatives in drawing the adoption curve: the bell-shaped curve displaying the absolute no. of adoption and the more common used adoption S-Curve showing the cumulative no. of adoptions. The curves are mainly used to explain the market penetration of new technologies and divide consumers in different adoption groups (e.g. Innovators, Early Adopters, Early Majority, Late Majority, Laggards) (Rogers, 2003, pp. 280-281). The basic model of the diffusion process is presented in Figure 1.

Another very popular model to analyse the evolution of a technological innovation is the (technology or performance) S-Curve (Nieto et al., 1998, p. 440). This curve demonstrates the typical trend of a technology’s performance over time or against the amount of effort (e.g.

R&D expenses) invested (Spath and Renz, 2005, pp. 237–238; Schilling and Esmundo, 2009, p. 1768). The S-Curve model is well-established for explaining innovation phenomena in various fields, e.g. technology, market, or product innovations and empirical evidence supports the cogency of this model (Nieto et al., 1998; Linden and Fenn, 2003, p. 6; Lu and Beamish, 2004). Generally, three phases can be distinguished within the performance S-Curve (Lu and Beamish, 2004, p. 601; Spath and Renz, 2005, pp. 237–238; Schilling and Esmundo, 2009, p. 1768): The emergence phase with little progress and reduced profits is followed by a growth phase with accelerating progress and growing profits. In the third phase, profit declines as the technology reaches its limit. The performance S-Curve is illustrated in Figure 2. Tightly related to the performance model is the concept of technological maturity that "places a technology along a continuum of technological advance" (Roussel et al., 1991, p. 59). The maturity of a technology cycle is typically divided into four maturity stages along a function of time (Roussel et al., 1991, pp. 61–63; Fenn and Raskino, 2008, pp. 36–37): Embryonic, Growth/Emerging, Adolescence/Mature, Aging.

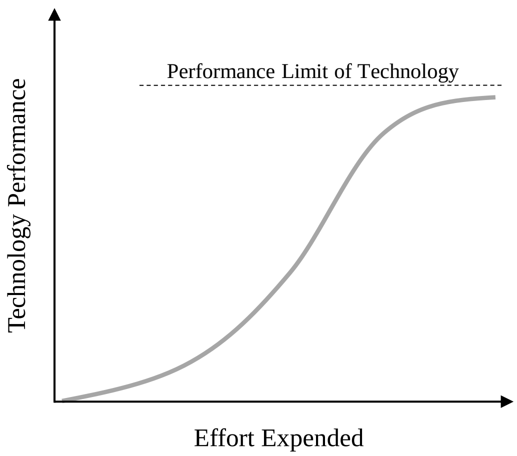

Figure 2: Performance S-Curve (Nieto et al., 1998, p. 445)

One of the most common ways to display a technology's evolution is to use the classic product life cycle model. The model has first been introduced in the 1960s and "refers to the life cycle of a product and describes the evolution of the volume of sales over time" (Nieto et al., 1998, p. 443). In analogy to the product life cycle, the technology life cycle displays the spread of a technology (e.g. measured based on product sales within a technology) over time (Spath and Renz, 2005, p. 236). Life cycles are commonly divided into the four phases introduction, penetration/growth, maturity, and decline (Nieto et al., 1998, p. 443; Figure 3). Innovative products are typically located in the introduction or growth phase of the life cycle (Huang et al., 2002, p. 194). Technologies in the different phases can be clustered as trendsetter (introduction), key (penetration), basic (maturity), and endangered technologies (Tschirky, 1998, pp. 232–238). Taking this life cycle model into consideration trendsetter technologies and key technologies are within the scope of this paper.

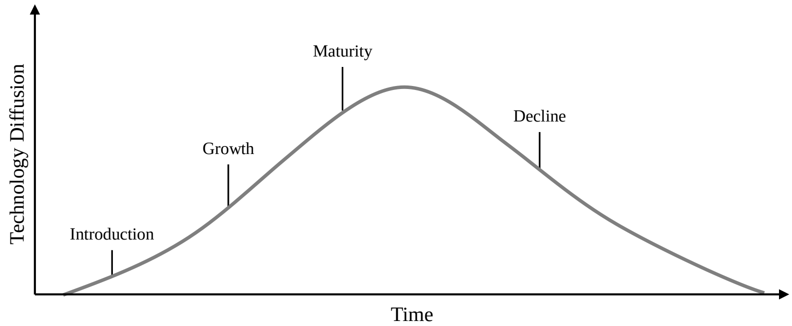

Figure 3: Technology life cycle (Tschirky, 1998, p. 238)

The last model that deals with the development of technological innovation introduced in this paper is Gartner's Hype Cycle. It has been developed by US-based information technology research and advisory company Gartner, Inc. (Gartner) in the 1990s (Fenn and Raskino, 2008, pp. XII–XVI; Gartner, 2012). The Hype Cycle describes the evolution process of a technological innovation as a function of expectations over time (Fenn and Raskino, 2008, pp. 7–9). Gartner holds the view that an emerging technology goes, starting with the technology trigger, through a period of inflated expectations, followed by disillusionment over a phase of enlightenment until it enters the plateau of productivity when broad market acceptance is reached (see Figure 4). Although the Hype Cycle model has mainly been used by Gartner in non-academic purposes, providing information and advices for their customers, the Hype Cycle has recently found its way into pure research and academics (O'Leary, 2008). The Hype Cycle model promises to be of high relevance for technological innovation research presented in this article since it focuses on the early stages of a new technology's life cycle (Linden and Fenn, 2003, p. 6).

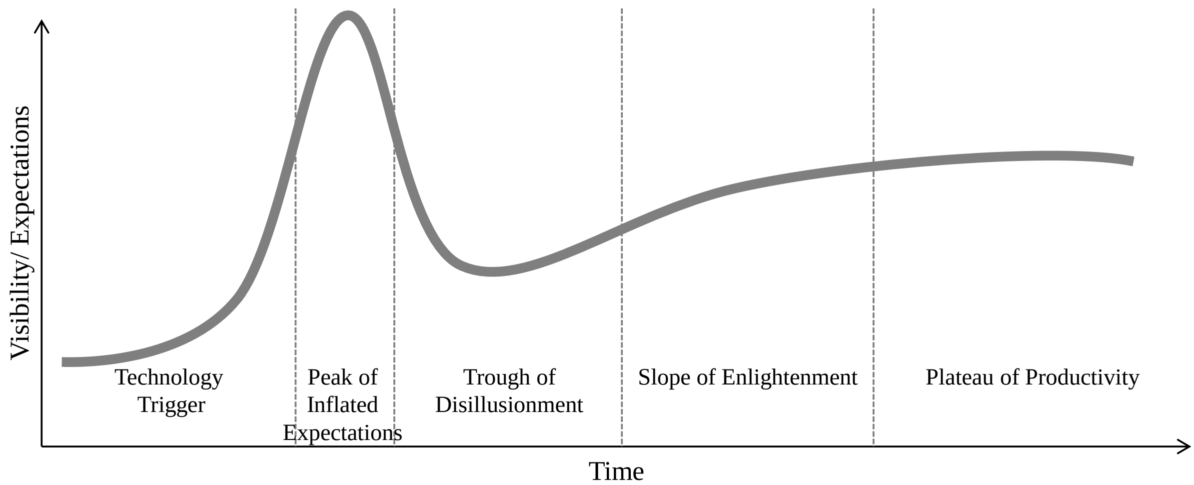

Figure 4: Gartner's hype cycle of innovation (Fenn and Raskino, 2008, p. 9)

After having introduced the most relevant life cycle models related to this paper's research topic, the following section provides a brief overview over the most important research works in the context of Supply Chain Management dealing with (technological) innovation.

2.3. SCM in the context of technological innovation and life cycle

Supply Chain Management research has put some emphasis on designing supply chain based on product characteristics and life cycle phases since the mid-1990s (Quick and Renner, 2010, pp. 360–362). One of the most appreciated works in this context is Fisher's (Fisher, 1997)

Supply Chain Matrix that matches supply chains to product characteristics. Fisher suggests implementing a responsive supply chain for innovative products and an efficient supply chain for functional products (Fisher, 1997, pp. 109–110). Fisher's work is an important basis for SCM research in the context of innovation but does not cover the scope of this research work since it focuses on innovative products rather than technological innovation and its advices are on a highly strategic level. The idea of adjusting Supply Chains with regard to external characteristics has further been developed by many researchers such as Mason-Jones et al. (2000) or Christopher and Towill (2000). In addition to product characteristics, they propose the consideration of market characteristics when choosing the right supply chain. Fisher's lean and responsive supply chains are complemented by risk-hedging, agile and leagile Supply Chains (Mason-Jones et al., 2000, pp. 55–56; Christopher and Towill, 2001, pp. 237–239; Lee, 2002, pp. 113–118). Lee's (2004) Triple-A Supply Chain can be seen as a highly sophisticated approach that combines many then state-of-the art recommendations. Besides the classic supply chain goals of high speed and low cost, supply chains would have to be agile, adaptable and aligned in order to achieve sustainable competitive advantage (Lee, 2004, pp. 102–104). Lee's approach is very promising but is mainly applicable to big supply chains with the focus on retail. Furthermore, it is developed as an "all-in-one approach" and does not consider different environments and market or product characteristics. All of the works still do not consider the development of products or technologies over time. The models support an assessment of the current state and subsequently recommend a corresponding supply chain strategy. In the following, two models are presented that consider the development of products or technologies over time and suggest corresponding supply chain strategies.

Aitken et al. (2003) propose a life cycle model with corresponding supply chain strategies that have been derived from a case study in lighting industry. Dependent on the life cycle phase of the respective product, it is matched to a corresponding supply chain. For this purpose, the company has to maintain multiple parallel supply chains (Aitken et al., 2003, p. 135). The model is rather not applicable for innovative products or technologies since it has been developed in the context of generic lighting products and the standard product life cycle is underlying. Furthermore, it deals with production logistics strategies and requires the existence of multiple supply chains (Aitken et al., 2003, p. 137).

Wang et al. (2004) as well as Vonderembse et al. (2006) have matched lean, agile, and hybrid (leagile) supply chains to product types and standard product life cycle phases. For innovative products, they propose implementing an agile supply chain in the first two life cycle phases. Supply Chain strategy should be changed to hybrid or lean when innovative products enter the stage of maturity. However, there is no procedure described on how to change to another supply chain strategy.

2.4. Conclusion and Outlook

Existing models and approaches in the context of innovation and SCM deal with innovative products rather than technologies. They are of a good use for companies that can inherently characterize their products as being innovative. With regard to innovation life cycles, different models have been introduced that can deliver valuable input for deriving an appropriate supply chain strategy throughout the innovation process. Previous research is rather not directly applicable to the problem dealt with in this paper: The development of a technological innovation that has to be accompanied by changing Supply Chain Strategies throughout the innovation process until a stable process of maturity is reached. Hence, a framework for mastering innovation from a supply chain perspective will be developed and its applicability will be demonstrated in the next chapter.

3. A framework for mastering innovation from a supply chain perspective

The framework is developed in a step-wise approach. In the first section technological innovation is classified. Following, technology life cycle phases are systematised from a supply chain perspective by the integration of different technology life cycle concepts. As an interim result, the technological innovation classification scheme is being presented in the third section. Based on this classification the framework for realigning supply chains along the innovation life is developed in the fourth section. Finally, the applicability and significance of this framework is demonstrated by taking the example of e-mobility.

3.1. Innovation classes and levels

Following Hauschildt and Salomo (2011, p. 5), innovations can be classified in five dimensions:

- **Content-wise:** What is new?
- **Procedural:** What is the beginning and the end of the innovation?
- **Normative:** Does innovation mean success?
- **Intensity:** How new is it?
- **Subjective:** For whom is it new?

In the content-wise dimension, this paper focuses on technological innovation which includes products and technologies. The procedural dimension will be displayed within the life cycle view introduced in the next section. The normative dimension is disputed since it depends on the highly subjective objective function of the decision maker (Corsten, 2006, p. 10). Concerning the intensity and subjective dimension of innovation, the much-noticed typology by Garcia and Calantone (2002) who classify technological innovations with regard to the level of "innovativeness" is being followed. In general, innovativeness can be seen as the "degree of newness of an innovation" (Garcia and Calantone, 2002, p. 112). Besides the mere intensity dimension, the subjective dimension is integrated in their classification. Garcia and Calantone (2002, pp. 118–120) suggest taking two levels into consideration to determine the degree of innovativeness:

- **Macro- vs. micro perspective:** Is the innovation new to the world, the market or an industry (macro) or is it only new to the firm or the customer (micro)?
- **Marketing vs. technology discontinuities:** To evolve, innovations may require new marketplaces or new marketing skills for the company. On the other hand, new state of science in technology, new R&D resources or new production processes may be required.

This classification is used by the authors to describe three distinct classes of innovations with regard to innovativeness (Garcia and Calantone, 2002, pp. 120–122):

- **Radical innovation:** To be considered radical, an innovation has to fulfil all four attributes being new from a macro and micro perspective as well as causing marketing and technology discontinuities.
- **Really new innovation:** Really new innovations result in marketing or technological discontinuity on a macro level, whereas on a microlevel, any combination any combination of the two can occur.

- **Incremental innovation:** If an innovation only occurs on a microlevel and does either cause marketing or technological discontinuity, it is considered being incremental.

The framework presented herein is directed to companies dealing with radical or really new technological innovations. It is assumed that incremental innovations evolve from an iterative process and are more or less day-to-day business to companies. It is understood that the occurrence of incremental innovations does not necessarily lead to a need to change a company’s supply chain and will typically be mastered by inherent flexibility of a supply chain.

Recapitulating the five dimension classes presented herein, the content-wise focus of this paper is laid on technological innovation. The normative dimension is excluded because of its subjective character and the procedural dimension is object of the life cycle systematisation in the next section. Regarding the dimensions of intensity and subjectivity, the innovativeness classification according to Garcia and Calantone (2002) is being applied. In the next section, relevant life cycle models will be systematised and integrated into a technology life cycle phase model in order to define the procedural dimension of the framework.

3.2. Systematisation of technological innovation life cycle phases

As has already been pointed out in the introductory chapter, the framework will be designed to support manufacturers and their Supply Chains in mastering technological innovations from a logistics perspective. For this reason, the framework will focus on the early stages of the life cycle, when the innovative product or technology has not yet fully been established. Internal and external impacts cause multiple challenges for designing appropriate logistics and supply chain systems. The following life cycles are being considered for the systematisation of technological innovation life cycles from a supply chain perspective:

For determining the actual state and future development of technological innovations’ early life cycle stages, Gartner’s Hype Cycle Model is chosen as the basis for the systematisation. By monitoring the visibility in media and society as well as human attitudes towards technology, it displays most detailed an innovation’s early development from a market perspective (Linden and Fenn, 2003, p. 6). For tracking the market penetration, the adoption curve which displays what share of the target market has already adopted the technology is integrated into the framework. The technology’s maturity provides an indication for product-based uncertainties that can influence the supply chain. To display the maturity development, the maturity curve is integrated into the framework. The development of a technology’s economic success is the fourth dimension to be integrated. This can be quantified using common performance indicators already existent in most companies and is best displayed in the performance s-curve.

The integrated technological life cycle model as a result of these considerations is illustrated in Figure 5. The phases underlying are derived from Gartner’s hype cycle. They can be identified by individual characteristics of the respective curves. Those characteristics are also very important for determining the Supply Chain challenges in each phase.

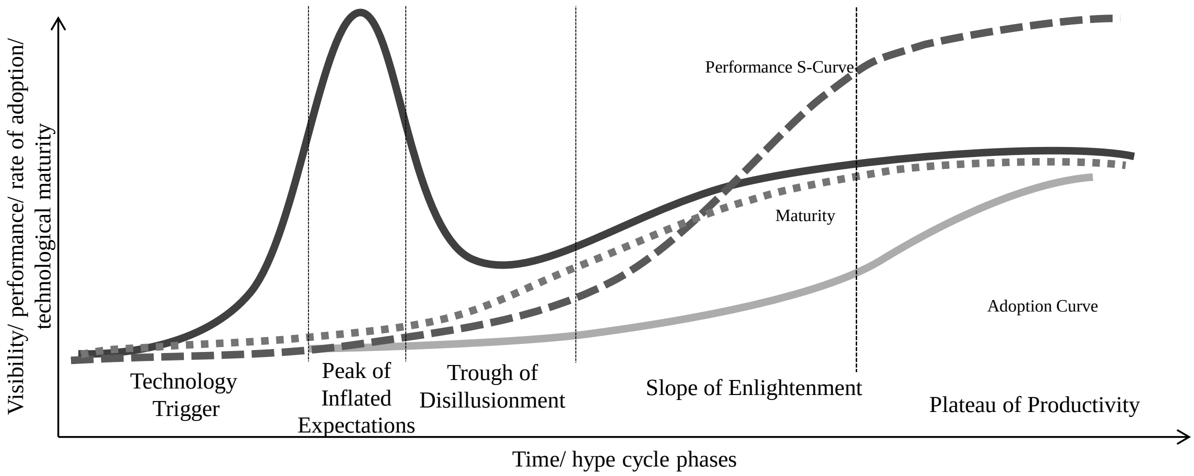

Figure 5: Integrated technological innovation life cycle model (based on and extended Linden and Fenn, 2003, p. 6; Fenn and Raskino, 2008, p. 26)

3.3. Technological Innovation classification scheme

The result of the considerations in the previous sections is summarized in the classification scheme displayed in Figure 6. The focus of this research work and therewith the applicability of the framework is framed. Within the content-wise class, the framework will be most applicable for manufacturers dealing with technological innovations. With regard to the innovativeness of the products and technologies, the framework will be designed to cope with the requirements and characteristics of radical and really new innovations. From the procedural view, the innovation life cycle will be covered from the trigger phase until the technology is established and enters the plateau of productivity. As companies have to become aware of the nature and status of the innovation they are dealing with, this morphology is a useful method to characterize the respective innovation.

Dimension	Technological Innovation Classification Scheme					
Content-wise	Product & Technology		Process		Market	Organisation
Innovativeness	Radical Innovation		Really New Innovation		Incremental Innovation	
Procedural / Life Cycle	Trigger Phase	Inflated Expectations	Disillusion	Enlightment	Plateau of Productivity	Maturity / Decline

Figure 6: Technological innovation classification scheme

On the basis of the classification of technological innovation and the implications of the life cycle model the framework to derive the right supply chain strategy will be developed in the following chapter.

3.4. A framework for mastering innovation from a supply chain perspective

General recommendations to deal with technological innovations from a logistics and Supply Chain Management perspective have been pointed out in chapter 2. There is a common understanding that Supply Chains have to be flexible, adaptive, responsive, and agile to successfully deal with innovation. Those preliminary works can well be integrated into the framework. However, this mainly strategic and static view has to be refined further since it has become clear that a single strategy is insufficient for accompanying companies along the technological innovation life cycle. Supply chains have to adapt their strategies and structures according to changing requirements along the life cycle. Especially in the context of radical and really new innovations, that are focused in this research, changing requirements due to distinct life cycle phases with different supply chain requirements can be expected. For realigning the supply chain and choosing the right strategy and structure it is essential to define the technological innovation phases and their characteristics from a supply chain perspective. Thus, the identification, distinction and characterisation of technological innovation life cycle phases is the core element of the framework. In the following, the phases introduced in chapter 3.2 are described and the phase-specific requirements on SCM are derived. Appropriate strategies and priority tasks for SCM are named.

Phase 1: Technology Trigger

On the hype cycle, the first phase of a technological innovation's life cycle is characterised by a technological breakthrough that generates press and industry interest in the innovation through an event like a public demonstration (Fenn and Raskino, 2008, p. 8). After the breakthrough, the hype begins to rise as mass media starts to explain the technology and its impact on business and society (Linden and Fenn, 2003, pp. 7–8). From the maturity point of view, the innovation is on the embryonic stage. While a vision of the possible application exists, the technology is still in the lab not exceeding the status of a prototype (Roussel et al., 1991, p. 59; Fenn and Raskino, 2008, p. 36). At this phase the adoption curve has not yet started to evolve since no adoption can exist without available products. With regard to its performance, the technology is on a stage of emergence. There is an initial period of turbulence with little progress and companies might have to pay some "tuition" (Lu and Beamish, 2004, p. 601; Spath and Renz, 2005, p. 237; Schilling and Esmundo, 2009, p. 1768).

In this early phase of a technology's life cycle, SCM has the unique chance to influence aspects like product design, vertical integration or supplier base it later has to cope with. The trigger phase offers a good opportunity to integrate the Supply Chain with the so-called "Design Chain". According to Cohen and Roussel (2006, p. 28) the Design Chain is the network of all partners inside and outside of the company who are involved in the definition and development of new products and services. By integrating the Supply Chain with the Design Chain, fast and sustainable introduction of new products and technologies is facilitated and the supply chain has the ability to quickly respond to fluctuations in demand (Cohen and Roussel, 2006, pp. 28–29). SCM should get itself ready and start analysing the characteristics of the technology. Potential supply chain risks may already be identified in advance. In summary, being aware of the trigger phase of a technological innovation offers a great opportunity for supply chain management to provide the basis for successfully mastering the technological life cycle from a logistics perspective.

Phase 2: The Peak of Inflated Expectations

From a hype cycle view, the second phase of a technological innovation's life cycle is characterised by high expectations and enthusiastic media coverage that lead up to the peak of inflated expectations (O'Leary, 2008, pp. 244–245). Venture capitalists get interested in the technology and the number of vendors increases (Linden and Fenn, 2003, p. 8). With regard to its maturity, the innovation is transitioning from a late embryonic to the early emerging/growth stage as first-generation products emerge. The adoption process begins with innovators adopting the new technology. Those "early prestigious customers" (Fenn and

Raskino, 2008, p. 8) not only command substantial financial resources but additionally have the ability to understand and apply complex technical knowledge (Rogers, 2003, pp. 282-283). The performance of the technological innovation is at an emergence stage. There might at most be poor return unless some specialised deployments or customised products find a high-margin niche (Linden and Fenn, 2003, p. 6).

From a supply chain perspective, this phase should be used to set up a responsive supply chain. SCM has to ensure building up the supply chain appropriate for the small scale production of first-generation products. It is important not to get infected by the media hype and resist building up excessive capacities that might match the level of hype. The supply chain should instead better be designed responsive in order to react to some irregular demand. A first supplier base must be built up containing of suppliers that are highly reliable rather than low-priced.

Phase 3: Trough of Disillusionment

The third phase is characterised by disillusionment as the technology does not fulfil the overinflated expectations and becomes unfashionable (O'Leary, 2008, p. 245). Failures and challenges are publicised by the media rather than opportunities and potential value (Fenn and Raskino, 2008, p. 8). With regard to its maturity, the technology is at the emerging/growth stage. Early feedback regarding problems and issues from first users and enhanced knowledge are the basis for further technological improvement by abandoning the impractical (Roussel et al., 1991, p. 60). Although the media hype declines, early adopters follow up innovators as they identify benefit coming with the new technology (Linden and Fenn, 2003, p. 8). Early adopters can be characterized as “the individual to check with”, being locally acknowledged role models (Rogers, 2003, p. 283). Up to 5% of the market volume has adopted the technology at the end of this phase (Linden and Fenn, 2003, p. 7). The performance of the technology is on a transition from late emergence to early growth state.

Supply Chain Management should use the calm down of the hype for a consolidation of the supplier base and a systematic elimination of all inefficiencies that might have crept in during the hype phase. Being cost-efficient is very important at this stage as the low performance of the technology in combination with little market adoption does not lead to sufficient profit. Additionally, it is getting harder for companies to acquire venture capital with disillusionment dominating the technology’s appreciation. If the company is not capable of diminishing its losses with the contribution by logistics and SCM, it might not make it to the next phase of sustainable growth. At the same time, ensuring the adaptability of the supply chain is of great importance for being ready to react immediately on rising demand when the technology starts climbing the slope of enlightenment at the end of disillusionment phase.

Phase 4: Slope of Enlightenment

As the understanding about the applicability, risks and benefits grows, a sustainable increase of the technology’s visibility rather than a media hype based on expectations begins (Fenn and Raskino, 2008, p. 10). Companies acquire later-round funding for marketing and sales support to pull themselves up the slope of enlightenment. The technology enters the adolescent/mature phase of the maturity cycle as second- and third generation products are launched and the pace of advance in understanding and development slows (Linden and Fenn, 2003, p. 8; Roussel et al., 1991, p. 60). As early adopters begin to experience benefits they overcome the trough and infect the early majority (Fenn and Raskino, 2008, p. 9). The early majority follows “with deliberate willingness in adopting innovations but seldom lead” (Rogers, 2003, p. 284). During this stage, adoption rises from 5% up to 30% of the potential market segment (Linden and Fenn, 2003, p. 9). With regard to its performance, the technology is in the middle of the growth phase characterised by accelerated performance improvement and a growing profitability (Lu and Beamish, 2004, p. 601; Schilling and Esmundo, 2009, p. 1769).

From a supply chain perspective, the appropriate strategy in this phase should be to implement agility. Although there is a general trend for rising demand, it is still volatile and cannot reliably be predicted. Availability is an important competitive factor at this stage. An agile supply chain that emphasizes short lead-time and a high service level is the best match for those requirements (Mason-Jones et al., 2000, pp. 55–56; Khalarmov and Ferreira, 2012, pp. 7–9). On the other hand, SCM has to scale up the capacities of logistics and the suppliers as the growing market adoption leads to higher demand.

Phase 5: Plateau of productivity

As the benefits of the new technology are broadly demonstrated to and accepted by the real-world, the technology enters the plateau of productivity. An ecosystem around the technology evolves (Linden and Fenn, 2003, p. 9). The innovation is considered proven and enters the mainstream stage of its maturity with risks being significantly lower (Fenn and Raskino, 2008, p. 37). Scientific and engineering advances have reached a substantial completion (Roussel et al., 1991, p. 60). The phase is further characterised by the beginning of mainstream adoption that represents the steepest part of the adoption curve (Linden and Fenn, 2003, pp. 7–9). The late majority starts adopting the technology because of economic necessities or increasing peer pressures (Rogers, 2003, p. 284). At the beginning of this phase, performance is still high but with competitive pressure rising, it slightly enters the aging stage and profits begin to diminish (Schilling and Esmundo, 2009, p. 1769).

As the technology enters the plateau of productivity, Supply Chain Management has to focus on implementing efficient structures and processes for high-scale production. Since the Hype Cycle with its high volatility and uncertainty is left behind, a hybrid, “leagile” supply chain that combines lean and agile benefits should be built up (Mason-Jones et al., 2000; Khalarmov and Ferreira, 2012, p. 8). This can be accomplished by using postponement strategies and supplier base reduction.

Based on this phase description, the framework for mastering technological innovation life cycles presented in Figure 7 is being derived. The upper part of the framework is used for the placement of a company’s technological innovation into its respective innovation life cycle phase. The appropriate supply chain strategies and priority SCM tasks are presented in the lower part. The applicability of this framework is now demonstrated by taking the example of e-mobility.

Hype Cycle Phases		Phase 1: Technology Trigger	Phase 2: Inflated Expectations	Phase 3: Trough of Disillusionmet	Phase 4: Slope of Enlightenment	Phase 5: Plateau of Productivity
Life Cycle Characteristics from a Supply Chain View	Level of Expectations and Visibility	Technological breaktrough Mass media coverage Rising hype	High expectations Enthusiastic media coverage Venture capital	Disillusionment, unfashionable Failures and challenges publicised	Sustainable increase of visibility Later-round funding	Broadly demonstated and accepted
	Level of Maturity	Embryonic stage Technology in lab Prototype status	Embryonic to early emerging First-generation products	Emerging Technological improvement Early feedback	Adolescent 2nd- and 3rd-generation products	Mainstream Considered proven Lower risks
	Level of Market Adoption	No adoption	Innovators Adoption starts	Early adopters < 5% market adoption	Early majority <30% market adoption	Steep adoption > 30% market adoption
	Level of Economic Performance	Emergence Companies paying „tuition“	Emergence Poor return	Late emergence to early growth	Accelerated improvement Growing profitability	Profits beginning to diminish
Supply Chain Phases		**Monitoring and Integration**	**Supply Chain Setup and Responsiveness**	**Consolidation and Adaptability**	**Scale-Up and Agility**	**Efficiency and Hybrid strategy**
Supply Chain Characteristics	SCM Strategy	Monitoring and Awareness	Responsive Supply Chain	Adaptable Supply Chain	Agile Supply Chain	Hybrid, leagile Supply Chain
	SCM Tasks	Design Chain Integration, Risk identification	Resist the hype Highly reliable supplier base	Consolidation of supplier base, Cost-efficiency	Scale-up logistics and supplier capabilities	High-scale production Efficiency

Figure 7: Framework for mastering innovation from a supply chain perspective

3.5. Applicability of the framework

In recent years, e-mobility has established itself as a serious alternative for automotive mobility: The expected shortage of fossil fuels leads to steadily increasing fuel costs. The ecological awareness of society in general and especially vehicle customers is rising. Legislative regulations like the limitation of CO_2 emissions and the implementation of emission-free city zones require new alternatives for mobility (Wallentowitz et al., 2010, pp. 3–34). Furthermore, the introductions of first electric life-style vehicles like the Tesla Roadster in 2008 have been well-covered by the media and contributed to the e-mobility hype (Tesla Motors, 2012). In summary, after several setbacks in the last century, there is a strong belief that e-mobility has already reached a sustainably breakthrough this time and will have further major impacts on the automotive industry and its supply chain structures (acatech, 2010, p. 32; Mietzel, 2011, pp. 96–97).

Hence, the analysis of the respective past and present automotive supply chain configurations in comparison with the respective recommendation of the developed framework may help to validate the framework’s applicability. To begin with, e-mobility has to be characterised by use of the technological innovation classification scheme (see Figure 6) and the development phases of e-mobility have to be analysed against the background of life cycle characteristics from a supply chain view.

Allocation of e-mobility within the technological innovation classification scheme
E-mobility emerges from the field of engineering since it founds on the respective technical knowledge. The electric vehicle as the outcome of the innovation is a product. Hence, e-mobility is clearly to be classified content-wisely as a technological innovation.

From a macro-perspective, e-mobility is not innovative since its basic technologies and functionalities have generally been known for a long time (Kirsch, 2000). Nevertheless, from a micro-perspective, e-mobility does have the characteristics of an innovation. Especially if the concept of “purpose design”[1] is being pursued, electric cars may be regarded as really new for automotive manufacturers. One example for a purpose-built electric car that carries the characteristics of being considered a really new technology is the mia, a battery-electric vehicle built in France since 2011 (mia electric, 2012, pp. 1–5). From a customer point of view, e-mobility is new since most customers have never been in touch with electric vehicles before. Both, marketing and technological discontinuities occur in the context of e-mobility. New marketing concepts have to be developed to spread the advantages of electric cars. And new mobility concepts like car sharing and new ownership models (e.g. battery leasing) evolve around e-mobility. Furthermore, the development of electric cars requires paradigm shifts in automotive technologies, e.g. battery concepts, wheel hub motors or light weight construction (Spiegelberg, 2009, pp. 69–74). Hence, it may be concluded that with regard to the degree of innovativeness, e-mobility is classified as being a really new technology for the automotive industry.

Concerning the procedural/life cycle dimension, e-mobility is entering the trough of disillusionment as news about technological failures (e.g. the battery explosion of the Chevrolet Volt, (Reed, 2012a)), unmet sales expectations (Nationale Plattform Elektromobilität, 2012) and financial trouble of market participants (e.g. Think! bankruptcy (Reed, 2012b)) replace the excitement about potentials. Figure 8 summarizes the respective classification. Following, the first three development phases of e-mobility are discussed against the background of life cycle characteristics and framework recommendations.

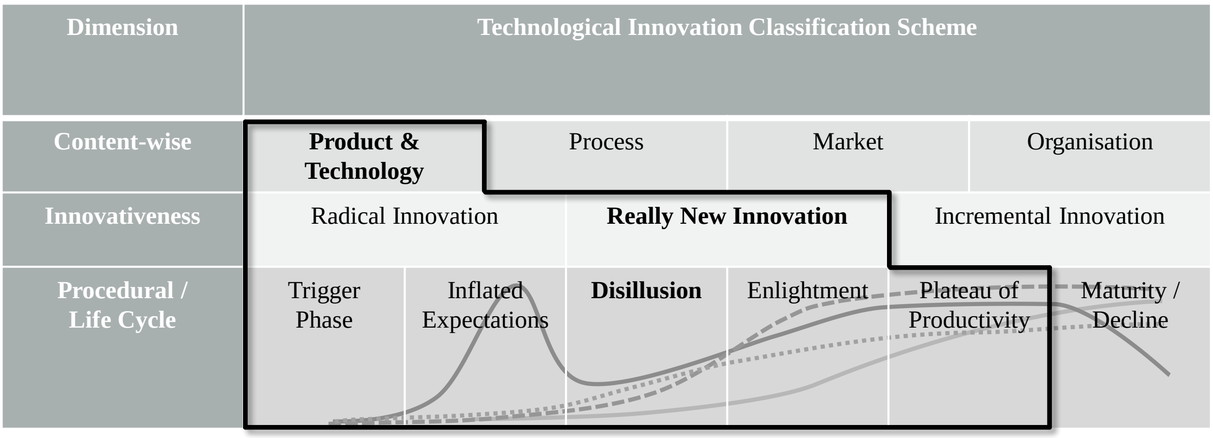

Figure 8: E-Mobility within the Technological Innovation Classification Scheme

Phase 1: Technology Trigger E-Mobility
The first phase of the innovation cycle in the context of e-mobility cannot be narrowed down to a single event. Different drivers have led to an intensified political, media and social

[1] Purpose design is defined as the fundamental new development and design of a vehicle according to the technological constraints and freedom of design of e-mobility (Wallentowitz et al. 2010, p. 117).

awareness of e-mobility during the last decade. In Germany, one of the last trigger points for e-mobility to step into phase 2 might have been the passage of the national development plan for e-mobility in 2009 which included the implementation of the national platform for e-mobility and the release of €500 million in research funds (Bundesregierung, 2009a, 2009b). But until then, electric cars have been almost not available for the regular customers. Nevertheless, most manufacturers have then started to increase their efforts in e-mobility R&D.

The developed framework for mastering innovation from a supply chain perspective recommends that companies should choose a strategy of monitoring and awareness for their supply chain for this phase. Major tasks should have been the identification of potential supply chain risks and the integration of the design chain. Looking into practice, it may be discovered that Volkswagen developed an indicator system for risk assessment at that time (Leohold, 2011). This system is used to monitor supply risk for natural resources which are important for battery production (e.g. lithium, cobalt and neodymium). Also the design chain integration could be observed in practice. For example in 2006 the joint venture Li-Tec Battery GmbH has been founded by Evonik Industries AG and Daimler AG (Li-Tec Battery GmbH, 2010).

Phase 2: Inflated E-Mobility Expectations

The peak of inflated expectations occurred at the beginning of this decade. Venture capitalists did provide large amounts of financial resources for the foundation of new companies like the franco-german mia electric (mia electric, 2012, pp. 1–2). First-generation products like the Tesla Roadster have been built in small batches (Tesla Motors, 2012). But companies still struggle to be profitable (Beissman, 2011). In this phase, the framework suggests a responsive supply chain strategy. Companies should resist the hype and avoid building up excessive capacities. Mia electric did not follow this strategy and has built up high capacities of 1.000 cars per month (mia electric, 2012, p. 1). In May 2012, the press reported that mia is getting into serious trouble due to world-wide sales dropping down to not more than 50 cars per month (Le Roux, 2012).Another priority task recommended within this phase comprises the building-up of relationships with highly reliable suppliers. In practice, we recently observed Daimler and its supplier Bosch building up a joint venture for the supply of electric engines which proves that point for the Daimler supply chain (Daimler AG, 2011).

Phase 3: E-Mobility Disillusionment

As already stated, e-mobility is very recently reaching the disillusionment stage of its life cycle. Adoption slightly increases, yet remains on a very low level (Kraftfahrt-Bundesamt, 2012). The appropriate supply chain strategy in this phase is adaptability. And again, recent news supports this recommendation: GM has to stop the production of their electric car Chevrolet Volt for the second time this year to adapt to low demand (dpa, 2012). The cool down of the hype should now give the time for consolidation. It may also be observed that the automotive supplier and battery producer Johnson Controls did end its partnership with Samsung, the joint venture “Johnson Controls-Saft” to sharpen its own battery supplier image (Morawietz, 2012). Cost-efficiency is obviously becoming increasingly important since electric vehicles are still far more expensive than comparable conventional cars.

4. Conclusion and further research

In this paper, an approach for dealing with change in supply chains triggered by technological innovations has been proposed. The discussion of the state of the art has clarified that existing models and approaches are primarily designed for companies that can inherently characterize products as being innovative rather than dealing with the management of technological innovations that lead to a demand for changing the supply chain. Although a wide range of life cycle models provide the basis for a distinct innovation characterisation, only the standard life cycle model has been applied to SCM so far. Thus, previous research is not directly applicable to supply chains prone to technological innovation, as these have to be accompanied by changing supply chain strategies throughout the innovation process until a stable process of maturity is reached.

Since innovation is a wide field, a technological innovation classification scheme has been developed to narrow down the scope and provide the means for classifying the individual innovation. Based on this classification scheme, the presented framework integrates existing life cycle models and supply chain strategies. For the classification of each innovation’s life cycle phase, general criteria have been derived from the underlying life cycle models. For each respective phase, an appropriate supply chain strategy along with priority tasks is provided.

Though the demonstration example discussed in chapter 3.4 shows the general applicability of the framework, it is now necessary to approve the selection of the life cycle models and the division into the phases by further empirical research. Besides its contribution to practitioners in SCM, the framework for mastering innovation from a supply chain perspective also provides a useful basis for further research. More precise indicators need to be integrated into the framework to determine the life cycle phase and measure criteria for the early determination of phase change. The phase transition has to be analysed in more detail to integrate an appropriate process of change into supply chain practice. And furthermore, this paper only focused on technological innovations. Since market and organisational innovations also bring along requirements for change in supply chain strategy and configuration, their integration into the framework is one of the next steps.

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Configuration and evaluation of production networks using a maturity model based approach

Omar Abdul Rahman[1,2], Andreas Kluth[1,2], Anja Schatz[1,2]

[1]Fraunhofer Institute for Manufacturing Engineering and Automation - IPA,Stuttgart

[2]Institute of Industrial Manufacturing and Management – IFF, University of Stuttgart

Nobelstr. 12, 70569 Stuttgart, Germany

omar.abdul-rahman@ipa.fraunhofer.de

andreas.kluth@ipa.fraunhofer.de

anja.schatz@ipa.fraunhofer.de

Abstract

Due to the globalization manufacturing enterprises have to be present locally with their own capacity in almost all markets, thereby greatly increasing the planning complexity of manufacturing networks. Today's high number of digital tools are deployed and used to support planners along their activities. However, the challenge remains not only to have better understanding of network configuration and evaluation but also to identify the most suitable digital tool with the required functionalities and capabilities for these purposes and needs. To meet these challenges, a new combined approach for the configuration and the evaluation of production networks using a maturity model has been conceived at the Fraunhofer-Institute for Manufacturing Engineering and Automation IPA. The maturity based approach also takes into account recommendations and measures to increase the degree of maturity. In a further step the developed approach is also suitable to measure and evaluate the progress made on the configuration of the supply chain.

Key Words: Supply chain, maturity model, evaluation.

1 INTRODUCTION

In comparison with the past, today's manufacturing enterprises in all industrial sectors are confronted with bigger market challenges. The markets getting global, goods and services are available all over the world within a short period of time. These circumstances increase the market challenge pressure for manufacturing enterprises worldwide (Westkämper 2006). To meet these challenges manufacturing enterprises have to be present locally with their own capacity in almost all markets. The presented approach in this paper provides large share to master them successfully. Therefore the approach combines two methods, for the strategic planning of production networks as well as for the evaluation and determination of the supply chains maturity, conceived at the Fraunhofer-Institute for Manufacturing Engineering and Automation IPA. For the strategic planning and value added ideal creation of supply chains, multiple planning scenarios are developed, implemented into holistic models and finally benchmarked and evaluated. These alternative planning scenarios are examined in terms of maturity aspects. The combined approach considers various uncertainties as well as dynamic aspects and their temporal trend. The results are statements to supply chain costs as well as its maturity. Furthermore the presented approach is a high potent support in strategic planning of production networks and the related decision making process.

2 PROBLEM STATEMENT

The globalization of markets and the related competitive pressure are permanently increasing (Risse 2003). This provides manufacturing enterprises with huge challenges (Klöpfer 2000). To meet these challenges, manufacturing enterprises have to be present locally with own capacity in almost all markets, thereby greatly increasing the complexity in the production networks. This leads to an increasing importance of location and network planning with the goal of flexible and cost effective distribution of the value creation (Fleischer 2004, Kinkl 2004). The significant efforts for the reduction as well as the decrease of the necessary investments are required to enable these companies to select the value added ideal production network. For the configuration and the planning of production networks it is more and more important to increase the collaboration and communication between actors within a value chain. Computer-based information systems are used to support the value-chain activities by allowing automated communication between single actors (Makris et al. 2008). They aim at keeping the production network competitive, by introducing a new depth of control and configuration. There is an excess supply of digital tools, all bringing their specific functions, risks and implications to the table. The selection, introduction and use of digital tools are difficult to assess. These digital tools and methods should be steadily and comprehensively reviewed and evaluated to regarding its current feasibility / performance in order to ensure continuous improvement. Evaluating and selecting suitable methods or digital tools to fit into the existing systems and addressing the specific needs of a value chain is difficult, and there is still a lot of potential to be realised. Therefore such tools and methods as well as the production networks themselves have to be evaluated regarding their maturity issues.

3 STATE OF THE ART

In order to define the scope of the combined approach and perhaps to use benefits of existing approaches, several approaches (from the research as well as the industrial side) dealing with at least two fields of the topic production network, simulation and costs as well as existing maturity models will be shortly described and highlighted in the following chapters. Since most of the maturity models often are very extensive, there will be no detailed description of all model elements, processes and skills. Therefore, mainly the basic structure of the models and the core elements and maturity levels will be briefly explained.

3.1 Network Planning and Configuration

The ideal connection of the different production sites is a critical point in assuring the competitiveness of manufacturing enterprises. Researches have already addressed the complexity of planning production networks with mathematical or electronic support in the early 90s. One of the first models (see Figure 1), which handle new production capacities in production network, was developed by Hagedorn (1992). In this approach a production network has been divided into two levels, the production site level as well as the headquarter level. By dividing the network into these levels Hagedorn generated a simulation model to analyze the future changes in the production program, as presented in Figure 1.

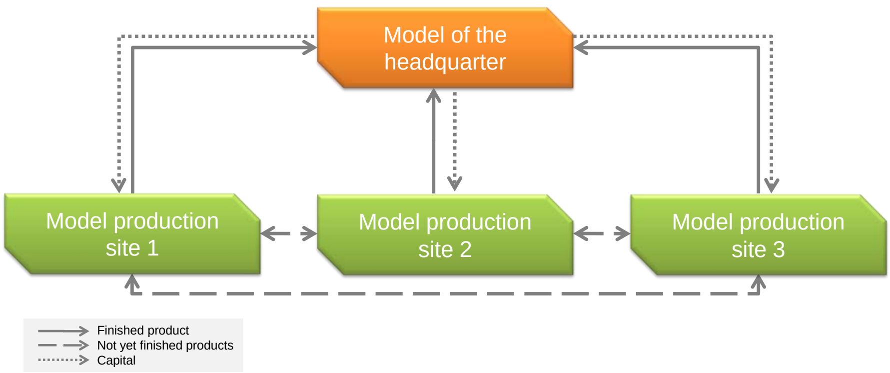

Figure 1: Two network level definition (adapted from Hagedorn 1992).

Schellberg (2000) and Merchiers (2008) adopted the division of networks and extended it in a further step to the three different levels. The first level is the network level, within the production sites are chosen and their roles are defined. The middle one describes the location level, where the production program of the single production locations is planned while the detailed planning of production processes is connected to the third level "production module" (see Figure 2).

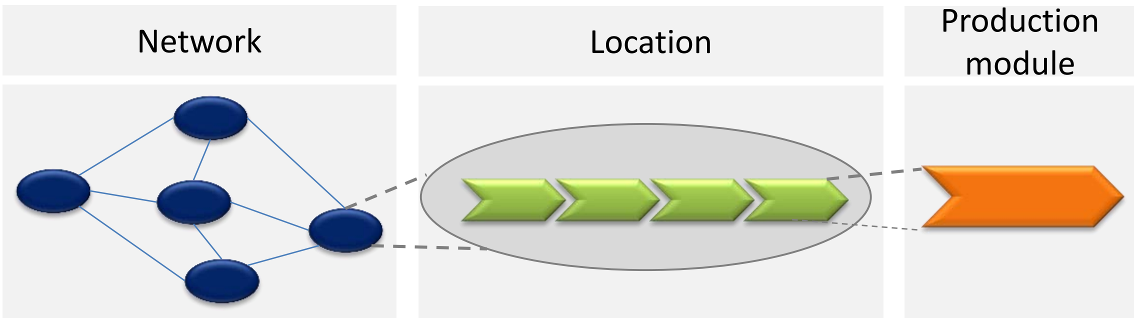

Figure 2: Definition of three different levels (Merchiers 2008)

Nevertheless the general idea of defining different levels is not found in all modern researches. One important work dealing with planning of production networks has been composed by Meyer (2005). He developed a method for designing and evaluation global production networks focused on a quantitative analysis of network costs by using a mathematical optimizing. Other research works focus more on the aspect of analyzing costs at one production site and neglect the extension to production networks.
From the industrial side, also several approaches are existing. Wunderlich (2002) developed based on MS Access the tool *KostSim* aiming at the calculation of costs using the simulation. A variable cost model is used in this tool, in order to provide enterprises the opportunities for mapping their own cost accounting methods. Wunderlich divided the costs into variable and fix costs as well as cash and purely imputed cost rates. Bierwirth (2004) developed a three level decision model according to the strategic planning phase, the concept planning phase and the fine planning phase. The main core of this approach was related to the logistic structures of production networks. The developed tool aims to support the decision making regarding the site planning in early phases using predefined key indicators. Within the concept and the fine planning, this approach addressed the transparency of processes using the visualization based on CAD. In the frame of the fine planning he created a dynamic simulation model for the monetary analysis of production networks. The calculation of the costs will be achieved according to the definition VDI (Association of German Engineers). Meyer (2006) developed a method for the configuration of global production networks. This approach aims to improve the configuration and the evaluation of alternative site structures using a quantita-

tive model, which supports at the determination of the cost optimal site structure as well as possible goal conflicts. Another approach for the optimization of supply chains was developed by *Volkswagen Nutzfahrzeuge* (2008). The developed tool *SCOT* (Supply Chain Optimization Tool) is designed for the optimization of production as well as purchase scenarios in the automotive industry. The calculation using *SCOT* provides statements about the ideal distribution of series production vehicle and derivatives. Within the calculation, costs aspects as well as local content requirements are integrated. These instructions determine the proportion of the value that has to be met at least at one production site. A further approach and tool *NetPlAn* for reducing the whole costs in production networks was developed by Prinz (2009). Using this tool the added value can be analyzed and visualized. For the monetary evaluation of the value added distribution the different costs (e.g. Personal, machine, quality, material, area, disposal, logistic and packaging costs) are taken into account. Grauer (2010) developed a methodology for the configuration/design of global production networks, where the main focus is on the interaction between product design, process design and site decisions. Considering these factors, a procedure for the design and subsequent evaluation of production networks is being developed. The quantitative evaluation is done by calculating the cost of an appropriate product for each module location and the qualitative evaluation can be done using the cost benefit analysis. The following figure (see Figure 3) shows an overview about the different approaches from the industry as well as the research side.

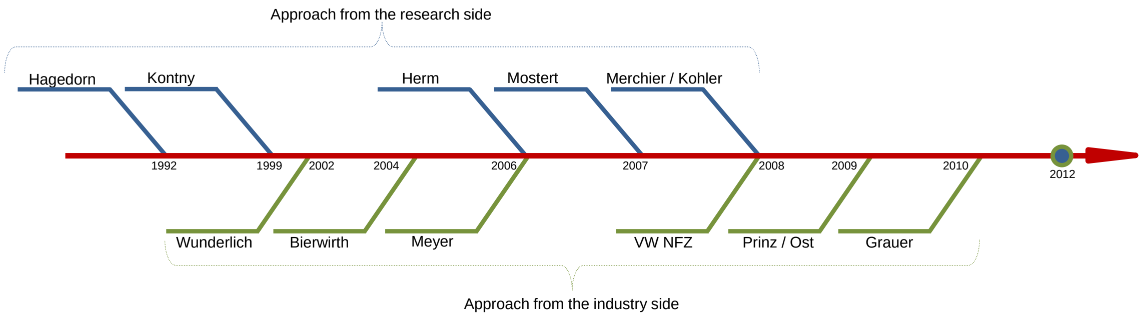

Figure 3: Overview of state of the art approaches

In conclusion several approaches of research as well as from the industrial side exist which deal with the matter of simulation or mathematical supported planning of networks or with the detailed analysis of cost structures in production sites or production networks. Although financial aspects are included in most of the methods, there is to date no method contains all the relevant costs in production networks. Furthermore the aspect of dynamic examination is less addressed as well as the consideration of uncertainly factors; most of the generated methods focus on static optimization.

3.2 Maturity Model Foundations

Maturity models are based on the assessment of competency objects with the goal of consistent and verifiable statements about their status and quality of their execution. Commonly used objects are organisations and their processes (de Bruin et al. 2005) (Mettler 2009) (Mettler and Rohner 2009). In recent years different maturity models have been used in different fields of application. The different levels/stages of maturity within such models can be used to describe the different achievable skill levels. Maturity models not only include methods for the assessment of skill levels, but also provide incentives and measures to increase the degree of maturity. After the introduction of measures to increase the skill level of maturity these models are also suitable to measure and evaluate the progress made (Wochinger et al. 2010).

Maturity models can have different purposes. A maturity model may be limited to a competency measurement, is part of a skills analysis and additionally can provide information on causes of the deficits of maturity level assignment or can propose instructions for solutions to improve the maturity level (Ahlemann et al. 2005). Different definitions of maturity models can be mentioned:

"A maturity model is a (simplified) representation of reality to measure the quality of business processes. Here, depending on the model, different stages of "maturity" of business processes are described." (Fritz 2009)

"Maturity models are using a staging system, which represents the performance of a specific area of a company. These stages are pre-defined by the maturity model." (Bürgin 2007)

In the literature and the praxis different existing maturity models are established in different fields:

- Maturity models in the fields of project- and process management;
- Based on Quality Management models and tools from the field of (SW) development;
- Maturity analyses and models to check status of business processes.

The most popular approach for measuring the maturity level is the "Capability Maturity Model" (CMM) of the Software Engineering Institute (SEI) of Carnegie Mellon University (Berg 2006). The Capability Maturity Model is the oldest and best known model, which is applied for the improvement of software processes. The five-step evaluation scheme was originally intended to assess the quality of software processes of software suppliers of the U.S. Department of Defense (Glinz 1999). The maturity levels of CMM are used as an indicator of the ability of an organization, to develop and provide software with the required quality and financial requirements within specified time frame (Paulik et al. 1995). In subsequent years the model has been enhanced, several upgraded versions were released and finally the successor model, the Capability Maturity Model Integration (CMMI) was developed. The CMMI consists of 5 different maturity levels (see Figure 4).

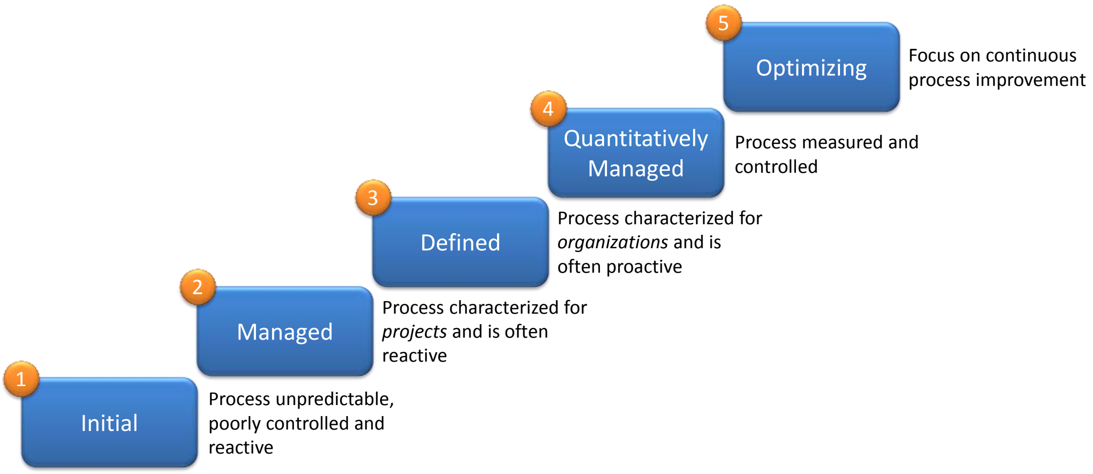

Figure 4: CMMI Maturity Levels (Carnigie Mellon University 2005)

In CMMI several previous models are integrated, that have the same basic ideas and goals, but are different in structure and field of application. CMMI has the following main fields of application (Kneuper, 2003):

- Software Engineering
- System Engineering
- Integrated Process and Product Development

Another validation model is the so called EFQM Business Excellence Model. It is not a classic maturity model, but it is often used as a basis for many maturity models. EFQM stands for European Foundation for Quality Management and describes the merger leading from the top European companies with the aim of developing and providing its own model to increase their own competitiveness in global markets (Kirstein 2010).

The EFQM Business Excellence Model is a model for the integrated quality management and it is based on the simultaneous consideration of people, processes and outcomes. The basic model consists of three main pillars of leadership, processes, and business results and is supplemented by specific implementation areas (people, policy and strategy, resources, etc.). The model explains the principle that people-focused results, customer-focused outcomes and results related to society can be achieved through leadership with the help of policy and strategy, employee orientation and management of resources. Besides the three major pillars and their subdivisions, that are individually emphasized and weighted in relation to the overall model, the model is divided into the areas of enablers and results. As enablers all input factors are known which are used to achieve the desired results (Kirstein 2010). If the EFQM Business Excellence Model will be compared to the CMMI model, then the commonality of definition and improvement of processes is recognizable. The other aspects of the EFQM Business excellence Model are only considered rudimentary in the CMMI model (Kneuper 2003).

ISO/IEC 15504, mostly referred as SPICE (Software Process Improvement and Capability Determination), is the international standard for process assessment, which was initiated in 1993 (Duncan 2002). The initiative was for supporting the development and validation of a practical international standard for software process improvement. The initial versions of ISO/IEC 15504 focused exclusively on software development processes. In further versions, it was enhanced to cover all processes related to software life cycle, project management, configuration management and quality assurance (Rout et al. 2007). The approach provided by SPICE can be used for process improvement as well as for capability determination (Dorling 1993) (Rouse 2008). The SPICE model makes it possible for organizations to use the standard for process capability determination mode, process improvement mode and self-assessment mode (Konrad et al. 1995). The SPICE approach was developed based on the weaknesses of previous standards and models. As other international standards and models SPICE takes into account the assessment of the capability, effectiveness and quality of processes and organizations.

4 OVERALL APPROACH

The flexible and cost optimized distribution of the value creation in production networks depends on three factors: costs, time and quality. These factors influence each other and the optimization of a single factor may adversely affect the other two factors. Therefore, these factors have to be considered parallel. Due to the globalization manufacturing enterprises have to be present locally with their own capacity in almost all markets, thereby greatly increasing the planning complexity of manufacturing networks. Today’s high number of digital tools are more and more deployed and used to support planners along their activities. However, the challenge remains not only to have better understanding of network configuration and evaluation but also to identify the most suitable digital tool with the required functionalities and capabilities for these purposes and needs. To meet these challenges and to reduce the complexity in production networks, new approaches, for the strategic planning of production networks as well as for the evaluation and determination of the supply chains maturity, have been conceived at the Fraunhofer-Institute for Manufacturing Engineering and Automation IPA. For the development of this approach, existing methods for classification costs were considered; corresponding cost models were analyzed and evaluated in a further step. Based on the results a new cost model is developed, which includes the different costs within a production network and integrated into the method. Within the developing of the cost model as well as its integration, based on the idea of Merchiers, three different levels are taken into account, the network level, the site level and the level of production consisting of various production modules. The next figure (see Figure 5) shows the distribution of the costs to the different levels.

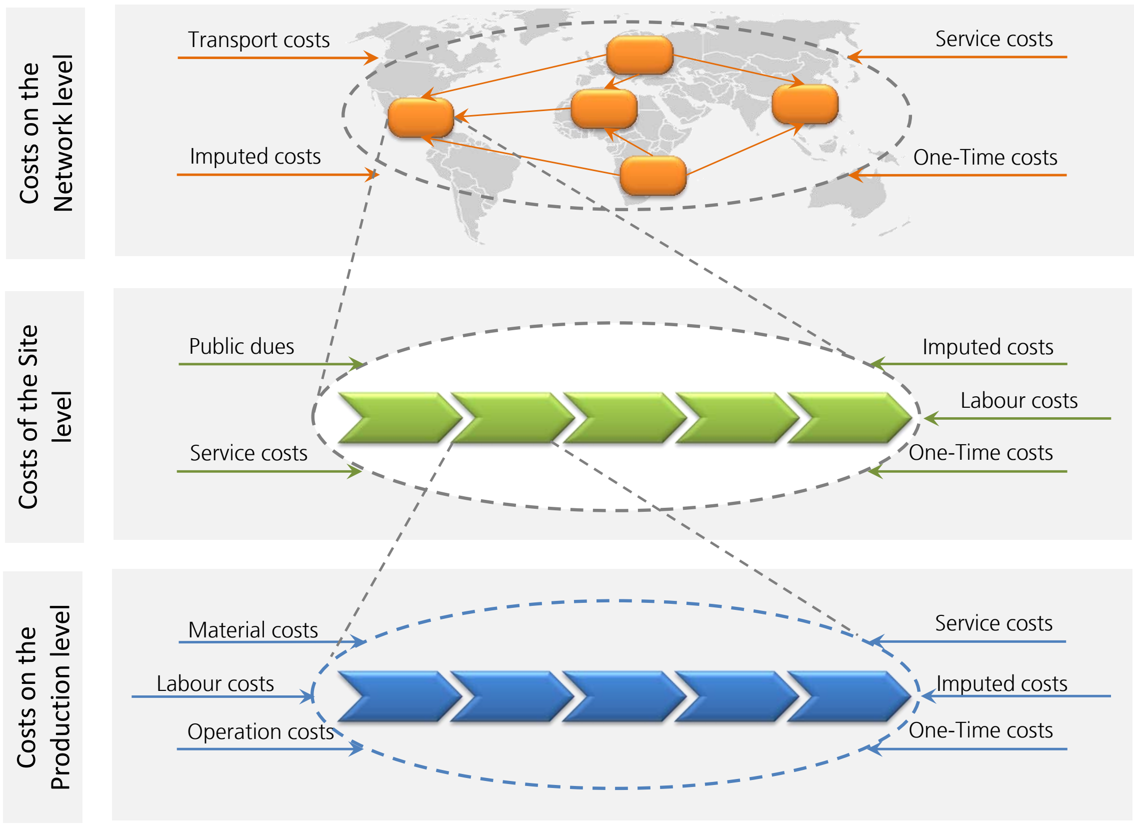

Figure 5: Cost distribution related to the different levels

Due to this approach, the distribution of the added value on already existing sites and/or new planned sites should be analyzed using a digital tool (simulation tool) and taken into account dynamic aspect and uncertainty factors. Because of the simulation based investigation, the detail level regarding the material flows has to be selected by using the *Pareto* principle. Therefore, only the cost-intensive product components/modules are taken into account within this investigation of the value added distribution during the strategic planning phase (Bierwirht 2004, Klug 2010).

The developed approach covers several phases in order to distribute the value added in global production networks as well as to determine the maturity level of the production network. The first phase is to analyze the structure of the product, the costs as well as the production related to the three level model. Based on the analyzed structures, different planning scenarios and a whole concept can be developed. In a further step, the maturity level of the developed concept can be determined and evaluated. In order to support the planning activities a digital tool is needed. Thus, possible tools, which are suitable for such topic, will be analyzed. Based on pre-defined criteria the maturity level of the tools will be determined and the most suitable one will be selected. In a further step, the implementation of the concept using the selected digital tool can be done.

Within the first phase, the product structure will be analyzed. The results of this step are the different products that will be produced in the production network as well as their different main components and who the producers for these Products/main components are (see Figure 6).

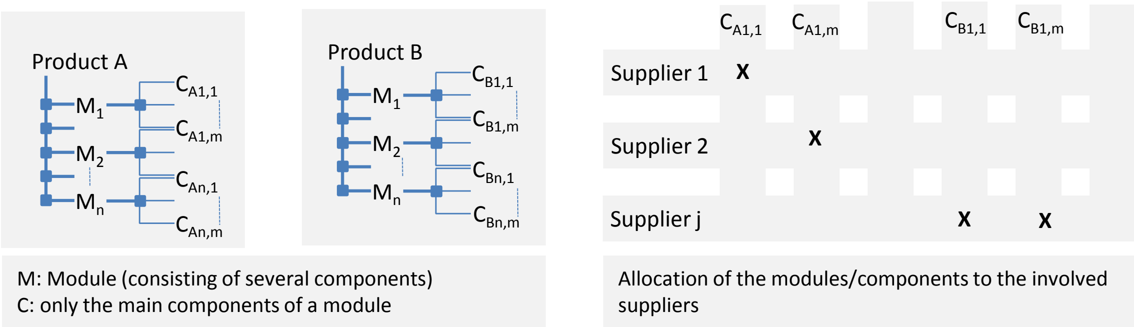

Figure 6: Analysis of the product structure / Allocation of the modules or components to the suppliers

The potential benefits of using digital tools supporting value chain planning and configuration are acknowledged by most manufacturing enterprises (Bierschenk et al. 2004). It is generally accepted that there are relevant potentials to be realised, but especially SMEs often hesitate in implementing these technologies when facing the evaluation of potential benefits and selection of suitable methods and tools for their specific needs. The maturity based approach should support manufacturing enterprises in introducing new digital tools or methods as well as technologies by providing a procedure as a status check of the current organizational and technical structures and processes along the whole value chain. This approach should help to answer to the following questions that arise while introducing new tools, methods or technologies:

- **What** is considered to be evaluated?
- **What** kind of technology / digital tool should be used / introduced / evaluated?
- **Where** / for what purpose should / could the technology / method / digital tool be used?
- **Whether or not** these tools / methods / technologies should be introduced, etc.? (Is it worth, will it be accepted?)
- **When** is the best time to introduce / use the new tool / method / technology?
- **What** implementation strategy / strategies can be applied?

The maturity based evaluation is set on a 2-dimensional approach. On the one hand the production network itself has to be analysed and evaluated in the context of capabilities for introducing and using new tools / methods / technologies. On the other hand these tools / methods / technologies has to be evaluated, if they are suitable and capable for the enterprise`s needs.

a) Evaluation of the production network point of view

Different issues regarding the organizational and technical conditions within the production network have to be taken into account while thinking about introducing new tools or technologies. Corporate structures include structural and operational structure of the enterprise. The human resources in the enterprise are an important factor for the successful introduction and the later use of the tools. This includes the aspects of training, skills, competencies, roles, personality, intrinsic values, corporate culture and leadership. The main objective is to analyse, if the production network / the value chain itself is able to introduce and use such tools or methods. That means for example is there an existing IT infrastructure and if yes, is it sufficient enough and are the personnel qualified for using such tools and methods?

b) Evaluation of the tool / method point of view

Similar to the production network point of view, the tools or methods that are intended to be introduced and used have to be analyzed and reviewed in detail. For example it has to be scrutinized, if the tool or the method can provide the functionalities for supporting the configuration of the production and the networks needs as well as if the tool is compatible to the existing IT infrastructure. Also the estimated period of the introduction phase has to be taken into account. Specific Key Performance Indicators, checklists, requirements as well as an evaluation scale has to be developed and predefined in order to select the most suitable tool or method.

c) Combination to an overall point of view

The previous mentioned single points of view can now be combined to an overall basic and general procedure for the maturity based evaluation approach (see Figure 7).

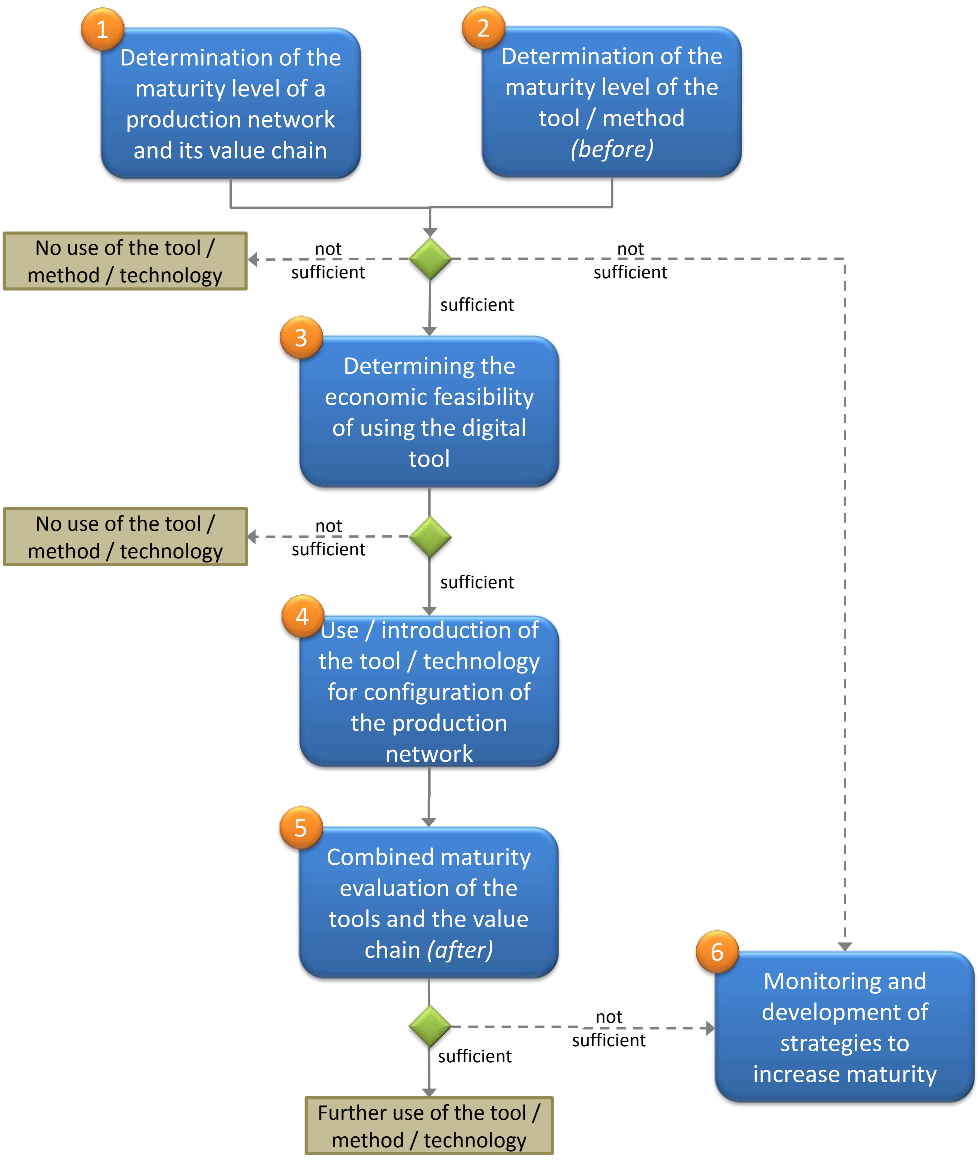

Figure 7 : Validation Process based on Maturity Evaluation

This overall procedure can be broke down into following steps:

1) *Determination of the maturity level of a production network and its value chain*
2) *Determination of the maturity level of the tool / method (before).*
   That means, determination of different maturity levels and criteria that must be complied by the different levels.

These first two steps are in accordance with the previous mentioned evaluation points of view. If the maturities are sufficient enough the introduction steps can be carried out. If the maturity is not sufficient enough, the introduction can be stopped or strategies for increasing the maturity has to be applied (step 6).

3) *Determination of the economic feasibility of using the digital tool or method*
   This step is not obligatory for maturity issues, but most enterprises also need to analyse the economic point of view, that means how high are the licence fees or the investment costs and what will be the efforts for the introduction, implementation and usage.
4) *Use / introduction of the tool / method / technology for configuration of the production network*
   If the economic feasibility is sufficient enough, the tool, method or technology can be introduced and used in the enterprise for network configuration and planning.
5) *Combined Maturity evaluation of the tools and the production network (after)*
   After using the tool it should be determined a combined maturity of the production network and the tool. That means if the introduced tool / method / technology supports the enterprise in achieving the overall predefined goals as well as how the tool or method is accepted.
6) *Monitoring and development of strategies to increase maturity*
   If the maturity is not sufficient enough strategies for increasing the maturity has to be applied. That means maturity indicators, maturity drivers and maturity enablers have to be identified and implemented.

After a suitable tool has been selected and its maturity as well as the maturity of the production network is sufficient, the overall concept can be implemented in order to configure the production network. The implementation will be done according to the "top down strategy". It means from the network level, down to the single sites and in a further step to the production modules. In this model various uncertainly factors and dynamic factors as well as their trend have to be presented, in order to reduce the risks in the decision making. In a further step, all the needed data and costs for the developed planning scenario will be collected related to the different level, the possible transport facilities and finally saved in a File based on MS Excel. This file supports the automated modelling and parameterizing of the developed scenario in the selected digital tool. While the development of the planning scenarios, the single sites will be linked according to the product modules and main components, their production quantity as well as the needed transport facilities. Beside these main activities, further parameters regarding the costs and the production structure have to be selected, that the results of a simulation studies can be clearly interpreted. Thereby, it should be noted that a sufficiently large number of simulation runs for each simulation study should be done, in order to secure a validity of the determined parameters, because stochastic aspects are integrated to take account of the dynamic behavior of the production network. Based on the calculated indicators as well as their corresponding visualization, the planning scenarios can be evaluated and compared. Figure 8 shows an example of a production scenario for a car manufacturer, where the demand for cars in Asia is highly rising. Currently 30% of the produced Press Work Parts (P) in Europe (home site) will be transported to North America. According to the high car demand in Asia, 50 % of the painted parts (L) will be transported from North America to Asia using the ship as a transport facility. In addition, 50% of the painted parts of the car will be exported from Europe to Asia. Related to these requirements, the production network can be configured.

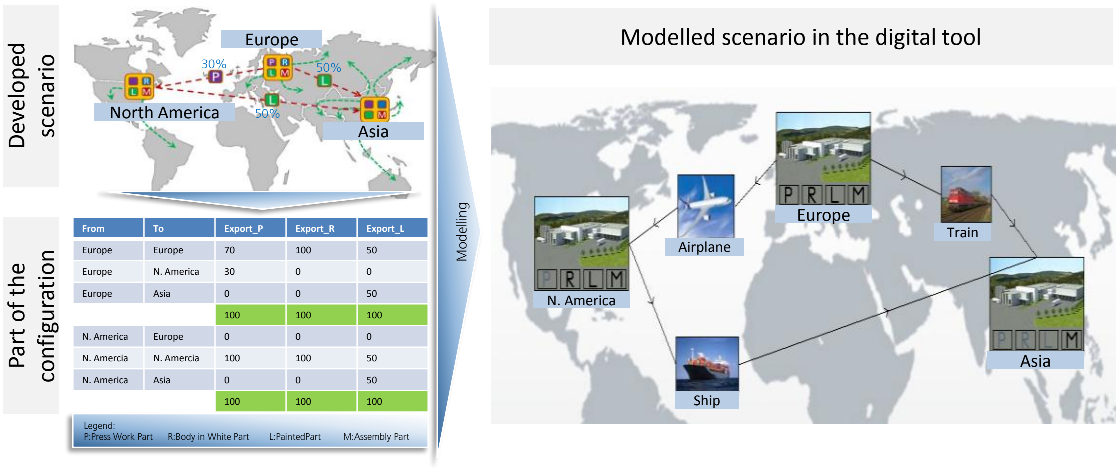

Figure 8:Example for a prototypical car manufacturer

After the modelling of the scenarios, different simulation studies can be run. The results of these studies will be visualized and exported, in order to be able to compare the different scenarios to each other. For the evaluation and synthesis of the scenarios, goal criteria have to be defined. The scenarios will be evaluated according to the goal criteria, which also have to get weighted. The next figure shows the visualization of some performance indicators (time, quality, costs) for a modelled scenario.

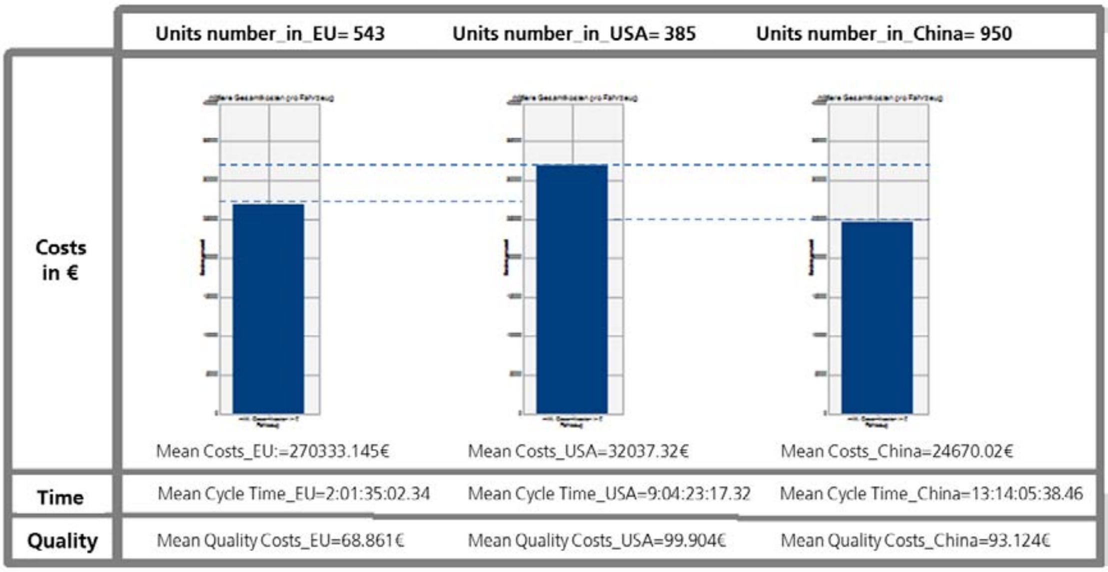

Figure 9 : Visualization of performance indicators related to three different sites.

5 BENEFITS

Maturity models for the purposes of evaluation issues have several benefits like finding vulnerabilities and identification of improvement measures, a better control over costs and time or an earlier and more accurate predictable release and introduction of tools and technologies. Further the production network get the capability for self-assessments and comparison with other companies by getting transparency of the organisational, technical and operational status as well as the early identification of deviations from targets and risks. The main objective will be to integrate this approach into a performance measurement system with which it can be possible to analyse and optimize the performance of ICT infrastructure of value chains of manufacturing enterprises. In this case the maturity based approach builds the foundation for the strategic and purposive network configuration. It is used for the determination of the overall production network's maturity as well as the selection of the most suitable digital tool for the implementation of the planning and configuration concept. The benefit of this approach is to reduce the planning efforts using a library based and user friendly simulation as well as the intuitive modelling of planning scenarios. On the other hand this approach provides a better tracing of the product information and the allocated costs in whole production network. It is possible to access this information, in order to track where and when the product were manufactured, when and where the components were produced, what the product costs are and how the costs are composed.

6 CONCLUSION & FUTURE WORK

The upcoming challenges for manufacturing enterprises as globalization, flexibility and adaptability in today's and future markets lead to the customer needs of high potent support in strategic network planning and the related decision making process. There are many tools, models, or methodologies which might be implemented to support the improvement of production network processes. Regarding these topics several questions may rise: How can an enterprise select from all of the tools and methodologies? Does the production network have the required maturity and capabilities for implementing and using such tools or methodologies?

This paper presents a combined approach for the configuration and the evaluation of production networks using a maturity analysis. The different stages of maturity within this analysis can be used to describe the different achievable skill levels of the production network and the digital planning tools. As work on the maturity model is still ongoing, this paper focuses on the foundations and the procedure for evaluation of digital tools for the purposes of production network configuration. The maturity based approach not only includes methods for the assessment of the skill status, but also provides recommendations and measures to increase the degree of maturity. In a further step the developed approach is also suitable to measure and evaluate the progress made on the configuration of the supply chain. For this topic, the production network will be segmented into three different levels (network level, site level and the production level). Based on these levels, several planning scenarios can be analyzed and modeled taken into account the structures of the product, the production and the costs. Therefore different performance indicators have to be taken into account e.g. technical performance and labour cost in different countries, regions and cities as well as various market requirements and legal regulations. Based on these indicators different planning scenario alternatives are developed and evaluated regarding quantitative and qualitative criteria. The definition of the different maturity and capability stages, as well as specific examples of tool areas or requirements is still in progress and will be addressed in future work. After the maturity model has been defined and the evaluation criteria have been set, suitable strategies for increase of maturity will be developed.

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The effects of demand patterns on supply chain costs for suppliers and manufacturers under supply chain constraints

Laird Burns, Assistant Professor of Management Science
Fan Tseng, Professor of Management Science
The University of Alabama in Huntsville
College of Business Administration[1]
301 Sparkman Drive, Huntsville, Alabama 35899, USA
laird.burns@uah.edu Ph. 256.824.6577, fan.tseng@uah.edu Ph. 256.824.6804

ABSTRACT

Suppliers and manufacturers face different demand patterns, cost structures and supply chain configurations. The pattern of demand can considerably affect supply chain configuration, firm costs, inventory policies and customer service policies. Demand patterns vary from low variation, such as in just-in-time production, high demand variation common in consumer goods, and periodic demand variation - repeated patterns - common to the computer industry.

In this study we examine the effects on supply chain costs from these demand patterns and how they affect supply chain costs under conditions of supplier and manufacturer capacity constraints and surges in customer demand.

Key words: demand variation, supply chain costs, optimization, computational model, capacity constraints

INTRODUCTION

As firms work together and coordinate supply chain strategies to improve competitiveness, prior strategies of optimizing each respective firm's inventories and production planning are recognized as suboptimal. Approaching the production planning process from the perspective of the supply chain as an integrated system yields opportunities to improve customer service, more effectively coordinate inventories, and increase profitability. These opportunities arise because suppliers and manufacturers face different demand patterns, cost structures and supply chain configurations. Coordinating production planning processes across firms creates opportunities for firms to improve profitability and customer service. The focus of this study is investigating the role that variation in demand patterns and safety stock inventories plays in supply chain performance, and in particular whether there are specific optimal levels or there exist ranges of optimality or near optimality that provide managers with increased flexibility for decision making.

The pattern of demand can considerably affect supply chain configuration, costs, inventory policies, and customer service policies. Demand patterns vary from low variation, such as in

[1] Laird Burns is Assistant Professor of Management Science at UAH, where he was the first group hire between Business and Engineering. His research interests include supply chain design, risk and resilience in supply networks, supply chain management, and complex systems modeling. Dr. Burns earned his Ph.D. in Operations and Supply Chain Management at Michigan State University. Fan Tseng is Professor of Management Science at UAH, where he applies operations research methods to research problems in management science, operations management, scheduling, supply chain management, and healthcare operations management. Dr. Tseng earned his Ph.D. at the University of Texas at Dallas.

just-in-time production, to high demand variation common in consumer goods, and to structural demand variation - repeated patterns - common to the computer industry. In this study we examine the effects on supply chain costs from variation in random demand patterns and how it affects supply chain costs under conditions of supplier capacity constraints. Specifically, we focus on the research question: *to maximize total supply chain profits, what is the optimal supply chain strategy for inventory and production scheduling strategies for an assemble to order (ATO) two-echelon computer supply chain*? We show that in some cases, but not all, the "optimal solution" may include a range of near-optimal solutions which provide managers with flexibility to negotiate with supply chain partners to improve profitability and customer service levels above locally optimized decisions.

BACKGROUND

It is widely known that demand patterns have considerable influence on supply chain performance (Fisher). One of the more widely known demand patterns affecting supply chain performance is the bullwhip effect (Lee, Padmanabhan and Whang), which results from forecasting error, batch sizes, price variations, and order rationing. Uncertainty in demand from increased forecasting error results in higher inventories, increased product stockouts, higher costs, and decreases in customer service.

Traditionally, uncertainty in forecasts and higher demand variation are remedied by holding higher safety stock. But this is expensive, especially if multiple safety stocks are held throughout the supply chain. One dramatic example of the perils of holding too much inventory due to forecast error is a $2.25 billion inventory write-off by Cisco Systems (Barrett). Inventory liquidations from mismatches in supply and demand are so common that they are the subject of trade publications (cf. Katz).

Yet holding too little inventory contributes to stockouts and decreased customer service. In 2005 the anticipated release of the Xbox 360 by Microsoft was hampered by product shortages just before the peak Christmas buying season, causing some customers to consider purchasing rival products for the upcoming holiday season (Businessweek).

To better manage inventory levels to enhance customer service, minimize stockouts, and maximize profits, firms may employ optimization models to predict optimal inventory levels. In this study we illustrate how local optimization by each firm may result in suboptimal SC profits and lower levels of customer service than could be provided for the same or higher levels of profitability.

Optimal models at the firm level can be extended to supply chain models when demand is constant or nearly constant. But examining the effects of variation in demand on firm performance across echelons in a supply chain, coupled with potential interactions between levels of demand variation and inventory levels, requires more advanced methods to generate insights into the complex effects exhibited by supply chains.

For example, deterministic demand optimal models specify shipping as late as possible within capacity limits while balancing standard or expedited freight costs and timing with holding costs of inventory. Models with random variation require safety stock inventory to accommodate peaks in demand, some of which may occur for several periods in a row. Thus a ship as late as possible policy will result in increased stockouts. Stockouts, in turn, affect profitability and customer service, as well as inventory levels and holding costs, which in turn affect the next period's inventories and costs. In the next section we discuss the methods employed in this study to accommodate these challenges and answer the research question.

METHODOLOGY

In this study we examine whether total supply chain profits under conditions of demand variation exhibit similar patterns to optimal solutions for deterministic models. While the general result is clearly expected to be similar, the functional shape of the optimal or near-optimal results across different degrees of demand variations and levels of safety stock inventory (SS) remains unexplored. In particular, we explore zones of optimal or nearly optimal performance across a range of CV and SS. A secondary consideration is evaluating whether customer service measures of low or zero product stockouts fall within these zones. If so, managers have additional options to positively influence supply chain performance across multiple performance objectives by seeking the lowest stockout levels within the nearly optimal profit zone.

To investigate the differences in supply chain costs between locally optimal (LO) and supply chain optimal (SCO) solutions we employ two methods. To examine LO for T0 (Tier 0 computer manufacturer) and T1 (key Tier 1 supplier), we use a mixed integer linear programming (MILP) model to determine optimal T0 production schedule and inventories, and repeat the process for T1. For SCO, in cases where demand is deterministic, we employ the same MILP model to determine the optimal supply chain revenue, costs, and gross profit. The MILP models show that the LO for T0 is a JIT policy that orders using the most economic shipping option just in time for customers' demands and the LO for T1 is also a JIT policy that produces orders from T0 just in time for shipping to meet T0's requirements.
It also shows that each firm can optimize its profits without the other firm or the supply chain achieving optimal profitability under conditions of deterministic demand. On the other hand, it can be proved that the optimal solution for total supply chain profitability also optimizes each firm's profitability. That is, there exists a local optimal solution for each of T0 and T1 that collectively form a supply chain optimal solution by coordinating inventories and production schedules.

For cases where demand is uncertain, we accommodate demand variation using a computational model that has been validated with the MILP model with known demand patterns. We employ the computational model to generate supply chain performance results for cases where weekly demand varies from low (CV = 0.25) to high (CV = 1.0). Using the computational model we can quantify the potential value of coordination to avoid excessive inventories and to reduce stockouts. We do this by comparing the profits of T0 and T1 separately and the customer service performance of T0, as measured by stockouts, to the results possible when SC performance is optimized. As demonstrated in the MILP model, only when T0 and T1 profits are optimized together will SC profits be optimized.

Experimental design

We set up an experiment with an example from the computer industry. The product is a high selling commercial computer product with high margins. Sales exceed 500,000 units per year with margins exceeding 60%. Actual sales volumes, margins and product data are disguised (but representative) or scaled to protect confidential information. T0 employs an assemble-to-order (ATO) policy and typically maintains two weeks of raw material inventory.

The experimental design includes three independent variables as factors: demand variation, weeks of safety stock inventory, and T1 capacity levels. A baseline case of zero variation is used to determine baseline profits from which changes in profitability are measured. Demand variation is measured as the coefficient of variation, with levels of 0.25, 0.50, 0.75 and 1.0 included in the study. Safety stock inventory levels range in integers from one to seven weeks. Seven weeks was sufficient to reduce stockouts to very small levels for high CV cases. T1 capacity was set at an upper bound to 25% above average T0 demand due to the traditionally high cost of excess capacity for key components of the product line. The two capacity limits, 112.5% and 125% of average demand, were chosen arbitrarily to provide available capacity for changes in demand without incurring excessive tooling costs to add additional production lines at T1. Tooling for key components of the computer equipment, such as chips and circuit boards, can be very expensive so excessive available capacity for such production lines is generally not readily available. This produced a 4 x 7 x 2 factoral experiment, plus a base case for a total of 57 cases.

Dependent variables include profitability and customer service levels. Profitability is measured as gross margin, where material costs, inbound transportation costs, and assembly costs and overhead are deducted from gross revenue. Customer service is measured by product stockouts, which results in lost revenue and lost profits. The quantity demanded but not shipped for stockouts is counted in gross demand, which is divided by total profits to yield average profit per unit for the quantity demanded. This results in lower per-unit profits when products incur stockouts, which is used as a performance penalty for lost sales. This approach was deemed necessary because actual profits or profit margin cannot be reported due to confidentiality.

FINDINGS

The results of this study are presented as differences between baseline performance and varying experimental factors for T0, T1 and SC. The baseline is established by setting CV = 0, where the firm achieves maximum profitability by meeting all demand. Only in the case of CV = 0 is no inventory held, since no variation in demand negates the need for safety stock. This no-variation case is used to compare changes in performance under the scenarios of capacity at T1 limited to 112.5% and 125% of average demand, respectively.

T0 near-optimal solutions

T1 capacity = 112.5%. The first scenarios investigated were for T1 capacity limits of 112.5% of average T0 demand. Figure 1 shows that for low variation, where CV = 0.25, profits are higher for fewer weeks of inventory with peak profitability at two to three weeks of inventory. For CV = 0.50, near-optimal profitability is in the range of two to four weeks of inventory, with a slight peak at three weeks. We note that near-optimal is a more accurate term to describe these peaks in profitability since the exact optimal point may be, for example, 3.56 weeks of inventory for a given scenario. Firms do not manage supply chain inventory targets to this level of precision, so we investigate integer weeks of safety stock inventory to more accurately represent the safety stock inventory targets by which firms measure inventories.

For CV = 0.75 the near-optimal range is five to seven weeks, with a gradual peak at six weeks. For CV = 1.00 the peak is at seven weeks of inventory. The minimum profitability for all of the T0 scenarios is for one week of safety stock for a CV = 1.00, which is expected given the variation in demand and minimal levels of safety stock. The difference is average profitability per unit from baseline for this minimum profitability case (SS = 1, CV = 1.0) is almost -5%.

We note that for CV = 0.25, the change in profitability by weeks of safety stock inventory is nearly linear with a peak at two weeks of safety stock inventory, but for CV > 0.25 the changes become nonlinear with a shallow peak for each CV except CV = 1.0. This suggests that the balance between the cost of holding safety stock and stocking out of product has an interactive effect on profitability of the product line.

Figure 1 demonstrates that there is a nearly-optimal *range* of safety stock inventory for differing levels of CV, providing managers with additional flexibility to balance inventories and stockouts without significantly affecting profitability. Further research is necessary to examine how profitability of products from different industries behaves in the presence of potential interactions between SS and CV.

Figure 1

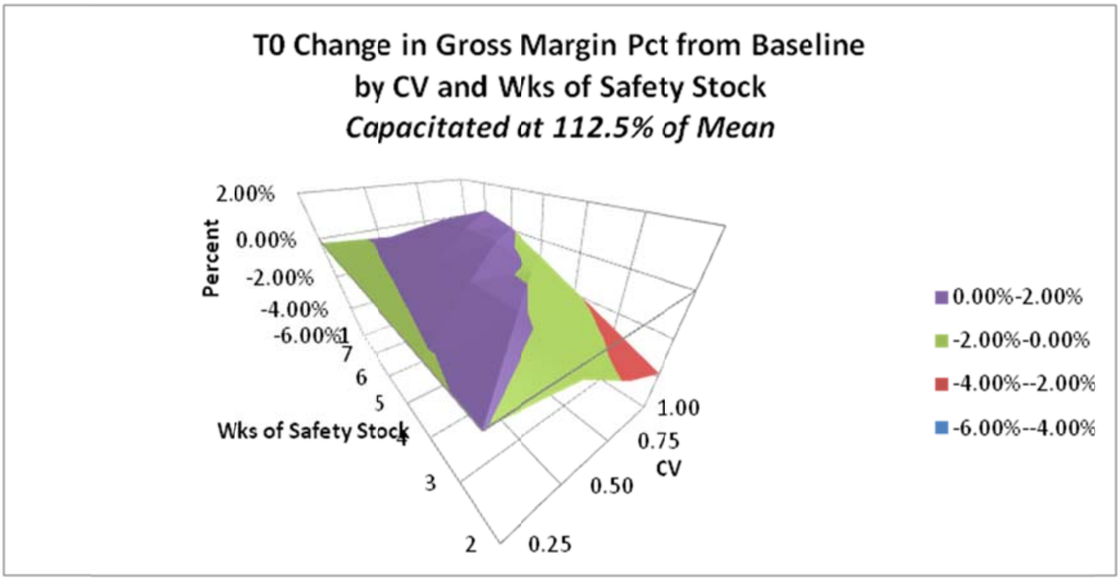
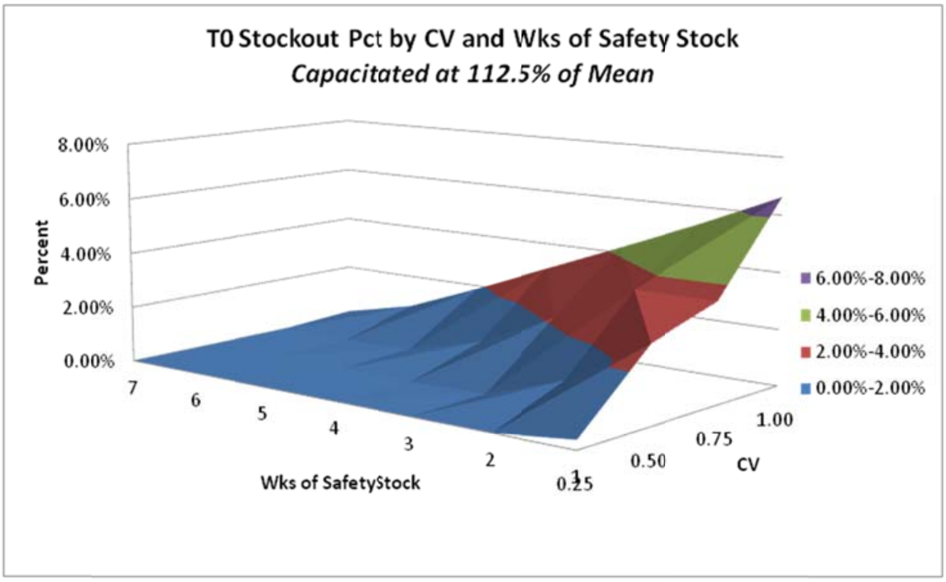


Figure 2 shows the T0 stockout percent by weeks of safety stock inventory and CV. Note the clear degradation in stockout performance for lower levels of safety stock and higher CV. While these results are consistent with prior theory and therefore not unexpected, during the discussion on SC profitability these observations lend additional insight to the results.

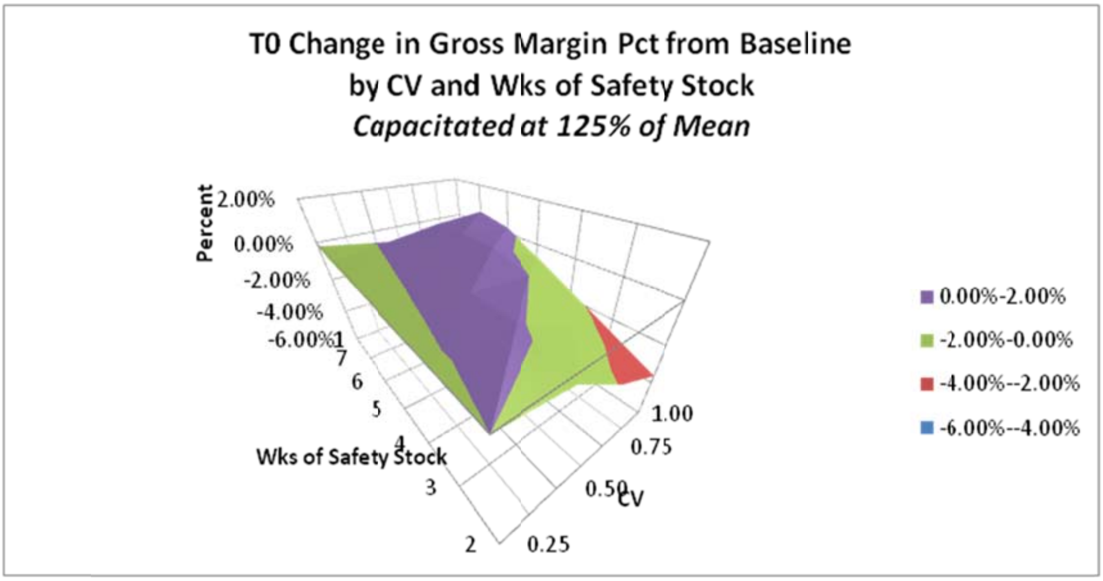
Figure 2



As shown in Figure 2 for CV = 0.25 and 0.50, there are almost no stockouts, and no stockouts for the corresponding optimal weeks of SS from Figure 1, so the firm is likely to choose the minimum SS from the optimal range as the preferred solution. For CV = 0.75, T0 has small (0.13% and 0.01%) stockouts for five and six weeks of SS. While small, 0.13% represents millions of dollars in lost sales and profits, and loss of customer goodwill for this product line. For CV = 1.0, T0 incurs stockouts for all levels of SS, with a minimum of 0.17% for SS = 7 and a maximum stockout of more than 6.5% for SS = 1.

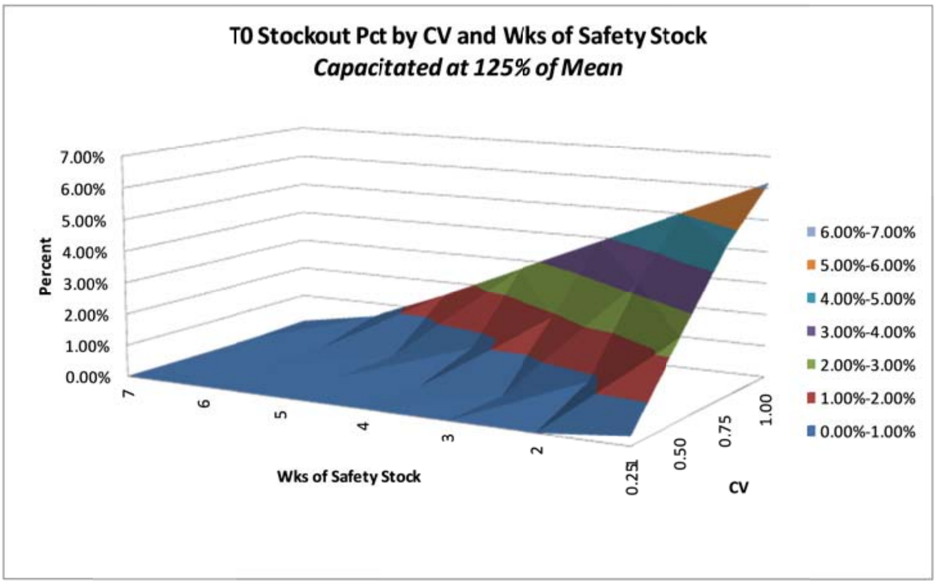
T0 capacity = 125%. The results for an increase in capacity for T1 to 125% of average T0 demand are shown in Figure 3. As before, the changes in near-optimum profitability exhibit a relatively flat curve. The difference in T0 performance from the case where capacity was set to 112.5% of average demand typically ranges from near zero to three-tenths of a percentage point. As before, this small percentage difference results in millions of dollars of increased profit for the product line. This is driven primarily due to the high margins for the product inducing significant effects on profitability relative to changes in holding costs by SS levels.

Figure 3



The stockouts for T0 customers (Figure 4) also exhibit a corresponding decrease from Figure 2 as well, up to one percentage point for CV = 0.75 and SS = 1. For those cases where stockouts occurred for capacity of 112.5% of average demand, the same scenarios exhibited stockouts for the higher capacity but the percentages were lower in all cases. This is to be expected from the increase in capacity providing increased responsiveness to fluctuations in demand. However, it is noted that the stockouts also affect average profitability per unit and total profits, creating an interactive effect. Given the range of near-optimality in profits for many levels of CV, once again these results suggest the firm may be able to simultaneously maximize profitability and minimize stockouts with careful coordination of production planning and inventory policies.

Figure 4

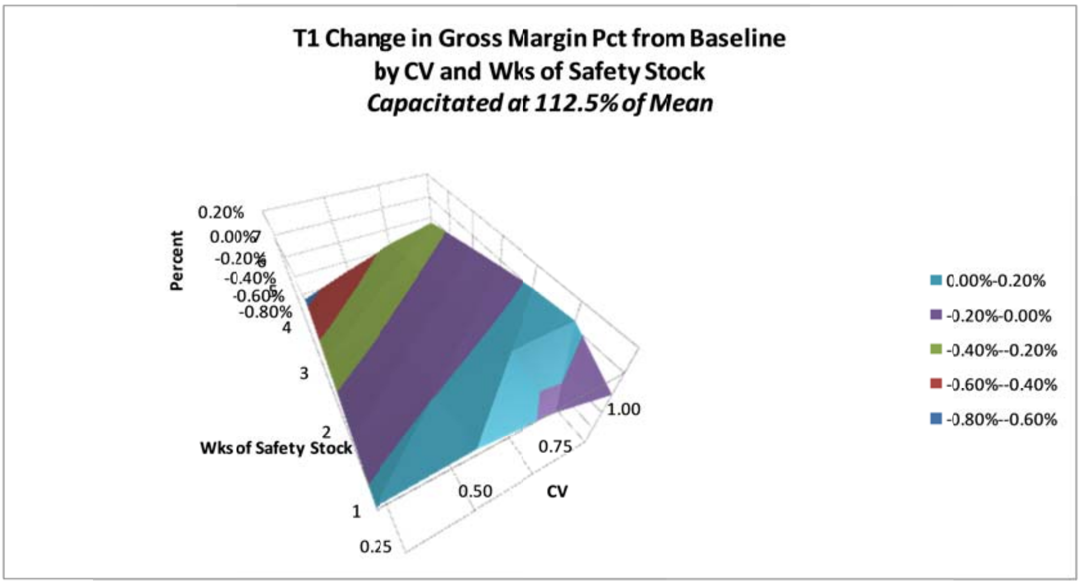


T1 near-optimal solutions

T1 capacity = 112.5% and 125%

T1 seeks to maximize profits by shipping on time to T0 while holding minimal inventories. For lower levels of safety stock profitability decreases linearly with additional safety stock, with profitability decreasing at a slightly faster rate as safety stock levels peak (Figure 5).

Figure 5



As expected, for T1 capacity set to 112.5% of average T0 demand profits decline consistently for lower levels of CV as safety stock inventory increases. For CV = 0.75 and 1.00, profits for T1 peak at SS = 2 and decline as safety stocks increase. The slight increase in profitability with increasing CV appears counterintuitive. However, stockouts at T1 are very low (Figure 6), appearing only for SS = 1 and CV >= 0.75. Thus, it appears that slightly lower inventory costs account for the very slight increase in profitability over the baseline case. These increases in profitability, however, are 0.05% or less.

Figure 6

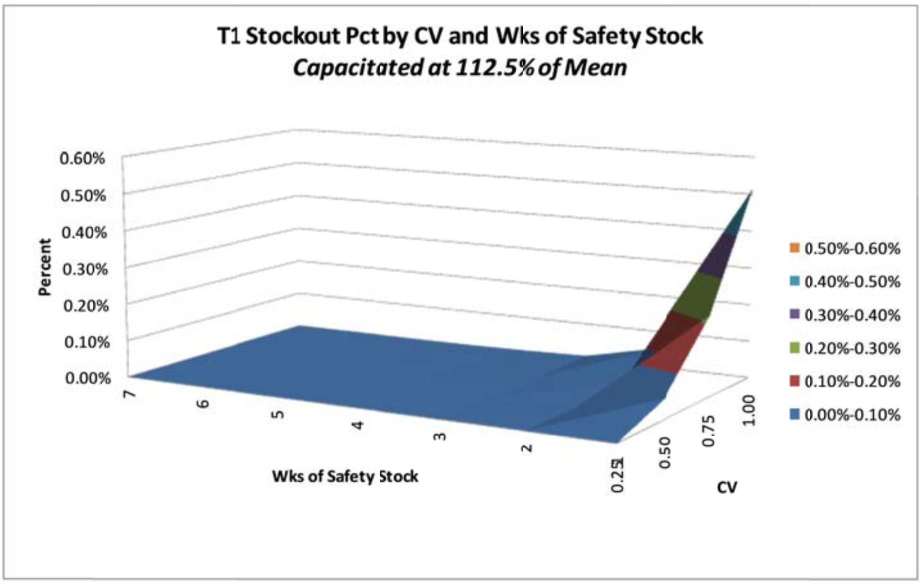
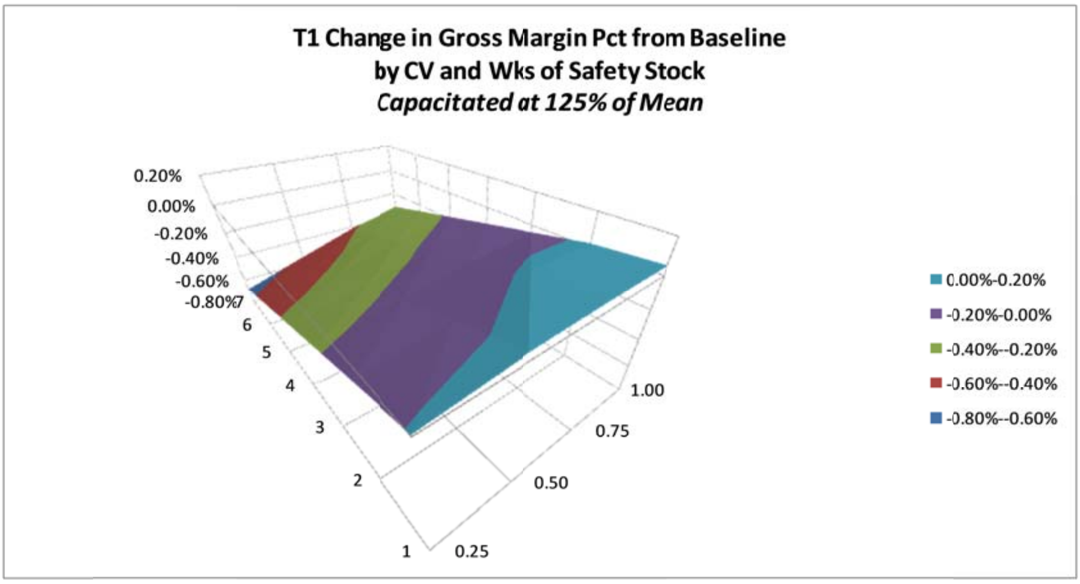


Figure 7

Figure 7 shows a similar result for T1 for capacity set to 125% of average T0 demand. As with lower capacity, profit declines almost monotonically with increases in safety stock, due to the low stockout rates and lack of demand for additional inventory.



The stockout rates for capacity set to 125% (not shown) are very similar to Figure 6, with high stockout rates only for SS = 1 and CV >= 0.75.

SC near-optimal solutions

The focus of this section is on evaluating whether total SC profitability is greater than the individual profitability of T0 and T1 under differing degrees of demand variation and safety stock inventories. Clearly they are linked through their supply chain transactions, and overall supply chain performance depends on the performance of both T0 and T1. The interaction of stockout costs and holding costs is evident in nonlinear effects in the data. The real question of the study is whether total supply chain performance, in dollars of profits and higher customer service in the form of fewer stockouts, could be higher with coordination of inventories between the firms than if each firm optimizes its own profitability.

To establish a baseline case for SC profitability, we employed the MILP model. As mentioned earlier, our MILP models show that each firm can optimize its profits without the other firm achieving optimal profitability under conditions of deterministic (known) demand. The baseline optimal solution for total supply chain profitability requires each firm to maximize its own profitability while coordinating inventories and production schedules to also maximize total SC profitability. In addition, the MILP model was used to calibrate the computational model using deterministic demand. Then the computational model was employed to generate data for analysis using differing levels of demand variation. Using the computational model results as shown below, we examine profitability of each firm under conditions of varying demand and safety stock inventories, and find similar results but also uncover additional findings.

For feasibility and to represent how managers use inventory metrics to manage production schedules and planned inventories, we examine total SC profitability using integer weeks rather than large scale computational modeling to find optimal values of SS that are precise to arbitrary fractions of a week. From a practical perspective, managers often target a specific number of weeks of inventory as a target level. Using this approach, when T0 and T1 each employ optimal levels of SS the results should be optimal or nearly optimal for the entire supply chain.

Table 1 shows results from this study for the near-optimal values of inventory for T0, T1 and SC. For those combinations of CV and safety stock inventory denoted SC, the results suggest that if T0 and T1 both choose an equal number of weeks of safety stock inventory the total SC profits will typically be as high or higher than the nearly-optimal values shown for T0 and T1, respectively. For example, for CV = 0.25, if both T0 and T1 choose to maintain two weeks of safety stock inventory, the total SC profits are approximately equal to those if T0 and T1 optimize separately, but higher customer service will result from both firms maintaining two weeks of inventory (Figure 2, Figure 4).

Table 1

Optimal Ranges for T0, T1 and SC by CV and Wks of Inventory					
Capacity = 112.5% of mean		CV			
		0.25	0.50	0.75	1.00
Safety Stock (wks)	1	T1	T1		
	2	T0, SC		T1	T1
	3	T0	T0, SC		T1
	4		T0, SC		
	5		T0	T0	
	6			T0, SC	
	7			T0	T0, SC

T1 capacity = 112.5%. For lower levels of CV, the near-optimal number of weeks of inventory for T0, T1 and SC are relatively close. For higher values of CV, the difference is quite large. For CV = 0.25, the optimal level of inventory for T1 is one week, two to three weeks for T0, and two weeks for the supply chain. Managers can compare these results to those combinations of CV and weeks of safety stock inventory for which T0 did not stockout to their customer (not shown). This is significant since results from Table 1 demonstrate that quite often a range of SS, in weeks, for T0 produces the same or nearly the same profitability. This finding allows managers additional flexibility to accommodate improved customer service through higher fill rates.

T1 capacity = 125%. Table 2 presents the results for capacity set to 125% of average demand. The pattern is similar to the 112.5% capacity levels, with a little less breadth to the optimal range (slightly higher peaks). We note that there will be some stockouts for all levels of CV = 1.0. For CV < 1.0 managers can maintain peak profitability while accommodating higher levels of customer service.

Table 2

Optimal Ranges for T0, T1 and SC by CV and Wks of Inventory					
Capacity = 125% of mean		CV			
		0.25	0.50	0.75	1.00
Safety Stock (wks)	1	T1	T1	T1	T1
	2	T0, SC		T1	T1
	3	T0	T0, SC		
	4		T0		
	5			T0, SC	
	6			T0	
	7				T0, SC

DISCUSSION

In this study we examine the research question: *to maximize total supply chain profits, what is the optimal supply chain strategy for inventory and production scheduling strategies for an assemble to order (ATO) two-echelon computer supply chain*? We have shown that in some but not all cases the optimal solution includes a range of near-optimal solutions which provide managers with flexibility to coordinate with supply chain partners to improve profitability and customer service levels above locally optimized decisions.

We have demonstrated that in the case of a computer manufacturer the total supply chain profits can be equal or greater than individual profits for T0 and T1. The benefit to coordinating production schedules and inventories lies on not only capturing any additional profits available to both firms if they cooperate, but also in reducing stockouts to improve customer service while still maintaining total SC profits in the optimal or near-optimal range.

In general and consistent with prior theory, we find that higher levels of demand variation require higher levels of SS. In this study one of the contributions is demonstrating that the slope of the concave profit function for T0 and SC is a gradual slope, with a near-optimal range of SS that is broader than the traditional mindset of a single optimal level of SS. This range of optimality or near-optimality allows managers additional freedom to pursue additional SC performance objectives such as improve customer service through decreased stockouts without sacrificing profitability.

CONCLUSION

This study has focused on random demand variation and supply chain performance by differing levels of CV and safety stock inventory. From these results it is observed that when T0 and T1 optimize their own profitability without regard to SC profitability they may “leave money on the table”. By coordinating production schedules and safety stock inventories the firms together can generate equal or greater total profits while concurrently increasing customer service through decreased stockouts.

The results demonstrate that in the case of a computer manufacturer there are large zones of near-optimality for SS by CV, where more than one single level of SS may provide equal profitability to each firm. When the firms cooperate, they have the opportunity to improve the competitive position of the product line and the supply chain by maximizing total SC profits while simultaneously improving customer service.

Future research. The next step is to extend this work beyond random variation in demand to what we term structural variation in demand under capacity constraints. Structural variation in demand results in short term cycles that repeat in a fixed pattern, such as the monthly and quarterly demand patterns observed in the computer industry. How these patterns affect SC performance and customer stockouts remains unclear, as most research focuses upon random and seasonal demand patterns.

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Drivers and Barriers of Continuous Manufacturing in the Pharmaceutical Industry

*Leila Alinaghian [1]**
Aylin Ates [2]
Umit Bititci [2]
Tomas Harrington [1]
Jag Srai [1]
Rajan Talati [2]

Abstract

Continuous manufacturing (CM) is a potentially game-changing shift in Pharma in terms of industry structure, product consistency, variety and its ability to encompass emerging technologies and product-service systems. While other industries, such as oil, gas, petrochemicals, polymers, and food currently operate in CM mode, extensive use of CM is still relatively new to the pharmaceutical industry where the current adoption rate of continuous processing is only 5 %. This research aims to explore the current state of the art of CM research in the pharmaceutical industry. In particular, this paper seeks to reveal the existing barriers and enablers to the adoption of the continuous manufacturing model in the industry, benefiting of collective discussions and one-to-one interviews with the companies currently going through this transition and encountering such challenges. In the empirical research path, this exploratory qualitative research includes two main phases of systematic literature review and exploratory case studies comprising of semi-structured interviews and theory building and concept development workshops involving industry practitioners, technologists and process engineers. The study revealed that despite recent efforts to quantify economic benefits of continuous manufacturing, the overall business impact of continuous manufacturing lacks an end-to-end supply chain assessment.

Introduction

While the adoption of continuous manufacturing is proceeding at a step-wise pace in the pharmaceutical industry, currently the industry is still dominated by batch processes. The key difference between a batch process and a continuous process is that in the batch mode, the process is in a dynamic state from the beginning to the end. Depending on the process the end point is predetermined so that when that point is reached, the process is stopped, and the unit operation is done. A continuous process, however, must undergo an initial start-up phase before reaching a steady state (Rios, 2007). Batch process manufacturing is segmented into many individual steps that are often performed at separate facilities, thereby requiring

[1] *Institute for Manufacturing, Engineering Department, University of Cambridge*
[2] *Design, Manufacture and Engineering Management Dept. University of Strathclyde*
* *Lsa27@cam.ac.uk*

frequent interruptions in production activities. In this manufacturing model, specific quantities of a drug are produced to fill an order and quality is assessed through sampling, using analytical test and measurement. If the quality standards are not met, the entire batch is rejected and sent back for reprocessing. It is estimated that rejected batches, rework and investigations can use as much as 25% of pharmaceutical company revenues. On the other hand, in a continuous manufacturing model, raw materials are put into the automated system that is capable of carrying out complex chemical tests according to the predetermined quality parameters. These quality checks occur throughout the manufacturing process and most importantly without interruption. Rejected products can be handled through recycling loops, enabling the reuse of some or all component parts (Schabel *et al*., 2011).

Batch process manufacturing, the current industry standard, offers several benefits and suffers several drawbacks. On the positive side, batch processing assures quality as a batch can be controlled, and thus, accepted or rejected (Leuenberger, 2001). Moreover, when compared with continuous processing, batch process manufacturing provides higher flexibility in producing multiple products in a single plant through the sharing of process equipment (Behr, 2004; Gorsek and Galvic, 1997). On the negative side, batch production presents many disadvantages including long throughput times from start to finish (Calabrese and Pissavini, 2011), large raw material and intermediate inventories (Gorsek and Galvic, 1997; Kim and Lee, 1993), extensive validation and scale-up activities. This means that products manufactured are often of a lower and without consistent quality. By-products lead to undesirable side effects; products have been rejected at the clinical trials stages because they could not be made pure enough. Due to the severe drawbacks, pharmaceutical industry and the regulatory bodies now actively encourage the development and implementation of innovative pharmaceutical manufacturing systems.

Continuous manufacturing, however, is gaining ever-increasing attention within the pharmaceutical industry because of the expanding profitability gap experienced by most pharmaceutical companies (Gerogiorgis and Barton, 2009). Today, it is becoming more difficult for pharmaceutical companies to meet profit expectation, due to increasing research and development (R&D) and operating costs and competition from generic manufactures. A review of the fine and commodity chemical industries demonstrate that continuous manufacturing could offer both operating expenditure (OpEx) and capital expenditure (CapEx) savings for the pharmaceutical industry. Furthermore, labour for transporting material between batch units, quality assurance/quality control (QA/QC), and in process inventory can all be significantly reduced in continuous manufacturing (Schabel et al., 2011).

According to the Trout research group, the increasing interest in continuous manufacturing can be attributed to a combination of three factors of the beginning of more flexible regulatory approaches, increasing cost pressure and increasing quality and controls specifications of pharmaceuticals.

Accordingly to our industrial survey, the current adoption rate of continuous manufacturing is only 5 % that means 95% pharmaceutical industries are following batch process to manufacture the products. While other industries, such as oil, gas, petrochemicals, polymers, and food currently operate in continuous manufacturing mode, full continuous manufacturing is still new to the pharmaceutical industry (Arnum and Whitworth, 2011).

This research aims to explore the current state of the art of continuous manufacturing research in the pharmaceutical industry. In particular, this paper seeks to reveal the existing barriers and enablers to the adoption of the continuous manufacturing model in the industry, benefiting of collective discussions and one-to-one interviews with the companies currently going through this transition and encountering such challenges. As discussed, there are obviously certain benefits for adopting continuous manufacturing. However, those barriers which appear to be preventing pharmaceutical manufacturers from embracing continuous manufacturing need to be identified and removed.

Research Approach

In the empirical research path, this is an exploratory qualitative research with inductive approach. The process designed for the research includes two main phases of systematic literature review and exploratory case studies comprising of multiple focus groups and semi-structured interviews.

In the first phase, the research approach utilises the chemical engineering and processing as well as pharmaceutical technology literature as a rich source of continuous processing within Pharma context. The literature domain pertaining to manufacturing and production systems is also found to give new insights into continuous manufacturing operationalisation in the pharmaceutical industry. The core literature reviewed in this research has been collected systematically (Tranfield, Denyer, and Smart, 2003) using a title, keyword, and abstract content search of the literature contained within the chemical engineering and processing and operations management subject databases. This has been supplemented by a citation review of the key literature. Scopus, EBSCO, ProQuest and Web of Knowledge with their comprehensive searching of a wide number of journals in the fields of interest, were explored with Google Scholar used as a cross check at the end. Table 1 below details the review protocol.

Table 1 – The Review Protocol

Databases	• Scopus • Web of Knowledge • ABI/INFORM (ProQuest) • EBSCO (Business Source Premier) • Google Scholar
Keywords	• Continuous Manufacturing • Continuous Process* • Continuous Production • Flow Process* • Batch to Continuous (batch versus continuous) • Pharma* • Supply Chain • Manufacturing Operations • Value Chain • Drivers • Barriers • Trends • Agil* • Responsive

Search Strings	(“Continuous Manufacturing” OR “Continuous Production” OR “Flow processing” OR “Batch to continuous”) AND (Pharma* OR (“supply chain” OR network OR “Manufacturing Operations” OR “Value Chain”) OR (Agile OR Responsive) OR (Challenge* OR Barrier* OR Trend*))

The next step, having conducted the searches detailed above, was to evaluate the articles and thereby decide which ones would be included in the review. Firstly, inclusion and exclusion criteria including subject matter, scholarly journals, nature of research (conceptual/ empirical) and language applied to titles and abstracts. As a result of this evaluation process, 50% of 178 articles were eliminated leaving 89. Industrial reports and interviews constitute a significant number of articles omitted. However, these types of items were stored separately as potential references to increase researchers understanding of the phenomenon under study. The remaining 98 articles were then examined fully. At this stage tighter selection criteria on subject matter and quality appraisal in terms of contribution and methodology is applied. Through this process, 47 journal papers, 3 conference paper and 3 dissertations are kept. The extracted items are then reviewed and coded by the authors. To decrease the bias, each paper is coded by more than one researcher.

The data extraction table includes three main categories of continuous manufacturing in Pharma, general continuous manufacturing models and continuous manufacturing in other industries. Cost/benefit analysis, enabling technologies, enabling processes and activities, barriers and enablers emerged as sub-categories during the coding practice.

In the second stage, in order to validate and extend the framework developed, a case study approach is adopted (Yin, 2003). Three pharmaceutical multinational companies with significant continuous manufacturing adoption were selected. The companies selected have applied continuous processing at different stages of their value chain from R&D pilot plant to Active Pharmaceutical Ingredient (API) and secondary production. The data captured largely through three focus group meetings and semi-structured interviews over the 6 month period from Jan 2012- Aug 2012. Respondents included the two key groups of process engineering team and operations managers actively involved in continuous manufacturing projects. The first focus group meeting was held at the location of a continuous production plant where participants had the chance to visit the plant. The second and third meeting however were conducted through teleconferencing. Participants included authors as well as three companies technical and business teams. Moreover, the use of multiple data collection instruments (i.e. documentation reviews and observation) within the case studies assists with triangulation of data thereby strengthening the largely qualitative outcomes of the research. The case studies allowed refinement to the initial barriers and enablers identified through an iterative process. The results then categorised around economic, process, technological, regulatory and social categories. Additionally, some examples where continuous manufacturing proved to be successful over batch manufacturing in pharmaceutical and non-pharmaceutical industries were identified.

Background Literature

The pharmaceutical industry has traditionally relied on batch-processing to manufacture the products (Vervaet and Remon, 2005). While it is not technically possible to run the entire pharmaceutical unit operations in a continuous mode, some recent efforts have been made to change the main manufacturing concept from batch into a continuous one. For instance, a large number of studies have recently focused on micro and continuous flow reactors demonstrating that various forms of micro-reactors can be used for chemical synthesis with very promising improvements in conversion and product quality. 50% of reactions in the pharmaceutical industry could benefit of a continuous process based on micro reactor technology. For small scale and pilot productions, speed in R&D processes, as well as the avoidance of the scale-up issues, is the main driver. On the other hand, for large scale productions, a gain in yield and safety are the main motivations for the use of micro reactor technology (Roberge et al., 2005). Roberge and colleagues (2005), for instance, compared for a campaign producing 5 tons of an isolated intermediate through a multistage reaction. They suggested that the best result is found when all of the reaction steps are transferred into a continuous-flow operation. Additionally they reported a decrease from 3.5 to 2.0 operators per shift and 16% economic gain when all reactions are transferred from batch to continuous flow operations. According to Plumb (2005), the existing micro-reactors developed are suitable for liquid but not for solids due to their very narrow pathways. Therefore, the main challenge of micro-reactor technology is now to optimise the number of reactions made possible, especially in solid phase (Pieters et al, 2007). According to the Yole developpement micro-reactor market is expected to reach € 140 million in 15 to 20 years with a transfer to production use.

Another area which has been widely studied is continuous granulation. Vervaet and Remon (2005) in a review paper reported six different methods of continuous granulation. The best method studied for continuous granulation is extrusion, on which the first papers for pharmaceutical applications were published in 1986 and much subsequent work has been completed (Schabel *et al*., 2011). The quasi continuous production concept for high shear granulation and fluid-bed drying offers many advantages over the classical methods to produce pharmaceutical granules (Betz et al., 2003). The continuous processing system took up 30% less manufacturing space and the overall investment cost is estimated to be only 40% of the cost for the standard line. Additionally, the continuous processing system offers expected labour saving of 40% (Pieters *et al*., 2007). Recently, Werani et al. (2004) presented an interesting comparison between a conventional batch granulation process (using a high shear mixer combined with a Glatt fluid bed drier) and the Glatt Multicell technique. The quasi-continuous processing clearly provided an increased output rate with less floor space required. However, despite its advantages, to date this technology has only been introduced in a few pharmaceutical production plants (Vervaet and Remon, 2005). The recent research on crystallisation shows that continuous crystallisation offers significant advantages in terms of process, operation and costs, and delivers the isolation of an API in just over 12 min compared to the 9h and 40 min in a batch process (Lawton et al., 2009).

Moreover, a common misbelieve is that continuous manufacturing is only suitable for the large volume. Gorsek and Galvic (1997a,b 2000) has carried out comparison of continuous and batch operation modes on the basis of economic evaluation and found that the continuous plant is more profitable than the batch one for all capacities (from 200 t/a) in the case of single purpose equipment. However, the batch process with multi-purpose equipment can be favoured over the continuous one when the equipment arrangement is appropriate. This is due to the merging of the tasks makes the batch alternative more attractive at small production rates. Grundmann et al., (2009) in their studies have performed 48h continuous production run for the manufacturing of the Ink and compared with the batch process. A significant reduction of the plant hold-up is reported for the continuous manufacturing plant in comparison with the batch process. Samples produced in the continuous run show a significantly lower standard deviation than the batch samples indicating a very high and constant product quality.

Moreover, some studies have endeavoured to propose some guideline determining when a batch process may be favoured over a continuous one. For instance, according to Plumb (2005), plants with a capacity of less than 500t/year are most appropriate for a batch or in some situations a combined continuous/batch process. Additionally, batch plants are often preferred for products with a seasonal demand and a short lifetime where a low capacity of slurries is handled.

Drivers of Continuous Manufacturing

One of the major advantages of continuous processing should be the reduction in the amount waste produced as a result of higher yield under better process control (Plumb, 2005). A recent study by Thomas (2004) also showed that by converting a batch process to a continuous process many of the utility and energy requirements could be cut to as much as 95%. Savings are also likely to occur in labour costs. Continuous flow reactors represent an emerging manufacturing technology that promises better product yields and quality, lower amount of catalyst, solvent and other materials use; less extreme operating condition, improved safety, improved impurity profiles and ease of scaling up. Calabrese and Pissavini (2011) performed nitration and hydrogenation reaction in continuous reactor and comparison is done with the batch reactor. When run in continuous flow, there is drastic reduction observed in hydrogenation reaction from 10h to <2 min. The overall cost of the plant found to be reduced because of the reduction in the amount of catalyst used and smaller equipment footprint.

Furthermore, continuous processing allows quality to be built in the process, to measure in-line, and to adjust parameters to drive the critical quality attributes to the requested target levels and is compatible with FDA's process analytical technology (PAT) initiative and Quality by Design (QbD) principles. In its PAT guidance, FDA identifies "facilitating continuous processing to improve efficiency and manage variability" such as small-scale equipment that eliminates scale-up issues, as a way to improve quality, safety, and efficiency (Arnum and Whitforth, 2011). Other side batch production techniques are very often inefficient and cannot manage variability of input material characteristics in a proper way. Therefore batch processes often have reduced reliability and poor yields (Pellak and Arnum, 2008).

Furthermore, in continuous manufacturing no scale-up development is necessary, as the early clinical batches are produced using exactly the same equipment as the large production batches. Thus, the development time and time needed to market can be reduced significantly (Leuenberger, 2001). According to Center for Drug Evaluation and research at FDA, elimination of scale-up related challenges and increased manufacturing flexibility will be the key benefits of continuous manufacturing. The other key advantages will be reduction of manufacturing footprints in terms of facilities and equipment, lower capital cost and less work-in-progress materials (Arnum and Whitworth, 2011). The equipment required for 100 Kg/h pharmaceutical processing for a directly compressible tablet is just a couple meters long, including feeding devices, the continuous blender and an analytical device. The entire system is small enough to be placed over a table press for direct discharge (Rios, 2007). Moreover, in an approach to manufacture the final drug product from starting materials, Novartis-MIT Center for Continuous Manufacturing (CCM) estimated CapEx, OpEx, and present cost of a dedicated batch process and four continuous processes that are enabled by new technologies developed for continuous production. Capital expenditure for continuous production were estimated to be 20 to 76% lower and overall cost savings were estimated from 9% to 40% depending upon the drug loading and the price of Key Ingredient (KI) (Schaber et al., 2011).

Moreover, according to Chowdary and George (2012) the application of lean manufacturing techniques like Value Stream Mapping (VSM), 5S, inspection at suppliers, eIMS can be apply in the continuous manufcaturing environment of pharmaceutical operatipons. The authors reported significant reduction in cycle time and floor space for the production of creams and ointments by applying those lean manufacturing technique. Benchmarking of four continuous modular mono-product plants against multi-product batch plant for production of four different recombinant proteins (1,500-6,000 kg/year), Seifert and colleagues (2012) demonstrated that a change from batch to continuous operation results in a more than 30% higher net present value at the end of the operating period. Moreover, they conclude that designing the continuous plants modularly leads to another 35% higher net present value assuming that the construction period can be reduced from three years to one year by this concept.

Barriers of Continuous Manufacturing

One of the key disadvantages of continuous processing is that the batch size is not well defined and system in general is not in equilibrium condition from the beginning (Leuenberger, 2001). According to Pavlou *et al*., (2010) lack of definition is a key issue that needs to be addressed. If a continuous process is used in the pharmaceutical industry the definition of a batch size needs to be discussed and agreed with the regulatory authorities. Additionally, accordingly to practitioners, once the technology is ready for commercial scale-up, one of the biggest barriers will be getting commercial approval from regulators such as the Food and Drug Administration (FDA) in the US or the European Medicines Agency (EMEA). However, this issue is not recognised by the related regulatory bodies.

Moreover, handling the material that does not meet specification is another issue. In commercial processes such as foods, detergents, and fertilizers, manufactures typically recycle the material back into a continuous process. In pharmaceutical manufacturing, companies will have to decide whether to scrap this material or reintroduce it in a controlled ways (Rios, 2007). The control system is one of the major design challenges for continuous processing. Online measurement are used for real time release, where the product is released immediately after production based on the online analyses, the product will no longer be tasted in the analytical laboratory. In this case, the measurement must be extremely accurate and reliable. Good integration with the machine control software and the manufacturing execution system will also be crucial (Pieters *et al*., 2007).

Another major challenge reported is how to reduce losses which occurs during start up and shut down phases. For small scale production and process which starts with very expensive key ingredient, the system needed to be developed with very limited or no start-up and shut down waste that reach steady state in extremely short time. Therefore, there may be a misconception that just by changing to a continuous process all problems will be resolved.

But, before one thinks of changing to a continuous process, the question must be asked whether the current batch process is fully understood (Pellak and Arnum, 2008).

Ensuring plug-flow while maintaining consistent mixing characteristics is another barrier reported. Many Peoples are under perception that continuous processing is only suitable for large volume and common misconception is the idea that continuous processing is not flexible.

Part of the barrier to advancing continuous manufacturing is also the lack of experience and fear of unknown (Arnum and Whitworth, 2011). Moreover, financial justification for investment in continuous processing projects in light of excess existing batch capacity is one of the challenges mentioned. There is an opinion that changing from batch production equipment to continuous production equipment will not bring a good return on investment. Pharmaceutical companies fear that the business case for investing in new continuous equipment is not strong enough compared with optimised utilisation of the currently installed base. However, according to Seifert *et al.*, (2012) globalisation, product diversity, varying customer demands, uncertain markets, and shorter product life-time are the new challenges.

Results

The initial list of drivers and barriers identified were refined within the case studies. Moreover, through an iterative process of selective coding, the items were categorised around the key clusters representing existing enablers and barriers. The main objective was to explore and integrate the common hurdles that practitioners might have come across in their journey of continuous manufacturing adoption. Table 2 and 3 details categories identified. As shown, cost, quality, delivery speed, flexibility and sustainability are the main drivers of continuous manufacturing. However, major technological, process, economic, social and regulatory barriers have created some challenges for the adoption of continuous manufacturing in the pharmaceutical industry.

Table 2 - Drivers

Drivers	

Cost	• **Capital investment**
	    • Continuous manufacturing allows the use of smaller production facilities with lower capital cost, with a reduced overall plant footprint.
	• **Operating Costs**
	    • Less labour required to operate the processes
	    • Continuous process is capable of increasing asset utilisation
	    • Lower catalyst and solvent use
	    • Minimize total reaction time through better temperature control
	    • Effective running and scale-up of exothermic reactions without special equipment/ additional precautions
	• **Inventory**
	    • Continuous manufacturing has potential for reducing inventory cost (Less WIP inventory, Reduced material handling and transport , Continuous flow of material)

	• **Improves process control** • CM system is considered to be integration of quality and compliance system.

Quality	• Product yield and quality will be better in CM compared to batch process. – Higher purity • **Less product reject** • The continuous manufacturing enables monitoring of drug quality on a continuous basis rather than through post-production, batch-based testing.
Delivery/dependability	• Continuous process enhances process reliability
Speed	• **Strategic** • Continuous manufacturing accelerates the introduction of new drugs through efficient production processes • Continuous process reduces the time to market • Continuous process is capable of reducing the cycle time • **Operational** • Continuous process is highly capable of minimizing total reaction time through better temperature control compared to batch process. • No Scale-up development is necessary in continuous manufacturing, as the early clinical batches are produced using exactly the same equipment as the large production batches.
Flexibility	• **Process flexibility** • Different degree of flexibility to change the product mix (product flexibility) • Different degree of flexibility to react to changes in demand (volume flexibility)
Sustainability	• Continuous manufacturing minimizes waste, energy consumption and raw material use. • Solvent can be recycling more effectively in continuous process compared to batch process.

Table 3 - Barriers

Barriers	
Technology	• Start up and shut down issues • Out Of Specification material handling (OOS) • Continuous crystallisation, isolation and drying technology • Long reaction times of solids • Smaller scale, multi-purpose line production technology
Process	• Process control and safety • Lack of process understanding • Supply chain issues • Uncertainty in time-to-market (R&D) • Process design and development • Change in already validated process • Process management and execution system
Social	• Market acceptance Varying customer demands in a global and agile market. • Perception of ‘only suitable for large volume’ • Lack of experience and fear of unknown
Regulatory	• FDA/ Regulatory approval • Lack of definition in terms of batch size. • Sterility issue as contaminants and by-products build up within the system in multi-product environment. • PAT and QbD requirements
Economic	• Resource availability at start-up • Equipment cost • Investment risks • Capital requirement to switch to continuous mode • Specialised personnel required

The results also suggest that a continuous process is not always better than batch systems. As supported by many authors (e.g. Rios, 2007), there are certainly cases in which a batch process may be a better choice such as when high throughput is not required. The choice of batch or continuous operations may depend on the production scale, control requirements, and availability of raw materials for the early stage development. Additionally, for the existing developed processes economic justification would be a real challenge.

Moreover, case studies suggested that drivers and barriers identified are product, process and supply network sensitive. To put if differently, some attributes associated with products, processes and network configurations create a unique set of qualities that not only could strengthen or weaken the drivers and barriers identified but also could completely remove them. Accordingly, identifying the key differentiating factors is a vital step enabling the identification of those product, process and supply network archetypes where applying continuous manufacturing is most favourable.

Product attributes identified include variety, volume, chemical and physical characteristics, cost of key ingredients (product value), technology platform (e.g. small molecule, large molecule, etc.), delivery platform (e.g. tablet, liquid, etc.), product life cycle and patent protection. Moreover, process attributes creating different scenarios in terms of impact include capacity, variety (i.e. single vs. multiple), application (e.g. discovery, pilot, production), stage (e.g. API, secondary and packaging and the nature of the process. For instance, not every pharmaceutical process can run continuously. Mixing and crystallisation are key areas where progress is only just starting to be made. Furthermore, supply network dimensions including network structure in terms of geographical dispersion and coordination mechanisms, dynamics (i.e. replenishment mode) and relationships and governance may potentially affect the outcome achieved as a result of the adoption of continuous manufacturing. The three cases selected have different profiles in terms of product, process and supply network archetype allowing the comparison of drivers and barriers across different profiles.

The study also revealed that despite recent efforts to quantify economic benefits of continuous manufacturing, the overall business impact of continuous manufacturing lacks an end-to-end supply chain assessment. Whilst the most opportunities lie in supply chain design and configuration, existing studies are largely focused on production and plant level. Therefore, a re-assessment of outcome variables identified led to the inclusion of end-to-end supply chain metrics. Additionally, as the industry gradually shifts more and more towards continuous manufacturing, a higher level of communication, cooperation and coordination among industrial, institutional and supply chain actors will be required. Finally, case studies suggest that in an ever-changing healthcare value chains and systems, the analysis of drivers and barriers of continuous manufacturing should capture such dynamics and emerging trends.

Conclusions

Continuous manufacturing is a potentially game-changing shift in Pharma in terms of industry structure, product consistency, variety and its ability to encompass emerging technologies and product-service systems. However, the implementation of the continuous processing is still in its early stages, and many challenges remain. This research has sought to explore the current state of the art of continuous manufacturing research in the pharmaceutical industry. In particular, this paper revealed the existing barriers and enablers to the adoption of the continuous manufacturing model in the industry, benefiting of collective discussions and one-to-one interviews with the companies currently going through this transition and encountering such challenges.

In order to gain continuous manufacturing benefits in terms of cost, quality, flexibility and delivery and speed, the industry must remove the technological, social, regulatory and process hurdles. Whilst there is nothing wrong with most batch processes, they are not always the most efficient approach (Rios, 2007).

In the empirical research path, this exploratory qualitative research includes two main phases of systematic literature review and exploratory case studies comprising of semi-structured interviews and theory building and concept development workshops involving industry practitioners, technologists and process engineers. The study revealed that despite recent efforts to quantify economic benefits of continuous manufacturing, the overall business impact of continuous manufacturing lacks an end-to-end supply chain assessment. Case studies also suggest that a vital step in continuous manufacturing impact analysis is the identification of the sensible product, process, archetypes where applying continuous manufacturing is most favourable.

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Global Value Chains, Global Production Networks: Towards "Global NetChains" Synthesis?

Luiz Ojima Sakuda and Afonso Fleury
University of São Paulo, Polytechnic School, Production Engineering Department
Av. Prof. Almeida Prado, 128, travessa 2 - 2º andar
CEP: 05508-070 - São Paulo/SP - Brazil
luizsakuda@gmail.com – acfleury@usp.br

Abstract

A common language on the study of Globalization, result of a critical dialogue beyond "parochial defending of intellectual territories" is a need and a hard goal to achieve. Global Value Chains (GVCs) and Global Production Networks (GPNs) are two schools of Globalization studies that have some common authors and seminal works, as well as some differences on concepts and focus.

On this paper, GVCs and GPNs´ literatures are reviewed and contextualized with their main concepts, similarities and differences, beginning with their roots on Global Commodity Chains (GCCs). Statistics of a sample of articles of ISI-World of Science of both schools are compared using HistCite software, including rankings by number of publications and citation scores of publications, authors, journals, cited references, words used, and other.

The concept of Global Netchains is suggested as a synthesis, and the relationship with other complementary concepts such as Global Manufacturing Virtual Networks and Multi-sided Platforms are discussed.

Keywords: Global Value Chains, Global Production Networks, Global Commodity Chains, Netchains, Global Netchains

1 Introduction

On international business and globalization studies, many theories have focused on the changes, relationships and dynamics of three dimensions: geography, activities and configuration (figure 1). Sometimes, a fourth dimension (virtual) is also added

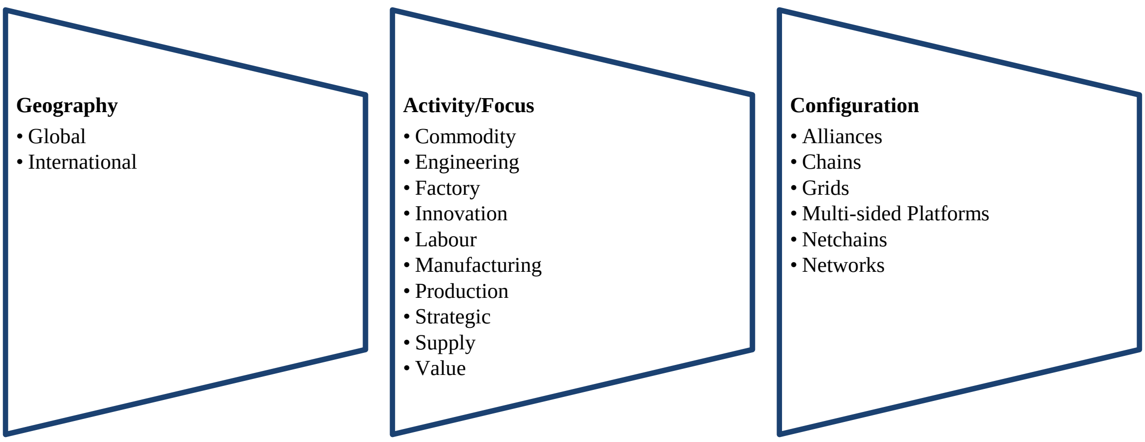

Figure 1: Terms used by integrative concepts of geography, activity/focus and configuration

To understand the influence of complementary/competing terms, a comparative of the number of articles that use the concept was organized (table 1). GSC – Global Supply Chains is the most cited, followed by Global Value Chains (GVCs), Global Production Networks, International Strategic Alliances (ISAs) and Global Commodity Chains (GCCs). Although GSCs is the most popular concept, it will not be analysed in this work as it is not comparable to GCCs/GVCs/GPNs approaches.

Concept	ISI	Scopus	EBSCO
IFNs – International Factory Networks	0	3	1
IPNs – International Production Networks	22	36	72
ISAs – International Strategic Alliances	121	94	160
IMNs – International Manufacturing Networks	4	11	5
GCCs – Global Commodity Chains	**78**	**138**	**139**
GENs – Global Engineering Networks	5	11	2
GINs – Global Innovation Networks	11	23	24
GLNs – Global Labour Networks	0	0	0
GMNs – Global Manufacturing Networks	10	34	6
GMVNs – Global Manufacturing Virtual Networks	5	14	7
GPNs – Global Production Networks	**197**	**215**	**242**
GSCs – Global Supply Chains	214	868	674
GSNs – Global Supply Networks	9	31	19
GVCs – Global Value Chains	**217**	**315**	**339**
GVNs – Global Value Networks	1	3	1

Table 1: Number of Publications until 2011 per Selected Concepts in ISI, Scopus and EBSCO Platforms

On each platform, the search was conducted until 2011, using the full concept between quotation marks (e.g. “global value chains”). On ISI, Web of Science databases selected were: Science Citation Index Expanded (1899-), Social Sciences Citation Index (1898-), Arts & Humanities Citation Index (1975-), Conference Proceedings Citation Index- Science (1990-), Conference Proceedings Citation Index- Social Science & Humanities (1990-). On SciVerse, the database selected was Scopus. On EBSCO, the selected databases were: Academic Search Premier, Information Science & Technology Abstracts (ISTA), SocINDEX with Full Text, EconLit with Full Text, Business Source Complete.

As the aim was to compare concepts that study the three dimensions integrated, many important concepts used to research the same phenomena, but not always with the same focus were not included:

- Some Configuration terms are local/regional oriented, such as clusters, industrial districts;
- Some Configuration terms were not identified in integrated concepts, such as grids
- Some Concepts did not include the geographic dimension, such as virtual organizations, virtual netchains, multi-sided platforms, platform-mediated networks, organizational networks, collaborative networks, industrial networks, manufacturing networks and network organizations
- Some Terms and Concepts are related to the configuration of Multinational Companies (MNCs) or their close ecosystem, such as keiretsu, chaebols and MNCs typologies.

GCCs, GVCs and GPNs´ research have common ground on (i) ontological level -variants of chain/network approaches, (ii) and on epistemological level - study social and development dynamics of contemporary capitalism at global-local nexus, especially governance structures, firm-level upgrading and regional development opportunities; as well as differences such as

(i) relative emphases/coverage on (sub-)national/regional institutions and dynamics, (ii) the role and agency of non-firm actors, and (iii) the relative impact of territorial development on firms´ competitiveness (Neil M. Coe, Peter Dicken, & Martin Hess, 2008).

On sections two to six, this paper aims to review the main concepts and evolution of the three traditions. On section seven, concept is introduced: the Netchains. Section eight describes the bibliometric analysis of the publications of GVCs and GPNs performed on ISI-WoK platform. Finally, section nine suggests "Global Netchains" as a synthesis concept, and also some other possible future research. The Annex is unusually extensive, but necessary as support the bibliometric findings.

2 Global Commodity Chains

The Global Commodity Chains approach is "a ´generally unacknowledged´ break of the traditional commodity chain research based on world-systems approach" (Bair, 2008). *Commodity Chains and Global Capitalism*, published by Gary Gereffi and Miguel Korzeniewicz included Gereffi´s chapter that introduced the framework of GCC. Since then, some GCC researchers migrated to GVC approach (including Gereffi), while others continued on GCC (Bair, 2005, 2008a, 2008b). Table 2 summarizes some key differences of the three chains approaches. PDCC/BDCC refers to Producer-Driven Commodity Chain/ Buyer-Driven Commodity Chain.

	Commodity Chains	Global Commodity Chains	Global Value Chains
Theoretical foundation	World-systems theory	World-systems theory Organizational Sociology	International business literature Global Commodity Chains
Object of inquiry	World-capitalist economy	Inter-firm networks in global industries	Sectoral logics of global industries
Orienting concepts	1. International division of labor 2. Core-periphery-semi-periphery 3.Unequal exchange Kondratieff cycles	1. Industry structure 2. Governance (PDCC/BDCC distinction) 3. Organizational learning/ Industrial upgrading	1. Value-added chains 2. Governance models (modular, relational, captive) 3. Transaction costs 4. Industrial upgrading and rents
Intellectual influences	1. Dependence theory 2. Structuralist development economics	1. MNC literature 2. Comparative development literature	1. International business/ Industrial Organization 2. Trade economics 3. Global/international production networks/systems
Key texts	Hopkins and Wallerstein (1977; 1986), Arrighi and Drangel (1986), Arrigui (1990), *Review*, 23 (1), 2000	Gereffi and Korzeniewicz (1994), Applebaum and Gereffi (1994), Gereffi (1999), Bair and Gereffi (2001)	Humphrey and Schmitz (2000), Sturgeon (2002), Gereffi et al. (2005)

Table 2: Contending chain frameworks (Bair, 2008, p.160)

A central similarity of the frameworks is the observation that globalization is not neutral, and may increase inequality between nations and firms. GCC and GVC focus on upgrading shows that the chains are dynamic, with changes of role, power, rent sharing and geography.

Recent dialogues of this approach with other approaches include *Global Networks* issue on World City Networks and GCCs. A cross-fertilization and further integration of the literatures is proposed to leverage the complementary global and local views (Brown et al., 2010). GPN researchers, while support the endeavour, point dangers on: (i) the emphasis on the common roots in World Systems Theory may not be relevant, as both took different paths and the core-periphery is less pertinent to the reality studied; (ii) the potential over-representation of certain kinds of connections and cities (leading tiers of global cities), and (iii) the limitation of the analysis on the corporate actors (Coe, Dicken, Hess, & Yeung, 2010).

3 Global Value Chains

The following paragraph summarizes the path and some key concepts of the GVCs approach:

> "There are four basic dimensions that the GVC methodology explores: (1) **an input-output structure**, which describes the process of transforming raw materials into final products; (2) a **geographical consideration**; (3) a **governance structure**, which explains how the value chain is controlled; and (4) an institutional context in which the industry value is embedded (Gereffi, 1995); Using these four fundamental dimensions, contributions from Gereffi (1999) and Humphrey & Schmidt (2002) developed an additional element of analysis referred to as **upgrading**, which described the movement within the value chain by examining how producers shift between different stages of the chain." (Gary Gereffi & Fernandez-Stark, 2011) p. 4

The (1) input-output structure provides a systematic view of the value chain, identifying the main activities/segments and the dynamic and structure of companies under each segment of the value chain, as well as inter/intra-organizational relationships. The (2) geographical consideration differentiates the approach from others cited on the introduction. The (3) governance structure goes beyond make-or-buy and the network as everything that is not on the dichotomy market/hierarchies. The study of the (4) institutional context integrates the macro, meso and micro levels of analysis.

Other important characteristic of GVCs analysis is the dynamic view, focusing more on the changes and potential changes of the chain than describing a static scenario. Historical and perspectives and longitudinal studies are valued.

The GVCs´ method was discussed and detailed in several publications over the years (Gary Gereffi & Fernandez-Stark, 2011; Kaplinsky & Morris, 2000; Messner & Meyer-Stamer, 2000; Schmitz, 2005), and have been used by policy makers, researchers, NGOs and practitioners.

The portal www.globalvaluechains.org hosts the Global Value Chains Initiative, which began in 2000. The co-organizers of are Gary Gereffi (Center on Globalization, Governance & Competitiveness, Duke University); John Humphrey (Institute for Development Studies, University of Sussex); and Timothy Sturgeon (Industrial Performance Center, Massachusetts Institute of Technology).

Inside GVCs research, although the similar thinking as shown in table 2, it is possible to identify many differences on unit of analysis (from clusters to industries and nations), geographical point of view (BRIC to countries with a very low stage of development), and others. Two different traditions, internationalists and industrialists, are compared on table 3. (Morrison, Pietrobelli, & Rabellotti, 2008).

	Internationalists	Industrialists
Main focus	GVCs´ governance and upgrading mainly in LDCs	GVCs´ governance and upgrading mainly in LDCs
Methodology	Macro approach Industry-level data/ trade data	Micro approach Case studies, qualitative data
Policy focus	International division of labour, role of bilateral/ multilateral trade agreements, FDI	Competitiveness of clusters, local and cluster development policies
Theoretical background	International economics, political economy, TNC theories	Industrial studies, local development, cluster studies
Authors (Institutions)	Gereffi (Duke), Kaplinsky (Open U), Gibbon (Danish IIS)	Humphrey (IDS/U Sussex)

Table 3: GVCs schools - Internationalists and Industrialists (adapted from Morrison, Pietrobelli, & Rabellotti, 2008)

Some representative themes of GVCs research include relationship of GVCs and industrial clusters (Humphrey & Schmitz, 2002), quality (Ponte & Gibbon, 2005) and labour (Khalid Nadvi, 2008; K. Nadvi, 2011) standards, SMEs (Pietrobelli & Rabellotti, 2006), innovation/learning (Pietrobelli & Rabellotti, 2011), and capabilities (Morrison, et al., 2008).

In 2008, two special editions were published on GVCs: "Economy and Society" and "International Journal of Technological Learning, Innovation and Development". The emphasis of the early research was on economic and competitiveness issues, and recent contributions include labour regulation, (Fichter, Helfen, & JÖRg, 2011; Riisgaard, 2009; Riisgaard & Hammer, 2011), sustainability/greening (Raynolds, Murray, & Heller, 2007; Vermeulen, 2010) and gender (Barrientos, 2001; Barrientos, Dolan, & Tallontire, 2003).

4 Governance in Global Value Chains

One of the central concepts in GVCs is governance since its roots on GCCs. Three dimensions of the interpretation of GVCs governance can be identified: (i) as driving, (ii) as coordination and as (iii) normatization (Gibbon, Bair, & Ponte, 2008). Defined in 1994 as "authority and power relationships that determine how financial, material and human resources are allocated and flow within a chain", started with the PDCC/BDCC distinction cited in table 1.

At Table 4, PDCC and BDCC contexts are compared to "Internet-Oriented Chains (G. Gereffi, 2001); a third concept that was not much used, but helpful to understand the original two types and how the concept matured.

Governance Structure	Leading industries and timing Main drivers Form and dominant principles of value chain integration	Institutional and organizational innovations	Corporate and national pioneers
Producer-driven chains	- Natural resources: late 19th and early 20th centuries - Capital goods & consumer durables 1950s/60s - Transnational manufacturers - Vertical integration (ownership and control)	- Vertically integrated TNCs[1] with international production networks - Mass production - Lean production	- Oil Companies (1870s onward) - Mining (early 20th century) - Agribusiness (early 20th century) - Fordism (1920s onward) - Japanese TNCs (Toyota, early 1960s on)
Buyer-driven chains	- Consumer non-durables 1970s & 1980s - Retailers and marketers - Network integration (logistics and trust)	- Growth of export processing zones - Global sourcing by retailers - Rise of pure marketers - Rise of speciality retailers - Growth of private labels (store brands) - Lean Retailing	- Mexico, the Philippines, Taiwan, South Korea, etc (mid-1960s onward) - Sears, Kmart, Montgomery Ward, JC Penney (early 1970s onward) - Liz Claidorne (1976), Nike (1976), Reebok (1979) - The limited (1969), Gap (1976) - JC Penney, Sears, Wal-Mart, Kmart (mid-1980s onward) - Wal-Mark, JC Penney, Dillard´s Federeted (late 1980s onward)
Internet-oriented chains (emerging)	- B2C Services (online retailing, online brokerage) - B2B Intermediates (autos, computers) 1990s & 2000s - Internet infomediaries (B2C market) and some established manufacturers (B2B market) - Virtual integration (information and access)	- Rise of e-commerce - Mass customization - Disintermediation: direct sales (skip retailers), online services (e.g. brokerage) - New Internet navigators	- Amazon.com (1997) - Dell (1988), Gateway (1993) - E*Trade (1992), Schwab (1996) - AOL (1992), Yahoo! (1996), Excite@Home (1999)
Specific dates indicate when companies were founded, went public (The Limited, The Gap, Dell, Gateway, Amazon, AOL, Yahoo!) or became established US firms (Nike, Reebok). Decades are used for onset of trends			

Table 4: The historical and institutional origins of changing governance structures in GVCs (adapted from Gereffi, 2001, p. 34)

The concept was also approached with the metaphor of the principals of civic governance exemplified in table 6 (Kaplinsky & Morris, 2000).

	Exercised by parties internal to chain	Exercised by parties external to chain
Legislative governance	- Setting standards for suppliers in relation to on-time deliveries, frequency of deliveries and quality	- Environmental standards - Child labour standards
Judicial governance	- Monitoring the performance of suppliers in meeting these standards	- Monitoring of labour standards by NGOs - Specialised firms monitoring conformance to ISO standards
Executive governance	- Supply chain management assisting suppliers to meet these standards - Producer associations assisting members to meet these standards	- Specialised service providers - Government industrial policy support

Table 5: Examples of Legislative, Judicial and Executive value chain governance (Kaplinsky, 2000, p. 13)

Other publications also discussed the concept that matured on "The governance of global value chains" (Gary Gereffi, Humphrey, & Sturgeon, 2005), the most influential publication in combined GVCs-GPNs literature. Table 6 make the relations of the five governance types (market, modular, relational, captive and hierarchy) and the combinations of the three key determinants of governance: (i) complexity complexity of information and knowledge transfer, (ii) complexity of to codify transactions and (iii) capabilities is the supply-base. The explicit coordination and power asymmetry is different on three types constructed beyond the non-market/hierarchy dichotomy: lower on modular, intermediary in relational and higher in captive type.

Governance	The complexity of information and knowledge transfer	Complexity of to codify transactions	Capabilities is the supply-base	Degree of explicit coordination and power asymmetry	Relationships/ Transactions
Market	Low	High	High		- Low costs of switching partners - Cost/benefit
Modular	High	High	High	Low	- Customers´ specifications - Turn-key services may limit transactions-specificity
Relational	High	Low	High	↕	- Mutual interdependence, high asset specificity - Trust, reputation, family/ ethnic ties
Captive	High	High	Low	High	- Small suppliers dependent of larger buyers (high switching costs) - High monitoring/control
Hierarchy	High	Low	Low		- Vertical integration - Managerial Control

Table 6: Key determinants and characteristics of global value chain governance types (adapted from Gereffi, Humphrey & Sturgeon, 2005)

Figure 2 illustrates the five GVCs governance types, with the lead firms of the three intermediary types are closer to the end user. Comparing with the BDCC/PDCC governance model, this typology introduces more complexity than the BDCC type, but doesn´t provide the same increase of sophistication to analyse PDCC-like chains.

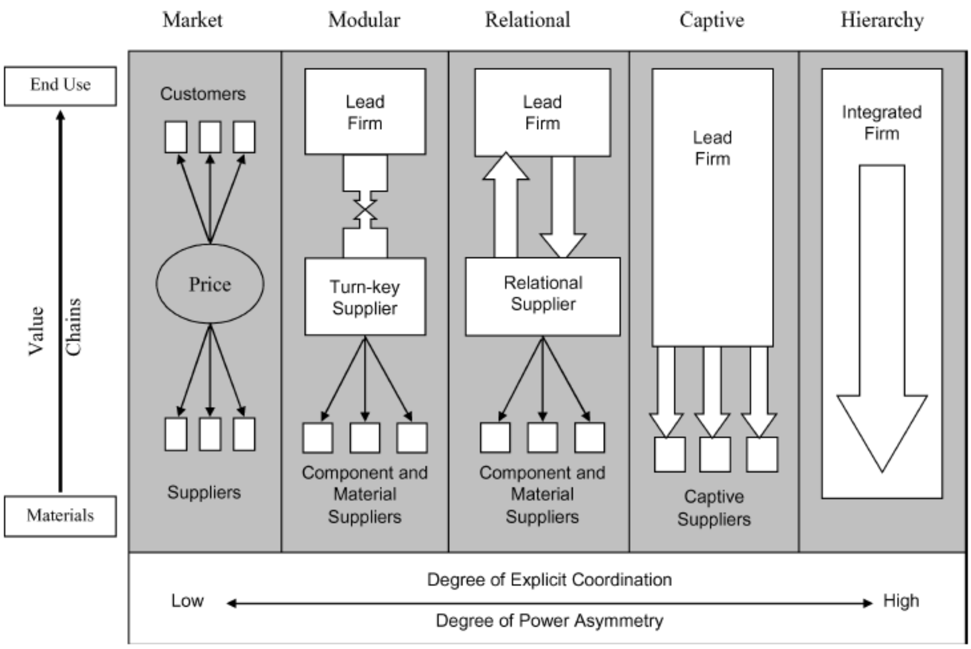

Figure 2: Five global value chain governance types (Gereffi, Humphrey & Sturgeon, 2005, p.89)

5 Global Production Networks

Considered a major innovation in the organization of international business, Global Production Networks have three driving forces: (i) liberalization, (ii) rapid development and diffusion of information and communication technology, and (iii) competition. Their widespread catalysed international knowledge diffusion, and changed the international geography of production and innovation. GPNs “combine(s) concentrated dispersion of the value chain across firm and national boundaries, with a parallel process of integration of hierarchical layers of network participants” (Ernst & Kim, 2002).

GPNs´ studies acknowledges the contributions of GCCs/GVCs studies, but criticizes chain approaches, considering that the vertical and linear view bias the analysis, as they (i) don´t incorporate all forms of configuration, (ii) focus on governance of inter-firms transactions, not considering other actors. Network structures with horizontal, vertical, and diagonal links, forming multi-dimensional, multi-layered combinations would reflect better the reality. Between the many network theories, Actor-network theory (ANT) is selected to complement GVCs´ approach, and brings the following contributions that are considered missing in GVCs (Henderson, Dicken, Hess, Coe, & Yeung, 2002):

- Emphasizes the relations and agency in heterogeneous networks
- Rejects “artificial dualisms” (global/local, structure/agency dichotomies)
- Conceptualizes networks as hybrid collectivises of human and non-human agents

GPNs critics also differentiate from GVCs arguing that (iii) the GPN approach is multi-scalar and gets more of the intra-variations, and (iv) captures the social and cultural dimensions in addition to the economic dimensions the GVCs focus (Yang & Coe, 2009).

The framework of analysis has three categories (value, power and embeddedness), two dimensions (value and structures), and four configuration coordination factors (firms, institutions, networks and sectors). The configuration may lead to development (Henderson, et al., 2002).

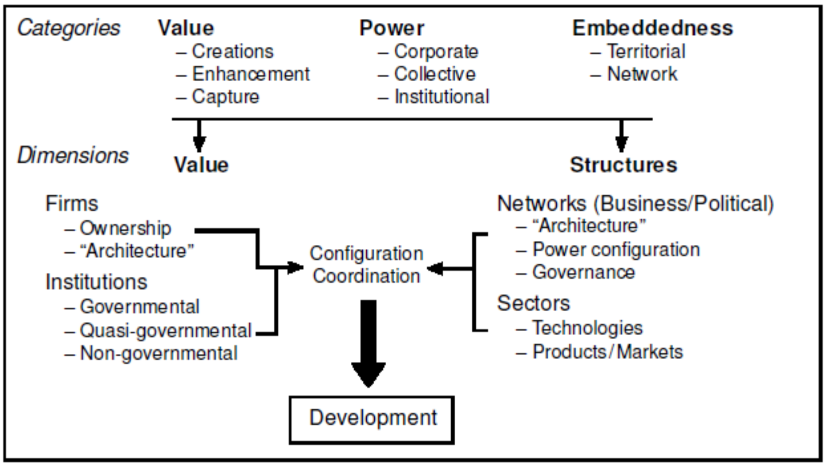

Figure 3: Framework for GPNs Analysis (Henderson et al. 2002, p. 448)

On value, the main questions are similar to GVCs approach: how it is created, enhanced and captured. Rent generation can be technological, organizational, relational, brand, trade-policy rents. Enhancement can be built on technology transfers, quality and technological sophistication, skilled labour and organizational process, or creation of new local rents. Capturing involve questions of government policy, firm ownership and corporate governance.

Power forms considered are corporate (firm-level), institutional (national/local, international inter-state, “Bretton Woods” institutions, UN agencies, and international credit rating agencies), and collective (trade unions, employers’ associations, NGOs - nationally, locally or industry specific).

Embeddedness is a term from network studies, and in this model releates to the connections of the firms functionally and territorially, and also how social and cultural influences strategies, values and priorities of firms, managers, workers and communities; and have two main forms: territorial and network embeddedness. Territorial embeddedness may become a key element in regional economic growth and in capturing global opportunities, as it may support or constrain economic activities and social dynamics. The network embeddedness is built by the connections between network members, institutions, and agents, both intra and inter organizational.

GVCs´ scholars defend the use of the value chain metaphor, and don´t perceive the chains with the same ways as GPNs (Sturgeon, Van Biesebroeck, & Gereffi, 2008):

> “The chain metaphor is not literal or exclusive. It does not assume a unidirectional flow of materials, finance or intellectual exchange, although a focus on buyer power does encourage researchers to be on the lookout for top-down governance and power asymmetries. A value chain can usefully be conceptualized as a subset of more complex and amorphous structures in the spatial economy, such as networks, webs and grids (Pil and Holweg, 2006). Value chains provide a snapshot of economic activity that cut through these larger structures, while at the same time clearly identifying smaller scale entities and actors, such as workers, clusters, firms, and narrowly defined industries (Sturgeon, 2001). This ‘meso-level’ view of the global economy provides enough richness to ground our analysis of global industries, but not so much that it becomes bogged down in excessive difference and variation, or is forced into overly narrow spatial, analytic or sectoral frames in response to the overwhelming complexity and variation that researchers inevitably encounter in the field.” (Sturgeon, Van Biesebroeck, & Gereffi, 2008, p. 302)

The defence position GVCs´ analysis in meso-level, bringing macro and micro snapshots to compose the full figure, instead of trying to get all with a multi-scalar approach; as well as value chains as one of the more “complex and amorphous structures in the spatial economy”. Doing this, restricts the scope and grants a deeper and more specific analysis of the phenomena. But at the same time it also deconstructs the nature of chains, not assuming a unidirectional flow.

The interaction between GVCs and GPNs scholars is very interesting, and may be illustrated in “Capturing the Gains: Economic and Social Upgrading in Global Production Networks and Trade” research network (www.capturingthegains.org), funded by the UK Department for International Development, (DFID), the Sustainable Consumption Institute (SCI), Chronic Poverty Research Centre (CPRC) and the The Economic and Social Research Council (ESRC). It include 20 partner institutions from developed (USA, UK, Denmark, Netherlands), emerging (Brazil, India, China, South Africa) and low development (Kenya, Uganda, Vietnam) countries and was built over a period of two years (2007- 2009). The two main contacts were Stephanie Barrientos (University of Manchester), and Gery Gereffi.

One of the papers produced is “*Economic and Social Upgrading in Global Production Networks: Developing a Framework for Analysis*”. The paper reviews GVCs and GPNs, their similarities and differences. Still, instead of integrating the traditions, GPN was used as a form of homogenization of language – as e.g. “*One solution to this problem is the emergence* *of 'modular' production in GPNs (Gereffi et al. 2005)*". This is a direct citation of GVCs´ governance typology, not GPNs´ (Barrientos, Gereffi, & Rossi, 2010).

6 Economic and Social Upgrading

There are two dimensions in upgrading: economic and social. Economic upgrading relates to the economic value generated that can be measured by metrics such as profits, value added, and price markups, and has four types (Gary Gereffi, Humphrey, Kaplinsky, & Sturgeon, 2001):

Upgrading Type	Upgrade
Product	- More sophisticated product lines
Process	- Transform inputs into outputs more efficiently (technology and/or production system)
Intra-chain	- New Functions (functional upgrading) - Move backward or forwards - Vertical integration
Inter-chain	- Apply a competence to a new sector

Table 7: Upgrading types (adapted from Gereffi, Humphrey, Kaplinsky, & Sturgeon, 2001)

These upgrading types are easier to understand and to be studied than social upgrading, that have been studied less and more recently.

Social upgrading is the process of improvement in the rights and entitlements of workers as social actors, which enhances the quality of their employment, which includes access to better work, enhancing working conditions, protection and rights (Barrientos, Gereffi, & Rossi, 2011). It might result from economic upgrading, but is not an automatic result. It can be subdivided into two components: measurable standards and enabling rights.

A framework is proposed to link economic and social upgrading. Five types of work are identified: (i) Small-scale household and home-based work, (ii) Low-skilled, labour-intensive work, (iii) Medium-skilled, mixed production technologies work, (iv) High-skilled, technology-intensive work, and (v) Knowledge-intensive work. It is important to note that the movement can be on both directions and in strategic decisions or forced by circumstances. Some choices might be considered downgrading for some actors, but not for others: a position that is lower for one actor can be higher for another. The relationship of both was also systematized by level of aggregation - Country, Sector of the GPN, and Firm (Milberg & Winkler, 2011).

7 Netchains

The concept of Netchain, defined as a "set of networks comprised of horizontal ties between firms within a particular industry or group, which are sequentially arranged based on vertical ties between firms in different layers" (Lazzarini, Chaddad, & Cook, 2001), aims to get the best of both worlds (chains and network analysis), integrating the two types of organization, not considering them as alternative types. Table 8 summarizes the sources of value and key concepts related to each source in value chains and networks perspectives.

	Sources of Value	Key concepts
Value Chains	- Optimization of production and operations	- Supply Chain Management - Cost-based. Technical efficiency measures, qualitative indicators
	- Reduction of transaction costs: Search, bargaining, monitoring, enforcement costs	- Agency theory: interests, asymmetric information, opportunistic behaviour, transaction efficiency - Transaction costs economics: contract incompleteness, markets vs hierarchies - Measurement: imperfect measurement
	- Capturing the innovation rents	- Appropriability regimes - Complementary assets
Networks	- Social Structure	- Type of social relationship/tie - Type of network (dense?) - Structural holes
	- Learning	- Knowledge diversity - Knowledge co-specialization
	- Network externalities	- Direct and indirect network externalities

Table 8: Sources of value emanating from supply chain and network analysis (adapted from Lazzarini, Chaddad, & Cook, 2001)

Netchains analysis considers that Value Chains and Network analysis are complementary because they correspond to different types of interdependence, according to Thompson sequential/pooled/reciprocal typology. Figure 4 relates the sources of value, the types of analysis and coordination mechanisms, and presents the Netchains analysis.

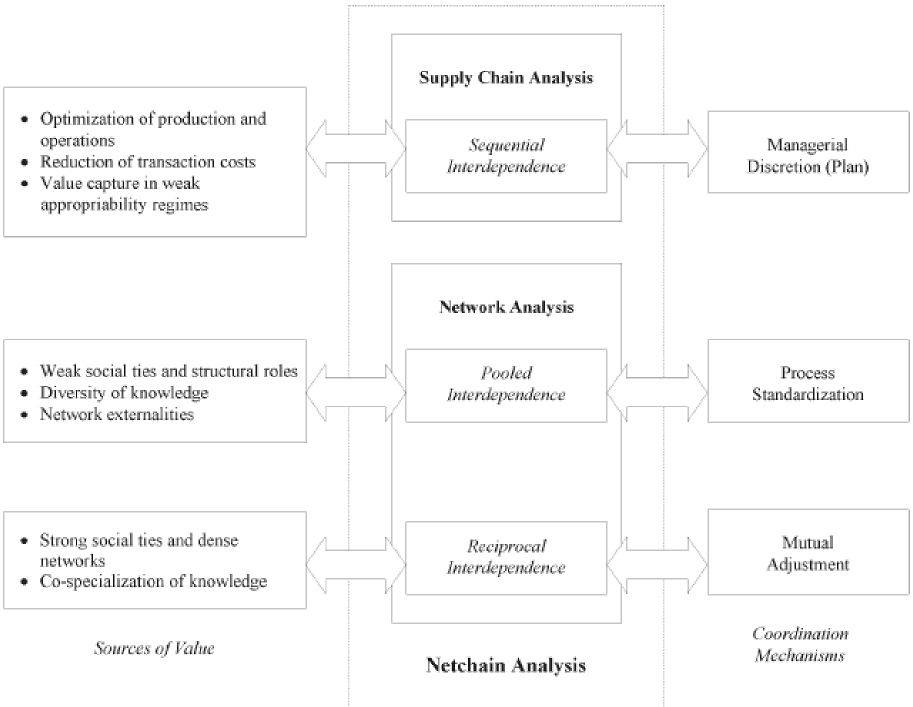

Figure 4: An overview of netchain analysis (Lazzarini, Chaddad & Cook, 2001, p. 14).

The netchain approach uses layers to be able to analyse both vertical and horizontal links at the same time (figure 5). The layers model was used without the concept "NetChains" to study the telecoms industry (Fransman, 2002).

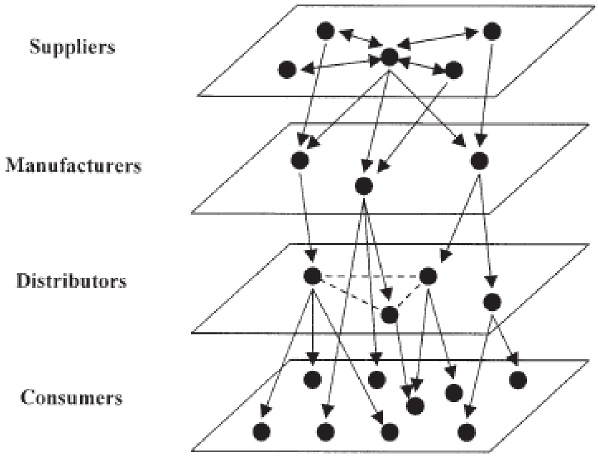

Figure 5: Generic Netchain (Lazzarini, Chaddad and Cook, 2001, p. 8)

Despite the fact of being known by many of the main scholars – 95 citations on Scopus, 408 citations in Google Scholar (as it is not on ISI platform, it is not possible to track there) – the concept was not widespread. Still, the consideration of GPNs scholars shall be quoted:

> "Although it seems unnecessary to add further terminological complexity to an already confused field, the ideas contained in the netchain concept are useful because they make us more aware of the multi-dimensional nature of production networks." (N. M. Coe, P. Dicken, & M. Hess, 2008)

A search for "netchains" until 2011 retrieves just 8 publications in ISI, 6 in Scopus and 2 in EBSCO, but a lot of theorization is included. The virtual dimension is included, and the concept of "virtual netchains" is presented and illustrated (Capó-Vicedo, Capó-Vicedo, Expósito-Langa, & Tomás-Miquel, 2008). Transparency in netchains is also defined (Hofstede, 2003), measured (Deimel, Frentrup, & Theuvsen, 2008) and explored on customer horizon perspective (Storer, Holmen, & Pedersen, 2003);. "social netchains" concept is proposed as a merge of netchain and social network (Talamini & Velloso Ferreira, 2010).

8 Bibliometric Study on GVCs and GPNs

An exploratory bibliometric study was performed to provide a better understanding of the GVCs and GPNs research streams with the use of the software HistCite. Developed by Eugene Garfield, founder of the Institute for Scientific Information and the inventor of the Science Citation Index®, HistCite is a software implementation of algorithmic historiography, and generates chronological maps of bibliographic collections resulting from subject, author, institutional or source journal searches of Thompson-Reuters ISI Web of Science (Garfield, 2009). For this paper, it was used the version 12.03.17. It is important to note the Web of Science (source for the current bibliometric study) does not include all publications of Web of Knowledge (source for table 1).

The choice of ISI/Histcite was made as there is no export/import process from the other platforms (e.g. Scopus, ESBCOhost, Proquest) to bibliometric softwares (e.g. HistCite, Sitkis, Citespace). Scopus has some native tools, but not as extensive as the software. Although many journals and papers are not in ISI, they are representative. HistCite is a free user-friendly software developed by Thompson-Reuters.

The analysis of the publications of the platforms has some limitations: it doesn´t consider United Nations´, States´, and NGOs´ publications, dissertations and thesis, nor books or electronic books. Some of the most GVCs´ and GPNs´ important publications are published by OCDE (Staying Competitive in Global Economy 2007; OCDE, 2011), Inter-American Development Bank (Pietrobelli & Rabellotti, 2006), ILO (Schmitz, 2005), World Bank (Cattanco, Gereffi & Staritz, 2010; Gereffi & Fernandez-Stark, 2011), WTO & IDE_JETRO (2011)

Some terms are used on the tables and statistics generated by HistCite are listed on Table 9

GCS	**Global Citation Score** shows the total number of citations to a paper in Web of Science.
LCR	**Local Cited References** shows the number of citations in a paper's reference list to other papers within the collection.
LCS	**Local Citation Score** shows the count of citations to a paper within the collection
CR	**Number of Cited References** shows the number of cited references in the paper's bibliography
Recs	**Number of Records** shows the number of records where a given item is found.
T*	**Total [score]** Any Total score represents a sum of respective scores for all records from a given author, source, other category, or all records. e.g. TLCS = Total Local Citation Scores

Table 9: HistCite Statistics

On each platform, the search was conducted until 2011, using the full concept between quotation marks (“global value chains” and “global production networks”). On ISI, Web of Science databases selected were: Science Citation Index Expanded (1899-), Social Sciences Citation Index (1898-), Arts & Humanities Citation Index (1975-), Conference Proceedings Citation Index- Science (1990-), Conference Proceedings Citation Index- Social Science & Humanities (1990-). The statistics of areas were taken directly from the platform, and all the others were generated by HistCite.

As ranking tables and Histgraph figures are available on the annex[1], the considerations of this section will focus on the similarities and differences, not on the description of the results that are self-explanatory on the tables.

The profile of sample of GVCs and GPNs publications, and the combined sample is show on table 10. The number of GVCs articles (217) is slightly bigger than GPNs (197), what may explain the superior number of authors (337/254) and authors´ institutions

	Total	GVCs	GPNs	Common
Records	406	217	197	8
Authors	561	337	254	30
Journals	178	131	82	35
Cited References	15574	8127	8722	1275
Words	1205	773	746	314
Institutions	325	209	159	43
Institutions with Subdivision	463	282	207	26

Table 10: Profile of the GVCs, GPNs, and combined ISI samples

[1] Coe N (1 record) is indexed also Coe NM (9 records), as well as Rutherford T/Rutherford TD (1 record each) and Sturgeon T/ Sturgeon TJ (3 recs/1 rec) On this analysis, the consolidated data was considered.

8.1 Main Areas

On ISI-WoS, the profile of the publications is alike, but already shows the differences of the two schools (Table 11). In GVC, the main group is business publications: Economics, Management, Business, Operations Research/ Management Science, Engineering Industrial (in Green). The Most GPN articles with a macro level view, with a public interest bias: Planning Development, Geography, Environmental Studies and International Relations (in Yellow). Third area in both is social sciences: Sociology, Urban Studies, Anthropology, Area Studies, and Political Sciences (in Blue).

On Scopus (Table 12), the classification system is different: Social Sciences is the main group in GVC is Social Sciences (blue), then Business (green) and macro level (yellow). If Decision Sciences is considered a Business area, then Business is the area with more publications. On GPN, the order of the areas is the same of the ISI table.

8.2 Years

Table 13 shows the GVCs, GPNs and GCCs Recs, TLCS and TGCS per year ISI-WoK until 2011. The GCCs publications started in 1997, GPNs´ in 1998 and GVCs´ in 2000. Two periods can be identified: until 2005 and from 2006-2011.

At the first period, the number of publications is low, as the field is being established: 2001-2005 article/year averages are 5 (GCCs), 5,8 (GVCs), and 4,6 (GPNs). On the second period (2006-2011) averages are 10,8 (GCCs), 31 (GVCs), and 29 (GPNs). It is also clear that despite GCCs research increase, its relative importance compared to GVCs/GPNs research declined.

8.3 Journals

On tables 14 to 17, GVCs and GPNs top 20 Journals Ranking per Recs/TCLS and TLCS/TGCS are detailed with Recs, TGCS, TLCS, and also position on each ranking (Recs, TGCS, and TLCS). Recs ranking shows the outlets that are more open to the theme/approach of each school, while TLCS and TGCS shows the impact of the publications. The similarities and differences on main areas (8.1) are reflected in journals: four journals are common on Recs ranking, and three in TLCS ranking, and no journals are common in all four rankings.

8.4 Articles and Authors

Tables 18 and 19 have GVCs and GPNs top 10 publications ranking per LCS without any common publications, and Tables 20 and 21 (top 20 authors rankings per recs) have just Barrientos; reinforcing that although their similarities, the two schools have autonomous paths.

8.5 Countries and Institutions

British and American researchers and institutions have much more publications than other countries´ (tables 20 to 27), and two British institutions lead the schools: IDS/Sussex (GVCs) and University of Manchester (GPNs). American researchers are not as concentrated as British ones.

8.6 References

Reference counting is not as sophisticated as co-citation analysis and other techniques, but is enough to identify some findings. Both schools have high percentage of citation of their top 10 references (tables 28 and 29 of top 30 references of GVCs and GPNs).

On GVCs ranking, it is interesting to note two Bair´s GCC publications between top 10 GVC, and just two Coe´s GPN publications on position 27. On GPNs´ ranking there are three Gereffi´s GVC publications in top 10, and other two in #11 and #30; and also Bair (2005) in #16 and Humphrey (2002) in #19. So GVCs have more impact on GPNs literature than the opposite.

There are no ANT references are in GPNs´ top 30 ranking, what reflects that (i) the basis of GPNs is much more GVCs than ATN, and (ii) the contribution of networks theories didn´t reach their potential, what is illustrated also by the absence of a seminal network governance publication (Jones, Hesterly, & Borgatti, 1997) in GPNs ranking and its low position on GVCs ranking (#251, 3 citations).

8.7 Words

No surprises in tables 30 and 31: upgrading, governance and innovation are in higher positions on GVCs ranking; while regional, and development are higher in GPNs. China is the only country word in both rankings. Cluster(s) and supply are only in GVCs ranking, and Embeddeness, Spatial, and Geography(ies) are only in GPNs ranking.

8.8 HistGraph

HistGraphs are very useful to understand and illustrate the historical path of research themes. In GVCs HistGraph it is possible to identify two groups of articles, but their data is not sufficient to label as two different streams of research. In GPNs Histgraph, no groups are identified.

9 Discussion

The discussion is organized in four parts. First, the GVCs/GPNs´ literature and bibliometric analysis are summarized. Then some comments about modelling trade-offs are remembered, and the usefulness of the concept “Global Netchains” is discussed. Finally, suggestions for future research are made, including considerations about two other potential streams of research that might have great contributions to Global Netchains research: Global Manufacturing Virtual Networks and Multi-Sided Platforms.

9.1 GVCs/GPNs´ Literature and Bibliometric analysis Summary

Comparing GVCs and GPNs publications, GVCs school has a deeper understanding of how organizations interact, giving practitioners, NGOs and policymakers tools to analyze the industries and the position of their organizations to make better decisions. Its meso-level focus enables to have the macro and micro inputs that are keys to governance and upgrading processes. Recent development incorporates themes and dimensions that GPNs scholars pointed as lacking until early-2000s.

GPNs school has a wider understanding of the multi-level connections, and has established a critical view not only of GVCs approach but also of the global process. It positioned itself as a GCCs/GVCs evolution, introducing ANT to build a synthesis that could enhance some points considered weak. The macro description is generally more detailed and includes more actors, and privileges the macro level. The analysis of references shows that ANT contribution might be underdeveloped.

The projects and publications that joined researchers from both schools prove that there is more than just goodwill from all parties to improve together the current theory: they are actively working on that.

9.2 Modelling Trade-offs

The eternal trade-off of modelling is how to balance comprehensiveness and the richness of the differences and details. Here, two trade-offs in Global Chains/Networks analysis are discussed.

The first trade-off is related to the levels of analysis, and how to identify and select the actors that are relevant maintaining the complexity manageable to the theory. GVCs´ approach started more focused and then incorporated critics and contributions to make it wider. GPNs´ replacing chains by networks and multi-scalar approach is an alternative with the same goal. This tension is intrinsic to the theme, and demands contributions from other fields to solve the gaps.

The second trade-off is about communication, particularly visual representation of the studied phenomena. One of the issues of chain metaphor is that it suggests that there is just one path, and that path is unidirectional. Networks and grids seem to reproduce better the multiplicity of the relationships nature, but are harder to represent and be understood. To show and analyse the diversity, some solutions were developed, such as displaying the variations of GVCs that exists on the same industry and compare them side-by-side as display on Figure 6 on annex (Erkus-Ozturk & Terhorst, 2010). On business models visualization it is proposed that for each customer segment, one canvas showing the specific configuration of infrastructure (activities, resources, and partners), value proposition, channels, customer relationship and finances (cost structure and revenue streams) shall be made (Osterwalder & Pigneur, 2010). To fully understand an actors´ interests, importance and behaviour, it is important to capture the many simultaneous scenarios that each actor is involved.

9.3 Global Netchains

NetChains approach helps to identify different roles of the same actor, as it represents both vertical and horizontal relationships simultaneously. The use of layers to do so does not discard the use of many figures to compare scenarios and/or display different dimensions (economic, institutional, social, political, cultural, etc).

Not all Netchains are global, but Global Netchains are an important subset, as GCCs/ GVCs/ GPNs research already showed. The Global/International can be developed on GCCs/ GVCs/ GPNs basis. Governance models and upgrading might have to be reconceptualised on this cross-fertilization process.

One of GPNs´ critics is on perceived GVCs´ over importance of governance based on inter-firms relationships. As the use of layers help to visualize horizontal, vertical and diagonal relationships of different natures and actors without losing the value creation process view, it may be easier to understand the power dynamics. As Netchains theoretical basis come from Supply Chain Analysis and Network Analysis, Global Netchains may have less difficulty to benefit from existing chain and network research, incorporating the contributions of strong research streams such as network governance (Jones, et al., 1997) that are not incorporated in GVCs or GPNs models. Producer drive may also be revisited.

Economic and social upgrading analysis can benefit from multi-layers approach, especially on the challenge of identifying the relationships between these two dimensions. With the possibility of better visualization of each actor in different scenarios and dimensions, it shall be easier to understand what economic upgrades are more viable. Product, Process, and Intra-chain are easier to visualize than Inter-chain upgrading, and being able to understand the role of the actor in different scenarios is particularly important for the last one. On social upgrading side, a similar same argument is valid.

9.4 Other Potential Contributors for future Global Netchains

Two emerging streams of research might have interesting and different contributions to GNCs: Global Manufacturing Virtual Networks (GMVNs) and Multi-sided Platforms (MSPs).

The model of Global Manufacturing Virtual Networks was introduced in 2000, as a response to four driving forces: (i) the globalization of markets and competition, (ii) the emergence of the virtual business network as a robust business model for innovation and development, (iii) the increasing participation of emerging countries in global manufacturing networks and (iv) practices that changes industries like contractual and electronic manufacturing services. (Shi, Fleet, & Gregory, 2002, 2003; Shi & Gregory, 2005). Although the original scope is firm-level operations and strategy, and the comparative is with other types of business models, such as MNCs (GVCs´ hierarchies) and international strategic alliances (could be GVCs´ relational or modular chains), there are many possibilities of cross-fertilization. Despite not as broad as GCCs/ GVCs/ GPNs approaches, the identification of internationalization and externalization as the key dimensions of the change leads to a positioning with similar questions about the functioning of global/international chains/networks.

Multi-sided Platform (MSP) is defined as “an organization that creates value primarily by enabling direct interactions between two (or more) distinct types of affiliated customers” (Hagiu & Wright, 2011). Platforms studies are published in strategy and organizational journals, and evolved of concepts such as two-sided markets/platforms, networked business, and platform-mediated networks (PMNs) (Thomas Eisenmann, Parker, & Alstyne, 2006; Thomas Eisenmann, Parker, & Van Alstyne, 2007; T. R. Eisenmann, 2008). Sixty of the world’s 100 largest companies (ranked by market value) earn >50% of their revenue from platform-mediated networks, including American Express, Cisco, Citigroup, Time Warner, UPS, and Vodafone. (Thomas Eisenmann, 2011). Product examples of platforms include (in 2012) eBay, Facebook, iPhone, Mall of America, Match.com, Skype, Sony PlayStation, Vogue magazine, Yellow Pages, and YouTube; but do not include traditional cable TV companies, department stores, movie theatres, satellite radio companies, or video game arcades. (Hagiu & Wright, 2011). Key concepts include network effects (Zhu & Iansiti, 2012) and envelopment (T. Eisenmann, Parker, & Van Alstyne, 2011). Although the geographic dimension is not central on platform approach, this type of configuration is different from traditional chains/networks, and shall be considered on further development of the concepts and methods in Global Netchains research. The MSPs have to reach critical mass in all sides, and they tend to need broad geographical coverage.

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11 Annex

GCCs		GVCs		GPNs	
Geography	39	Planning Development	56	Geography	112
Economics	22	Economics	54	Economics	45
Sociology	18	Geography	40	Environmental Studies	36
Environmental Studies	12	Management	32	Planning Development	23
Planning Development	12	Business	31	Management	14
Anthropology	10	Sociology	19	Sociology	13
International Relations	6	Environmental Studies	17	Urban Studies	12
Political Science	5	Operations Research Management Science	12	Anthropology	10
Business	4	Area Studies	10	Business	8
Management	4	Urban Studies	10	Area Studies	7
Urban Studies	4	Computer Science Information Systems	8	Engineering Industrial	6
Social Sciences Interdisciplinary	3	Political Science	7	International Relations	6
Area Studies	2	Engineering Industrial	6	Political Science	6
		International Relations	6	Operations Research Management Science	5
		Agriculture Multidisciplinary	4	Engineering Electrical Electronic	4
		Anthropology	4	Computer Science Theory Methods	3
		Telecommunications	4	Engineering Manufacturing	3
				Geography Physical	3
				Transportation	3

Table 11: Areas of GVCs and GPNs publications in ISI-WoS until 2011

GVCs		GPNs	
Social Sciences	160	Geography	112
Business, Management and Accounting	98	Economics	45
Economics, Econometrics and Finance	60	Environmental Studies	36
Environmental Science	30	Planning Development	23
Decision Sciences	26	Management	14
Computer Science	22	Sociology	13
Engineering	20	Urban Studies	12
Earth and Planetary Sciences	16	Anthropology	10
Energy	8	Business	8
Agricultural and Biological Sciences	5	Area Studies	7
		Engineering Industrial	6
		International Relations	6
		Political Science	6
		Operations Research Management Science	5

Table 12: Areas of GVCs and GPNs publications in Scopus until 2011

11.1 Years

	Total			GVCs			GPN			GCC		
	Recs	TLCS	TGCS	Recs	TLCS	TGCS	Recs	TLCS	TGCS	Recs	TLCS	TGCS
1997										3	0	32
1998	1	4	9				1	2	9	5	0	66
1999	1	0	7				1	0	7	5	0	485
2000	1	1	35	1	0	35				3	0	128
2001	7	33	139	5	27	115	2	0	24	6	0	297
2002	8	229	631	4	76	229	4	115	402	3	0	197
2003	5	19	138	4	13	114	2	4	54	5	0	69
2004	14	153	446	5	5	24	9	131	422	4	0	218
2005	17	308	1050	11	208	873	6	34	177	7	0	162
2006	33	147	406	14	15	143	19	103	263	10	0	98
2007	40	68	308	20	16	100	20	43	208	8	0	92
2008	65	245	659	38	66	308	28	125	364	15	0	131
2009	60	55	277	33	18	139	27	27	138	7	0	16
2010	65	20	141	38	13	78	29	7	63	18	0	83
2011	89	12	56	44	1	17	49	11	45	7	0	7
	406	1294	4302	217	458	2175	197	602	2176	106	0	2081

Table 13: GVCs, GPNs and GCCs Recs, TLCS and TGCS per year ISI-WoK until 2011

Due to technical issues, GCCs´ TLCS data was not retrived.

11.2 Journals

Recs Rank	Journal (Recs/TLCS)	Recs	TLCS	TGCS	TLCS Rank	TGCS Rank
1	World Development	15	79	328	2	2
2	Ids Bulletin-Institute Of Development Studies	7	32	129	5	5
3	Journal Of Economic Geography	7	19	87	6	7
4	Entrepreneurship And Regional Development	7	16	75	7	8
5	Economy And Society	5	68	189	4	4
6	European Planning Studies	5	1	20	24	18
7	Research Policy	4	4	56	11	9
8	Global Networks-A Journal Of Transnational Affairs	4	2	30	17	15
9	Regional Studies	3	76	228	3	3
10	Journal Of Rural Studies	3	7	91	9	6
11	Agriculture And Human Values	3	5	50	10	10
12	Journal Of Agrarian Change	3	1	31	21	13
13	Geoforum	3	2	19	19	20
14	Environment And Planning A	3	1	15	25	23
15	Journal Of Business Ethics	3	1	13	26	26
16	Industrial And Corporate Change	3	2	9	20	31
17	Erdkunde	3	1	3	31	43
18	Revista De Economia Mundial	3	1	1	35	54
19	Review Of International Political Economy	2	106	434	1	1
20	European Urban And Regional Studies	2	2	43	16	11

Table 14: GVCs Journals Ranking per Recs/TCLS in ISI-WoK until 2011

First criteria of the ranking is Recs, and the second is TCLS.

TLCS Rank	Journal (TLCS/TGCS)	TGCS	Recs	TLCS	Recs Rank	TGCS Rank
1	Review Of International Political Economy	434	2	106	19	1
2	World Development	328	15	79	1	2
3	Regional Studies	228	3	76	9	3
4	Economy And Society	189	5	68	5	4
5	Ids Bulletin-Institute Of Development Studies	129	7	32	2	5
6	Journal Of Economic Geography	87	7	19	3	7
7	Entrepreneurship And Regional Development	75	7	16	4	8
8	Development Policy Review	14	2	8	25	25
9	Journal Of Rural Studies	91	3	7	10	6
10	Agriculture And Human Values	50	3	5	11	10
11	Research Policy	56	4	4	7	9
12	Cambridge Journal Of Economics	11	2	4	27	28
13	Geographical Journal	15	2	3	23	21
14	Politics & Society	15	2	3	24	22
15	Third World Quarterly	12	2	3	26	27
16	European Urban And Regional Studies	43	2	2	20	11
17	Global Networks-A Journal Of Transnational Affairs	30	4	2	8	15
18	Sociologia Ruralis	20	2	2	22	17
19	Geoforum	19	3	2	13	20
20	Industrial And Corporate Change	9	3	2	16	31

Table 15: GVCs Journals Ranking per TLCS/TGCS in ISI-WoK until 2011

First criteria of the ranking is TCLS, and the second is TGLS.

Recs Rank	Journal (Recs/TLCS)	Recs	TLCS	TGCS	TLCS Rank	TGCS Rank
1	Environment And Planning A	19	92	224	4	3
2	Journal Of Economic Geography	14	119	323	1	1
3	Economic Geography	11	41	136	5	7
4	Growth And Change	11	19	84	7	8
5	Progress In Human Geography	10	34	195	6	5
6	Global Networks-A Journal Of Transnation	10	13	76	10	9
7	Regional Studies	8	15	43	9	11
8	European Planning Studies	7	5	75	13	10
9	European Urban And Regional Studies	4	3	22	17	18
10	Singapore Journal Of Tropical Geography	4	1	10	24	25
11	Geografiska Annaler Series B-Human Geog	4	1	8	25	30
12	International Labour Review	4	0	0	55	55
13	Antipode	3	3	28	16	14
14	Eurasian Geography And Economics	3	5	16	15	21
15	Cambridge Journal Of Regions Economy An	3	0	10	36	26
16	Norsk Geografisk Tidsskrift-Norwegian Jou	3	2	2	22	39
17	Transactions Of The Institute Of British Ge	2	93	208	3	4
18	Asia Pacific Viewpoint	2	10	30	12	13
19	Economy And Society	2	5	20	14	20
20	Environment And Planning C-Government A	2	2	8	21	29

Table 16: GPNs Journals Ranking per Recs/TCLS in ISI-WoK until 2011

TLCS Rank	Journal (TLCS/TGCS)	TLCS	Recs	TGCS	Recs Rank	TGCS Rank
1	Journal Of Economic Geography	119	14	323	2	1
2	Review Of International Political Economy	97	1	259	30	2
3	Transactions Of The Institute Of British Ge	93	2	208	17	4
4	Environment And Planning A	92	19	224	1	3
5	Economic Geography	41	11	136	3	7
6	Progress In Human Geography	34	10	195	5	5
7	Growth And Change	19	11	84	4	8
8	Research Policy	18	1	141	31	6
9	Regional Studies	15	8	43	7	11
10	Global Networks-A Journal Of Transnation	13	10	76	6	9
11	Academy Of Management Review	11	1	36	32	12
12	Asia Pacific Viewpoint	10	2	30	18	13
13	European Planning Studies	5	7	75	8	10
14	Economy And Society	5	2	20	19	20
15	Eurasian Geography And Economics	5	3	16	14	21
16	Antipode	3	3	28	13	14
17	European Urban And Regional Studies	3	4	22	9	18
18	Journal Of Agrarian Change	2	1	13	38	23
19	International Journal Of Technology Mana	2	1	12	39	24
20	Development And Change	2	1	9	40	27

Table 17: GPNs Journals Ranking per TCLS in ISI-WoK until 2011

11.3 Publications

#	Date / Author / Journal	LCS	GCS	LCR	CR
1	Gereffi G, Humphrey J, Sturgeon T The governance of global value chains REVIEW OF INTERNATIONAL POLITICAL ECONOMY. 2005 FEB; 12 (1): 78-104	106	426	1	62
2	Humphrey J, Schmitz H How does insertion in global value chains affect upgrading in industrialclusters? REGIONAL STUDIES. 2002 DEC; 36 (9): 1017-1027	76	227	0	56
3	Ponte S, Gibbon P Quality standards, conventions and the governance of global value chains ECONOMY AND SOCIETY. 2005 FEB; 34 (1): 1-31	33	110	2	119
4	Giuliani E, Pietrobelli C, Rabellotti R Upgrading in global value chains: Lessons from Latin American clusters WORLD DEVELOPMENT. 2005 APR; 33 (4): 549-573	35	90	1	109
5	Barrientos S, Dolan C, Tallontire A A gendered value chain approach to codes of conduct in Africanhorticulture WORLD DEVELOPMENT. 2003 SEP; 31 (9): 1511-1526	10	61	3	60
6	Humphrey J, Schmitz H Governance in global value chains IDS BULLETIN-INSTITUTE OF DEVELOPMENT STUDIES. 2001 JUL; 32 (3): 19-+	15	54	0	24
7	Klooster D Environmental certification of forests: The evolution of environmental governance in a commodity network JOURNAL OF RURAL STUDIES. 2005 OCT; 21 (4): 403-417	3	46	3	83
8	Sturgeon T, Van Biesebroeck J, Gereffi G Value chains, networks and clusters: reframing the global automotiveindustry JOURNAL OF ECONOMIC GEOGRAPHY. 2008 MAY; 8 (3): 297-321	8	43	4	60
9	Giuliani E Cluster absorptive capacity - Why do some clusters forge ahead and others lag behind? EUROPEAN URBAN AND REGIONAL STUDIES. 2005 JUL; 12 (3): 269-288	2	42	2	128
10	Mutersbaugh T Just-in-space: Certified rural products, labor of quality, and regulatory spaces JOURNAL OF RURAL STUDIES. 2005 OCT; 21 (4): 389-402	4	41	2	65

Table 18: GVCs publications ranking per LCS in ISI-WoK until 2011

#	Date / Author / Journal	LCS	GCS	LCR	CR
1	Henderson J, Dicken P, Hess M, Coe N, Yeung HWC Global production networks and the analysis of economic development REVIEW OF INTERNATIONAL POLITICAL ECONOMY. 2002 AUG; 9 (3): 436-464	97	259	1	83
2	Coe NM, Hess M, Yeung HWC, Dicken P, Henderson J 'Globalizing' regional development: a global production networksperspective TRANSACTIONS OF THE INSTITUTE OF BRITISH GEOGRAPHERS. 2004 DEC; 29 (4): 468-484	93	205	1	61
3	Hess M 'Spatial' relationships? Towards a reconceptualization of embeddedness PROGRESS IN HUMAN GEOGRAPHY. 2004 APR; 28 (2): 165-186	29	145	1	92
4	Ernst D, Kim L Global production networks, knowledge diffusion, and local capabilityformation RESEARCH POLICY. 2002 DEC; 31 (8-9): 1417-1429	18	141	0	49
5	Coe NM, Dicken P, Hess M Global production networks: realizing the potential JOURNAL OF ECONOMIC GEOGRAPHY. 2008 MAY; 8 (3): 271-295	43	91	15	119
6	Hassink R How to unlock regional economies from path dependency? From learningregion to learning cluster EUROPEAN PLANNING STUDIES. 2005 JUN; 13 (4): 521-535	3	64	0	61
7	Hess M, Yeung HWC Whither global production networks in economic geography? Past, present, and future ENVIRONMENT AND PLANNING A. 2006 JUL; 38 (7): 1193-1204	41	60	7	70
8	Coe NM, Hess M The internationalization of retailing: implications for supply network restructuring in East Asia and Eastern Europe JOURNAL OF ECONOMIC GEOGRAPHY. 2005 AUG; 5 (4): 449-473	16	47	2	57
9	Yeung HWC The firm as social networks: An organisational perspective GROWTH AND CHANGE. 2005 SUM; 36 (3): 307-328	11	38	2	133
10	Sunley P Relational economic geography: A partial understanding or a newparadigm? ECONOMIC GEOGRAPHY. 2008 JAN; 84 (1): 1-26	7	38	5	139

Table 19: GPNs publications ranking per LCS in ISI-WoK until 2011

11.4 Authors

Rank Recs	Author	Recs	TLCS	TGCS	Rank TLCS	Rank TGCS
1	Gereffi G	7	121	521	2	2
2	Ponte S	7	70	192	6	5
3	Nadvi K	6	19	71	11	12
4	Riisgaard L	5	16	31	13	32
5	Sturgeon TJ	4	115	476	3	3
6	Gibbon P	4	71	185	5	6
7	Tallontire A	4	14	77	15	11
8	Humphrey J	3	197	707	1	1
9	Schmitz H	3	93	302	4	4
10	Barrientos S	3	15	105	14	8
11	Pietrobelli C	3	39	100	7	9
12	Rabellotti R	3	35	96	9	10
13	Belussi F	3	6	42	23	20
14	Lund-Thomsen P	3	0	6	103	83
15	Thoburn J	3	1	5	66	89
16	Albors-Garrigos J	3	0	3	123	117
17	Hervas-Oliver JL	3	0	3	124	118
18	Tejada P	3	1	3	71	111
19	Hu YQ	3	0	0	177	177
20	Giuliani E	2	37	132	8	7

Table 20: GVCs authors ranking per Recs

Rank Recs	Author	Recs	TLCS	TGCS	Rank TLCS	Rank TGCS
1	Hess M	10	342	859	1	1
2	Coe NM	10	280	673	2	2
3	Yeung HWC	10	269	638	3	3
4	Dicken P	6	251	598	4	4
5	Wei YHD	6	6	20	33	47
6	Henderson J	4	193	474	5	5
7	Ernst D	4	20	153	6	6
8	Pickles J	4	9	33	13	12
9	Rodrigue JP	4	5	28	36	21
10	Lee YS	4	9	25	18	27
11	Bowen JT	3	10	33	9	11
12	Smith A	3	9	33	14	13
13	Pavlinek P	3	3	22	46	42
14	Hesse M	3	2	21	50	44
15	Barrientos S	3	2	9	53	65
16	Franz M	3	0	3	120	107
17	Begg R	2	9	33	15	14
18	Bucek M	2	9	33	16	15
19	Roukova P	2	9	33	17	16
20	Leinbach TR	2	10	31	10	17

Table 21: GPNs authors ranking per Recs

11.5 Countries

Rank Recs	Country	Recs	TLCS	TGCS	Rank TLCS	Rank TGCS
1	USA	41	169	846	2	2
2	UK	38	261	1110	1	1
3	Peoples R China	26	0	3	23	22
4	Denmark	17	51	150	3	3
5	Germany	14	10	75	5	4
6	Italy	14	12	70	4	5
7	Spain	14	1	11	15	15
8	Netherlands	10	5	49	8	7
9	France	7	2	34	9	9
10	Sweden	7	2	27	11	12
11	Canada	5	9	60	6	6
12	Australia	5	1	35	12	8
13	South Africa	5	8	21	7	13
14	Taiwan	4	1	33	13	10
15	Switzerland	4	2	32	10	11
16	Brazil	4	1	12	14	14
17	Japan	4	1	6	17	19
18	New Zealand	3	0	1	26	26
19	Belgium	2	0	8	20	18
20	Norway	2	0	4	21	20

Table 22: GVCs authors´ country of origin ranking per Recs

Rank Recs	Country	Recs	TLCS	TGCS	Rank TLCS	Rank TGCS
1	UK	53	371	1044	1	1
2	USA	51	45	277	3	3
3	Germany	20	37	249	4	4
4	Peoples R China	17	21	58	5	7
5	Singapore	14	237	603	2	2
6	Canada	8	9	30	11	13
7	Netherlands	6	1	14	16	17
8	South Korea	5	20	149	6	5
9	Taiwan	5	17	48	7	8
10	Australia	5	4	40	14	9
11	Norway	5	6	13	13	18
12	France	3	14	63	8	6
13	Switzerland	3	6	37	12	10
14	Ireland	3	0	19	20	15
15	Denmark	3	2	16	15	16
16	Czech Republic	3	1	4	18	20
17	Bulgaria	2	9	33	9	11
18	Slovakia	2	9	33	10	12
19	South Africa	2	0	1	26	26
20	Italy	1	0	25	19	14

Table 23: GPNs authors´ country of origin ranking per Recs

11.6 Institutions

Rank Recs	Institution with Subdivision	Recs	TLCS	TGCS	Rank TLCS	Rank TGCS
1	Danish Inst Int Studies	9	86	230	4	4
2	Univ Sussex, Inst Dev Studies	4	183	680	1	1
3	Univ Manchester, Sch Environm & Dev	3	7	31	20	27
4	Univ Copenhagen, Dept Geog & Geol	3	2	28	43	32
5	Univ Roma Tre	2	35	92	5	5
6	Florida State Univ, Dept Geog	2	4	67	26	7
7	Univ E Anglia, Norwich NR4 7TJ	2	11	65	9	8
8	Duke Univ	2	9	50	12	11
9	Univ Colorado, Dept Sociol	2	25	49	7	12
10	Harvard Univ, John F Kennedy Sch Govt	2	0	44	77	13

Table 24: GVCs authors´ institutions and department ranking per Recs

Rank TGCS	Institution with Subdivision	TLCS	TGCS	Recs	Rank TLCS	Rank Recs
1	Univ Sussex, Inst Dev Studies	183	680	4	1	2
2	Duke Univ, Ctr Globalizat Governance & Competitiveness	106	426	1	2	26
3	MIT, IPC	106	426	1	3	27
4	Danish Inst Int Studies	86	230	9	4	1
5	Univ Roma Tre	35	92	2	5	5
6	Univ Sussex, Brighton BN1 9RH	35	90	1	6	28
7	Florida State Univ, Dept Geog	4	67	2	26	6
8	Univ E Anglia, Norwich NR4 7TJ	11	65	2	9	7
9	Inst Dev Studies, Brighton	10	61	1	10	29
10	Univ Greenwich, Chatham	10	61	1	11	30

Table 25: GVCs authors´ institutions and department ranking TGCS

Rank Recs	Institution with Subdivision	Recs	TLCS	TGCS	Rank TLCS	Rank TGCS
1	Univ Manchester, Sch Environm & Dev	15	211	501	2	2
2	Natl Univ Singapore, Dept Geog	11	236	598	1	1
3	Univ N Carolina, Dept Geog	6	9	38	15	13
4	Univ Utah, Dept Geog	6	6	20	29	41
5	Univ Utah, Inst Publ & Int Affairs	6	6	20	30	42
6	Univ Southampton, Sch Geog	5	19	75	9	9
7	Univ Marburg, Dept Geog	5	1	5	73	93
8	East West Ctr	4	20	153	8	6
9	Hofstra Univ, Dept Econ & Geog	4	5	28	33	22
10	Univ Kentucky, Dept Geog	3	10	34	12	14

Table 26: GPNs authors´ institutions and department ranking per Recs ´

Rank TGCS	Institution with Subdivision	TGCS	Recs	TLCS	Rank Recs	Rank TLCS
1	Natl Univ Singapore, Dept Geog	598	11	236	2	1
2	Univ Manchester, Sch Environm & Dev	501	15	211	1	2
3	Univ Manchester, Manchester Business Sch	464	2	190	16	3
4	DUXX Grad Sch Business Leadership	259	1	97	47	4
5	Univ Manchester, Sch Geog	259	1	97	48	5
6	East West Ctr	153	4	20	9	8
7	Univ Munich, Inst Econ Geog	145	1	29	49	7
8	Korea Univ, Coll Business Adm	141	1	18	50	10
9	Univ Southampton, Sch Geog	75	5	19	6	9
10	Univ Duisburg Essen, Inst Geog	64	1	3	51	39

Table 27: GPNs authors´ institutions and department ranking per TGCS

11.7 References

Rank	Author / Year / Journal	GVC	%GVC
1	Gereffi G, 2005, REV INT POLIT ECON, V12, P78, DOI 10.1080/09692290500049805	106	48,8%
2	Humphrey J, 2002, REG STUD, V36, P1017, DOI 10.1080/0034340022000022198	76	35,0%
3	Gereffi G, 1999, J INT ECON, V48, P37, DOI 10.1016/S0022-1996(98)00075-0	75	34,6%
4	Gereffi G., 1994, COMMODITY CHAINS GLO, P95	55	25,3%
5	Gereffi G., 1994, COMMODITY CHAINS GLO	52	24,0%
6	Giuliani E, 2005, WORLD DEV, V33, P549, DOI 10.1016/j.worlddev.2005.01.002	35	16,1%
7	Ponte S, 2005, ECON SOC, V34, P1, DOI 10.1080/0308514042000329315	33	15,2%
8	BAIR J, 2005, COMPETITION CHANGE, V9, P153, DOI 10.1179/102452905X45382	30	13,8%
9	Bair J, 2001, WORLD DEV, V29, P1885, DOI 10.1016/S0305-750X(01)00075-4	29	13,4%
10	Dolan C, 2000, J DEV STUD, V37, P147, DOI 10.1080/713600072	29	13,4%
11	Kaplinsky R, 2000, J DEV STUD, V37, P117, DOI 10.1080/713600071	28	12,9%
12	Schmitz H, 2000, J DEV STUD, V37, P177, DOI 10.1080/713600073	27	12,4%
13	Henderson J, 2002, REV INT POLIT ECON, V9, P436, DOI 10.1080/09692290210150842	26	12,0%
14	Schmitz H, 2004, LOCAL ENTERPRISES IN THE GLOBAL ECONOMY: ISSUES OF GOVERNANCE AND UPGRADING, P1	25	11,5%
15	Sturgeon TJ, 2002, IND CORP CHANGE, V11, P451, DOI 10.1093/icc/11.3.451	24	11,1%
16	Porter M.E., 1990, COMPETITIVE ADVANTAG	21	9,7%
17	Gereffi G, 2001, IDS BULL-I DEV STUD, V32, P1	19	8,8%
18	Dolan C, 2004, ENVIRON PLANN A, V36, P491, DOI 10.1068/a35281	18	8,3%
18	Gibbon P, 2001, WORLD DEV, V29, P345, DOI 10.1016/S0305-750X(00)00093-0	18	8,3%
18	Gibbon P, 2008, ECON SOC, V37, P315, DOI 10.1080/03085140802172656	18	8,3%
21	Gibbon P., 2005, TRADING AFRICA VALUE	16	7,4%
21	Kaplinsky R., 2001, HDB VALUE CHAIN RES	16	7,4%
23	Humphrey J, 2001, IDS BULL-I DEV STUD, V32, P19	15	6,9%
24	Dicken P., 2001, GLOBAL NETW, V1, P89, DOI 10.1111/1471-0374.00007	14	6,5%
24	Ponte S, 2002, WORLD DEV, V30, P1099, DOI 10.1016/S0305-750X(02)00032-3	14	6,5%
24	Raikes P, 2000, ECON SOC, V29, P390	14	6,5%
27	Coe NM, 2004, T I BRIT GEOGR, V29, P468, DOI 10.1111/j.0020-2754.2004.00142.x	13	6,0%
27	Coe NM, 2008, J ECON GEOGR, V8, P271, DOI 10.1093/jeg/lbn002	13	6,0%
27	Humphrey J., 2000, 120 IDS U SUSS	13	6,0%
27	Schmitz H, 1999, WORLD DEV, V27, P1503, DOI 10.1016/S0305-750X(99)00072-8	13	6,0%
31	COHEN WM, 1990, ADMIN SCI QUART, V35, P128, DOI 10.2307/2393553	12	5,5%
31	Palpacuer F, 2005, WORLD DEV, V33, P409, DOI 10.1016/j.worlddev.2004.09.007	12	5,5%

Table 28: GVCs References ranking per citing Recs

Rank	Author / Year / Journal	GPN	%GPN
1	Henderson J, 2002, REV INT POLIT ECON, V9, P436, DOI 10.1080/09692290210150842	97	49,2%
2	Coe NM, 2004, T I BRIT GEOGR, V29, P468, DOI 10.1111/j.0020-2754.2004.00142.x	93	47,2%
3	Gereffi G, 2005, REV INT POLIT ECON, V12, P78, DOI 10.1080/09692290500049805	57	28,9%
4	Dicken P., 2001, GLOBAL NETW, V1, P89, DOI 10.1111/1471-0374.00007	49	24,9%
5	Coe NM, 2008, J ECON GEOGR, V8, P271, DOI 10.1093/jeg/lbn002	43	21,8%
6	Hess M, 2006, ENVIRON PLANN A, V38, P1193, DOI 10.1068/a38463	41	20,8%
7	Gereffi G., 1994, COMMODITY CHAINS GLO	39	19,8%
8	Gereffi G, 1999, J INT ECON, V48, P37, DOI 10.1016/S0022-1996(98)00075-0	29	14,7%
8	Hess M, 2004, PROG HUM GEOG, V28, P165, DOI 10.1191/0309132504ph479oa	29	14,7%
10	Dicken P, 2001, ECON GEOGR, V77, P345, DOI 10.2307/3594105	27	13,7%
11	Bathelt H, 2004, PROG HUM GEOG, V28, P31, DOI 10.1191/0309132504ph469oa	26	13,2%
11	Gereffi G., 1994, COMMODITY CHAINS GLO, P95	26	13,2%
13	Yeung HWC, 2005, T I BRIT GEOGR, V30, P37, DOI 10.1111/j.1475-5661.2005.00150.x	25	12,7%
14	Storper M., 1997, REGIONAL WORLD TERRI	24	12,2%
15	Smith A, 2002, PROG HUM GEOG, V26, P41, DOI 10.1191/0309132502ph355ra	23	11,7%
16	BAIR J, 2005, COMPETITION CHANGE, V9, P153, DOI 10.1179/102452905X45382	22	11,2%
16	Dicken P., 2007, GLOBAL SHIFT MAPPING	22	11,2%
18	Dicken Peter, 2003, GLOBAL SHIFT RESHAPI	19	9,6%
19	Ernst D, 2002, RES POLICY, V31, P1417, DOI 10.1016/S0048-7333(02)00072-0	18	9,1%
19	GRANOVETTER M, 1985, AM J SOCIOL, V91, P481, DOI 10.1086/228311	18	9,1%
19	Humphrey J, 2002, REG STUD, V36, P1017, DOI 10.1080/0034340022000022198	18	9,1%
19	Markusen A, 1996, ECON GEOGR, V72, P293, DOI 10.2307/144402	18	9,1%
23	Coe NM, 2005, J ECON GEOGR, V5, P449, DOI 10.1093/jeg/lbh068	16	8,1%
24	SCHOENBERGER E., 1997, CULTURAL CRISIS FIRM	15	7,6%
25	Bathelt H, 2006, PROG HUM GEOG, V30, P223, DOI 10.1191/0309132506ph603pr	14	7,1%
25	Bunnell TG, 2001, PROG HUM GEOG, V25, P569, DOI 10.1191/030913201682688940	14	7,1%
25	DICKEN P, 1992, T I BRIT GEOGR, V17, P279, DOI 10.2307/622880	14	7,1%
25	Porter M.E., 1990, COMPETITIVE ADVANTAG	14	7,1%
25	Whitley R., 1999, DIVERGENT CAPITALISM	14	7,1%
30	Bathelt H, 2003, J ECON GEOGR, V3, P117, DOI 10.1093/jeg/3.2.117	13	6,6%
30	Gereffi G, 1996, COMPETITION CHANGE J, V1, P427	13	6,6%
30	Yeung HWC, 2009, REG STUD, V43, P325, DOI 10.1080/00343400902777059	13	6,6%

Table 29 : GPNs References ranking per citing Recs

11.8 Words

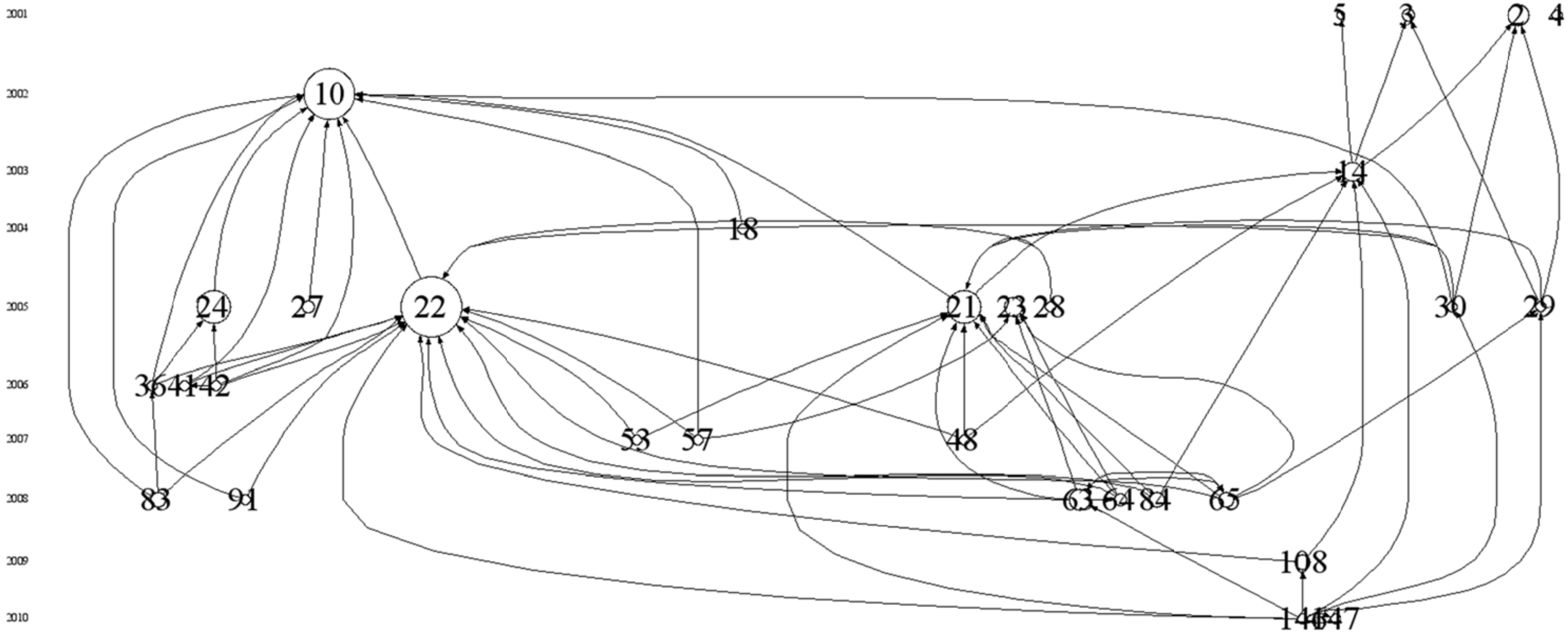
Rank Recs	Word	Recs	TLCS	TGCS	Rank TLCS	Rank TGCS
1	Value	93	383	1339	1	1
2	Global	85	378	1326	2	2
3	Chains	75	369	1264	3	3
4	Industry	38	19	121	18	12
5	Chain	33	42	203	11	9
6	Upgrading	30	122	395	6	6
7	Case	26	8	69	48	34
8	Governance	24	174	719	4	4
9	China	21	8	104	47	20
10	Clusters	18	128	438	5	5
11	Local	16	16	112	22	18
12	Innovation	16	5	66	72	39
13	Development	15	3	50	107	52
14	Industrial	14	84	269	7	7
15	Cluster	13	5	83	69	25
16	Sector	13	5	71	70	31
17	South	12	4	38	89	62
18	Standards	11	52	177	9	10
19	Production	11	5	68	71	36
20	Trade	11	2	63	112	42
21	Globalization	10	7	67	58	37
22	Knowledge	10	8	39	51	58
23	Networks	9	17	103	20	21
24	Social	9	13	73	27	30
25	Systems	9	11	65	37	40
26	Supply	9	1	18	133	115
27	Analysis	8	12	54	31	46
28	Market	8	1	40	124	57
29	Evidence	8	4	32	91	81
30	Regional	8	1	31	128	83

Table 30: Words ranking per citing Recs in GVCs publications

Rank Recs	Word	Recs	TLCS	TGCS	Rank TLCS	Rank TGCS
1	Global	74	425	1208	3	2
2	Networks	72	447	1241	1	1
3	Production	71	428	1174	2	3
4	Industry	40	61	252	11	10
5	China	24	43	144	13	15
6	Development	22	224	596	4	4
7	Regional	19	118	354	6	6
8	Chains	15	10	69	55	32
9	Case	14	23	71	23	26
10	Economic	11	148	398	5	5
11	Governance	11	19	71	28	27
12	Network	11	18	71	33	29
13	Upgrading	11	12	49	46	45
14	Commodity	11	5	46	97	53
15	Firm	10	19	71	29	28
16	Economy	10	22	66	25	33
17	Value	10	17	54	36	43
18	Embeddedness	9	70	253	10	9
19	Knowledge	9	20	155	27	14
20	Electronics	9	29	94	18	19
21	Innovation	9	8	29	78	88
22	Spatial	8	39	179	15	13
23	East	8	39	137	16	16
24	Geography	8	52	131	12	17
25	Asia	8	28	93	19	20
26	Competitive	8	26	77	20	24
27	Transnational	8	19	70	30	31
28	Investment	8	12	43	47	54
29	Geographies	8	4	38	104	65
30	Manufacturing	8	2	7	151	177

Table 31: Words ranking per citing Recs in GPNs publications

11.9 HistGraphs



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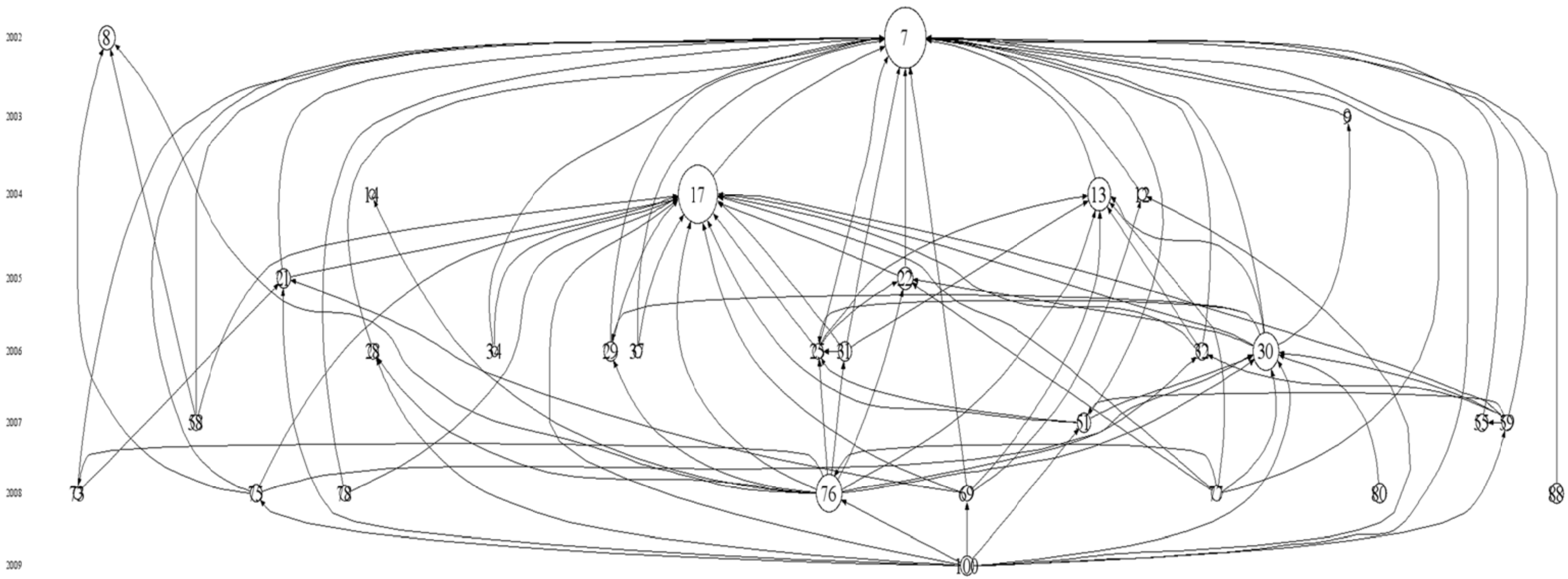
Nodes: 30, Links: 67
LCS, top 30; Min: 2, Max: 95 (LCS scaled)

		LCS	GCS
1.	2 Humphrey J, 2001, IDS BULL-I DEV STUD, V32, P19	14	49
2.	3 Gereffi G, 2001, IDS BULL-I DEV STUD, V32, P30	5	31
3.	4 Barrientos S, 2001, IDS BULL-I DEV STUD, V32, P83	4	16
4.	5 Dolan CS, 2001, IDS BULL-I DEV STUD, V32, P94	2	7
5.	10 Humphrey J, 2002, REG STUD, V36, P1017	68	197
6.	14 Barrientos S, 2003, WORLD DEV, V31, P1511	10	58
7.	18 Nadvi K, 2004, IDS BULL-I DEV STUD, V35, P20	4	10
8.	21 Ponte S, 2005, ECON SOC, V34, P1	32	103
9.	22 Gereffi G, 2005, REV INT POLIT ECON, V12, P78	95	363
10.	23 Palpacuer F, 2005, WORLD DEV, V33, P409	12	25
11.	24 Giuliani E, 2005, WORLD DEV, V33, P549	30	73
12.	27 Nadvi K, 2005, ENTREP REGION DEV, V17, P339	5	19
13.	28 Mutersbaugh T, 2005, J RURAL STUD, V21, P389	4	37
14.	29 Klooster D, 2005, J RURAL STUD, V21, P403	3	42
15.	30 Muradian R, 2005, WORLD DEV, V33, P2029	3	32
16.	36 Yeung HWC, 2006, WORLD DEV, V34, P520	3	29
17.	41 Biggiero L, 2006, ENTREP REGION DEV, V18, P443	4	9
18.	42 Sammarra A, 2006, ENTREP REGION DEV, V18, P543	3	17
19.	48 Tallontire A, 2007, THIRD WORLD Q, V28, P775	3	10
20.	53 Raynolds LT, 2007, AGR HUM VALUES, V24, P147	3	29
21.	57 Thomsen L, 2007, J ECON GEOGR, V7, P753	3	6
22.	63 Gibbon P, 2008, ECON SOC, V37, P315	15	23
23.	64 Bair J, 2008, ECON SOC, V37, P339	5	10
24.	65 Gibbon P, 2008, ECON SOC, V37, P365	6	11
25.	83 Sturgeon T, 2008, J ECON GEOGR, V8, P297	7	38
26.	84 Nadvi K, 2008, J ECON GEOGR, V8, P323	7	21
27.	91 Pietrobelli C, 2008, CAMB J ECON, V32, P947	3	7
28.	108 Riisgaard L, 2009, WORLD DEV, V37, P326	7	13
29.	146 Bolwig S, 2010, DEV POLICY REV, V28, P173	4	5
30.	147 Riisgaard L, 2010, DEV POLICY REV, V28, P195	4	4



Nodes: 30, Links: 91
LCS, top 30; Min: 4, Max: 92 (LCS scaled)

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			LCS	GCS
1.	7	Henderson J, 2002, REV INT POLIT ECON, V9, P436	92	233
2.	8	Ernst D, 2002, RES POLICY, V31, P1417	15	122
3.	9	Palpacuer F, 2003, GLOBAL NETW, V3, P97	4	30
4.	12	Phelps NA, 2004, ECON GEOGR, V80, P191	5	13
5.	13	Hess M, 2004, PROG HUM GEOG, V28, P165	28	132
6.	14	Leinbach TR, 2004, J ECON GEOGR, V4, P299	4	16
7.	17	Coe NM, 2004, T I BRIT GEOGR, V29, P468	86	177
8.	21	Yeung HWC, 2005, GROWTH CHANGE, V36, P307	10	32
9.	22	Coe NM, 2005, J ECON GEOGR, V5, P449	14	42
10.	25	Coe NM, 2006, ECON GEOGR, V82, P61	6	15
11.	28	Bowen JT, 2006, ECON GEOGR, V82, P147	6	12
12.	29	Johns J, 2006, J ECON GEOGR, V6, P151	10	25
13.	30	Hess M, 2006, ENVIRON PLANN A, V38, P1193	37	52
14.	31	Hess M, 2006, ENVIRON PLANN A, V38, P1205	10	18
15.	32	Liu WD, 2006, ENVIRON PLANN A, V38, P1229	9	16
16.	34	Rodrigue JP, 2006, ENVIRON PLANN A, V38, P1449	4	9
17.	37	Pickles J, 2006, ENVIRON PLANN A, V38, P2305	5	25
18.	51	Yeung HWC, 2007, ASIA PAC VIEWP, V48, P1	10	24
19.	55	Yang YR, 2007, ENVIRON PLANN A, V39, P1346	9	22
20.	58	Wang JH, 2007, ENVIRON PLANN A, V39, P1873	7	12
21.	59	Yang C, 2007, ECON GEOGR, V83, P395	7	20
22.	69	Sunley P, 2008, ECON GEOGR, V84, P1	7	28
23.	73	Weller S, 2008, GROWTH CHANGE, V39, P104	5	11
24.	75	Coe NM, 2008, J ECON GEOGR, V8, P267	8	14
25.	76	Coe NM, 2008, J ECON GEOGR, V8, P271	37	70
26.	77	Hughes A, 2008, J ECON GEOGR, V8, P345	7	13
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28.	80	Hudson R, 2008, J ECON GEOGR, V8, P421	10	13
29.	88	Levy DL, 2008, ACAD MANAGE REV, V33, P943	11	33
30.	100	Yeung HWC, 2009, REG STUD, V43, P325	11	20

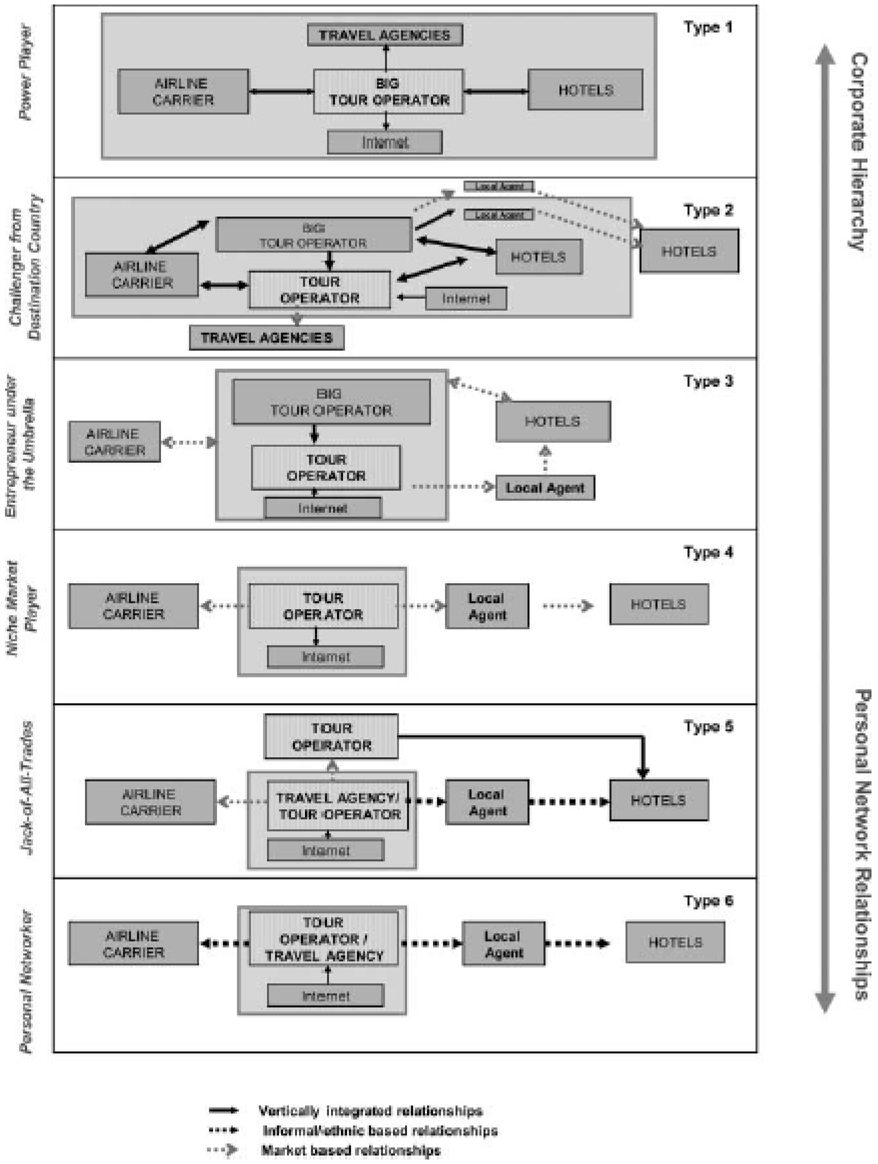

Figure 8: Modes of governance in the tourism value chains from the Netherlands to Turkey (Erkus-Ozturk, Terhorst, 2010, p. 232)

Characterizing business networks for moving from products to solutions

Heiko Gebauer: *heiko.gebauer@eawag.ch*
Associate Professor
Department of Innovation Research in Utility Sectors (Cirus).
Eawag: Swiss Federal Institute of Aquatic Science & Technology, Switzerland
Guest professor at the Service Research Center (CTF) at the Karlstad University in Sweden

Marco Paiola: *marco.paiola@unipd.it*
Department of Economics & Management,
University of Padua, Via del Santo 33, 35100 Padova, Italy

Nicola Saccani: *nicola.saccani@ing.unibs.it*
Supply Chain & Service Management Research Centre,
Department of Mechanical Engineering, Università di Brescia, Via Branze 38, 25123 Brescia, Italy

Abstract
Manufacturers of capital goods may not be able to internally master all the relevant value creation activities for moving from products to solutions; it is rarely economically sensible for them. Consequently, they increasingly resort to complex business networks that are replacing traditional vertically integrated supplier-customer relationships in the provision of solutions. Through multiple case studies, this paper attempts to identify the different types of business networks involved in the provision of solutions as well as the capabilities necessary for forming and utilizing the networks. The paper classifies the network approaches adopted by firms in moving from products to solutions into four types, namely: “vertical after-sales service network”, “horizontal outsourcing service network”, “vertical life-cycle solution network”, and “horizontal solution network”. These network types, analyzed through the perspective of the “focal firm” in the network, foster our understanding of the movement towards integrated solutions of products and services. The formation and utilization of business networks require dynamic and operational capabilities. Dynamic capabilities allow to initiate a business network formation, whilst operational capabilities allow the network firms to develop, integrate, and deliver the product and service components of the solution. Each network type requires a specific set of dynamic and operational capabilities.

Key words: Manufacturers of capital goods, business networks, products and services, solutions, dynamic and operational capabilities

1 Introduction

Manufacturers of capital goods are moving from selling products to providing solutions (Wise & Baumgartner, 1999; Jacob & Ulaga, 2008). They depart from the traditional concept of designing, manufacturing and selling products to providing innovative combinations of *products* and *services*, which leads to high-value unified responses to customers' needs (Davies, Brady & Hobday, 2007). Individual companies, even major multi-nationals, such as Alstom, Ericsson Operating Systems, General Electric, IBM, John Deere, Rolls-Royce, or Siemens, can neither internally master all the relevant value creation activities for providing solutions, nor is it economically sensible. As a consequence, these firms are replacing traditional vertically integrated supplier-customer relationships through business networks for providing solutions.

A typical illustration is Rolls-Royce's "power-by-the-hour" solution, where customers pay a fixed warranty and operational fee for the effective run time of the jet engines (Koudal, 2006). Rolls-Royce's entire solution package encompassing the jet engine, installation, after-sales maintenance, repair, and overhaul services is provided through a complex business network, which consists of specialized components suppliers such as Volvo Aero and maintenance specialists such as Lufthansa Technik. This business network replaced the traditional vertically integrated supplier-customer relationship between Rolls-Royce and its direct customers such as Boeing and Airbus.

Existing literature concentrates on single firms' efforts in moving from products to solutions. For instance, Oliva and Kallenberg's (2003) transition line from products to services is derived from individual companies, moving along the stages of (1) consolidating services, (2) entering the installed base service market, (3) expanding to relationship-based and process-centered services, and (4) taking over end-users' operation. Similarly, Neu and Brown's (2005) illustration of the shift in the offering from services as adds-on to products to products as add-ons to services relies on individual efforts of four IT-companies. Davies' (2004) investigation of manufacturing firms moving to integrated systems, integrated solutions, and further on to operational services concentrates also on single firm efforts.

Recent literature begins to include the business network perspective. Companies follow a business network approach because they rely on other companies to contribute to products and service components forming the solution (Davies *et al.*, 2007). Companies identify, select and manage other network actors across different supply chains, which contribute to the solutions (Johnson & Mena, 2008; Pawar *et al.*, 2009). Yet existing studies have neither analyzed in-depth nor conceptualized the characteristics of business networks in this context. From both an empirical and a theoretical perspective, it remains unclear what types of business networks contribute to the provision of solutions and how companies can form and utilize business networks.

The paper addresses these issues by adopting the standpoint of the focal firm in the network. A multiple case study analysis of companies engaged in business networks was carried out. The empirical observation provides insights regarding the types of business networks as well as the capabilities for forming and utilizing the business networks. This paper extends the practical implications for and theoretical discussion of the move from products to solutions beyond the focus on single firm efforts (Davies *et al.*, 2007; Windahl & Lakemond, 2010; Wise & Baumgartner, 1999).

The remainder of the paper is structured as follows: section 2 discusses the existing literature and the research method is presented in section 3. A discussion and interpretation of the results is presented in section 4. Finally, section 5 describes and highlights the implications of the findings for practitioners and researchers.

2. THEORETICAL BACKGROUND

2.1 Moving from products to solutions

Solutions encapsulate all product and service components, which are necessary to provide unified responses to customers' operational and business needs (Davies *et al.*, 2007; Nordin & Kowalkowski, 2010; Sawhney, 2006; Tuli, Kohli & Bharadwaj, 2007). Components upstream in the value chain include sources of supply such as sub-components of products and services (sub-modules, assembly of sub-modules, logistic services to guarantee assembly and manufacturing activities). Components downstream in the value chain refer to the provision of products and services towards the customers in order to install, maintain, operate, or finance the equipment (Davies, 2004). The extension of service components in the total offering starts with basic services for the installed base such as spare parts, inspections, repair, maintenance, and modernization services. Further service components are operational services, where customers outsource their operational or maintenance services (Gebauer *et al.*, 2010). Moreover, such outsourcing and operational services lead to additional performance-guarantees, as a component of the solution (Windahl & Lakemond, 2010). Performance-guarantees change the revenue models and make financial services necessary: pay-for-performance, for example, requires financial arrangements in order to pay for the actual performance (Hünerberg & Hüttmann, 2003). Further service components encompass consulting services, addressing customer's business needs, as well as design and constructions services, in order to fulfill customer's technical needs (Davies *et al.*, 2007). All these upstream and downstream activities related to product and service components reflect the vertical dimension of the value chain.

Additional product and service components can also be positioned along the horizontal dimension of the value chain. Typical illustrations include the integration of third-party products and services into the solutions. In this case, instead of focusing exclusively on the company's own products, the total offering can include products offered by competitors or that are complementary in nature to their own products. Including such third-party products into the total offering does not necessarily enhance the breadth of services but rather extends services to include those from competitor products and/or supplement products from other vendors (Raddats & Easingwood, 2010).

Finally, the increasing number of service and product components embraced by the solution requires some integration services (Davies, 2004). These include customization activities, which ensure that all the product and service components fit together and can be reconfigured according to the customer needs.

2.2 Business networks and solutions

The literature increasingly devotes attention to the study of business networks. The contributions explore the economic behavior and connectedness of business networks (Basole & Rouse, 2008). The literature conceptualizes business networks through various concepts, such as strategic business nets (Möller *et al.*, 2005), value networks (Möller & Svahn, 2003), value constellations and business systems (Normann & Ramirez, 1993), as well as business in networks (Håkansson & Snehota 2006). Moreover, the research stream dealing with the service-dominant logic and service science discusses the ‘service system’, which constitutes the value co-creation configuration of firms, institutions, and customers (Maglio & Spohrer, 2008). In this research stream, the network is the basic locus of innovation and the principal unit of analysis in business and marketing (Vargo *et al*., 2008).

In the context of this study, we use the term “business networks”. Business networks consist of a loosely coupled collection of upstream suppliers, downstream channels to market, and ancillary service providers (Basole & Rouse, 2008; Ritter *et al.*, 2004). Our study focuses on describing the value creation activities of the network, the capabilities of the actors, the goal of the network and the focal firm, and the structure of the network along its vertical and horizontal dimension (Möller *et al.*, 2005).

In the business network, value is co-created by different actors (suppliers, OEMs, third-party service providers, customers, and so on) (Kothandaraman & Wilson, 2001), and each actor contributes to the overall offering (Vargo & Lusch, 2011). In the context of solution provision, this view of value creation emphasizes the focus on core capabilities (competences) and competence complementarities. Actors’ contribution to solutions focuses on their core competences and on the cooperation with other network actors, such as suppliers, partners, allies, and customers (Basole & Rouse, 2008). Therefore, providing solutions is a complex value creating process, enabled by multiple actors (Ford *et al.*, 1998; Matthyssens *et al.*, 2009).

Whereas single companies normally provide the product, there is a multiplicity of actors in the supply network providing the services. Thus, solutions involving the combination of products and services require the coordination of value creating processes in the manufacturing systems, maintenance systems, spare parts supply systems, logistic systems, and so on (Cohen *et al.*, 2006; Davies *et al.*, 2007). Strong relationships between the different firms, the firm's position in the network, and the firm's network horizon arguably enhance the provision of solutions (Windahl & Lakemond, 2006).

2.3 Capabilities for forming and utilizing business networks

The concept of “capabilities” refers to a company’s capacity to deploy its resources to achieve a desired end (Amit & Schoemaker, 1993). Capabilities can be categorized as operational and dynamic (Winter, 2003). Operational capabilities enable companies to earn a living under the condition of a specific business environment (Winter, 2003). By encapsulating the evolutionary nature of resources (Eisenhardt & Martin, 2000), dynamic capabilities enable companies to respond to changes in the business environment (Teece *et al*., 1997).

Operational capabilities enable companies to provide products, services, or solutions (Fischer *et al.*, 2010). Operational capabilities refer to designing, manufacturing, selling and delivering product and service components and then integrating these components into customer-specific solutions (Windahl & Lakemond, 2010). These operational capabilities may not be concentrated in a single actor of the network as they may embrace various actors. Typical examples of network-related operational capabilities are demand-forecasting, cross-firm R&D management, supply chain and customer relationship management, as well as partnering and collaborating competencies (Möller & Svahn, 2003). All these operational capabilities reside at the network level and ensure that network actors can contribute to the value creation process.

Dynamic capabilities enable firms to address changes in the business environment (Teece, 2007). Dynamic capabilities include: (1) sensing opportunities and threats as well as the resulting need to change, (2) seizing the opportunities sensed and (3) reconfiguring operational capabilities to maintain competitiveness (Teece, 2007). The dynamic capabilities have to embrace various actors in the business networks in order to envision the value contribution of other actors. Focal firms of business networks mobilize other actors and motivate them to develop the necessary capabilities for the intended value contribution. These focal firms also orchestrate the network actors (Möller & Svahn, 2003). The notions of sensing and seizing business opportunities and threats as well as visioning, mobilizing, and orchestrating network actors are closely related to the sense-making in business networks (Möller, 2010). Sense-making refers to anticipating the potential of development paths by identifying and shaping opportunities and by formulating strategic responses. It bridges the perception and interpretation of opportunities and threats by influencing the reconfiguration of capabilities among network actors (Möller, 2010; Henneberg, Naude & Mouzas, 2010).

2.4 Research gap and questions

The literature review suggests that a network of firms, rather than a single actor, drives the movement from products to solutions. However, most research has neglected the network perspective when addressing the provision of solutions. Specific dynamic and operational capabilities are required to form, orchestrate, and utilize the network. The present paper therefore aims to address this gap through multiple case studies, with particular reference to two key questions. (1) What are the possible types of business networks for providing solutions? (2) What kind of dynamic and operational capabilities are required to form and utilize these networks?

3 Research methodology

3.1 Research process

Given the research objective, the research methodology concentrates on exploration and theory building. A methodology based on qualitative research is thus particularly suitable. The empirical research was conducted between 2006 and 2010. The research process follows an “iterative-grounded” theory (Orton, 1997), which suggests that the researcher examines the relevant literature and employs the empirical data obtained to fill in the gaps presented by the literature. It is through this procedure that researchers reveal flaws in the empirical data and literature and elaborate their explanations in order to confirm the explanatory logic for the structure and capabilities of the business networks in the context of solution provision. The research process is divided into an exploratory and a main study (Neu & Brown, 2005).

3.1.2 Exploratory study

An exploratory study was conducted in preparation for the main study. This exploratory study involved 17 companies in Western European countries (France, Germany, Italy, Sweden, Switzerland, and the United Kingdom). The participating companies cover various manufacturing industries and offer variation in company size and value chain position. Table 1 describes the participating firms in terms of industry and type of products.

Single semi-structured interviews were carried out with managers within each of the 17 companies. Managers were asked questions about the products and service components embedded in the solution offering. Follow-up questions were used to explore key issues about the business networks (strategic partners, network structure, focal firm, goal and value proposition of the network). The interview data were supplemented with secondary data, such as annual reports and company documents. Graphical illustrations of the network were developed for each exploratory case, including downstream and upstream activities in the value chain of the focal firm (vertical dimension) as well as auxiliary service and product providers (vertical dimension) (Miles & Huberman, 1994).

The exploratory case studies were analyzed through a pattern-matching logic in which key issues of the business networks are aggregated to similar network types. The pattern-matching logic compares different business networks through the product and service components they offer, the downstream and upstream activities in the value chain of the focal firm as well as auxiliary service and product providers. Network types that emerge empirically are compared with those drawn from theory (Yin, 1989).

3.1.2 The main study

The exploratory study was followed by the main study. The main study deepens our understanding of the network types. In-depth case-studies concentrate on the focal (hub) firm in each business network, collecting richer and more comprehensive information on the focal firm. It means that we deliberately use the perspective of the focal firm in order to understand how this firm visualized, mobilized, and orchestrates other network actors. In fact, the main study aimed at understanding, which dynamic capabilities contribute to the network formation and which operational capabilities ensure the utilization of the network.

Because four types of business networks emerged from the exploratory study, we decided to carry out four in-depth case studies. We selected these four cases based on their considerable experience in the business network formation and utilization. General information on focal firms was collected from various documental sources (e.g. company literature, websites, press, etc.). Additionally, multiple semi-structured interviews were conducted with key executives in marketing, sales and after-sales departments. Altogether, 27 executives were interviewed (i.e. between 4 and 9 in each case study). The first part of each interview concentrated on the historical development of the focal firm and the business network, since it is important to understand the origins and not just where they are at present or aim to be in the future. The development of the focal firm in the business network was specified according to dynamic and operational capabilities. In the interviews, the authors searched for capabilities necessary to form and utilize the business network. Follow-up questions similar to the "narrative" approach (Yin, 1989) were used to explore key issues in the dynamic and operational capabilities. At the end of the interviews, the participants were asked for additional comments.

Interview transcripts, in combination with secondary data such as internal documents on partner relationships, were used to develop chronological case histories on business network formation. We began by drawing up a list of capabilities, in chronological order, pertaining to the development of business networks, which we then used as the basis for structuring the case histories. Tables were developed for each case, listing dynamic and operational capabilities, and tracking their impact on the business network formation and utilization (Miles & Huberman, 1994).

3.2 Ensuring trustworthiness of the research process

Because identifying network types and capabilities for forming and utilizing business networks is far from easy (Henneberg *et al.*, 2010; Möller *et al.*, 2005), we ensure reliability and validity through following procedures: 1) triangulation of the data (interviews, annual reports and company documentation) and methods (exploratory and in-depth case studies) to ensure internal validation; 2) differences in attributes such as size of the company, value in the chain position and type of capital goods to enhance external validity; 3) letting participants review their research reports and documents to ensure internal validity and reliability. The reviews often led participants to provide more detailed information and finally, 4) the reliability and validity of the data analysis was assured by the use of manual and computer-aided content analyses of the data collected (Yin, 1989).

4 Results – Types of business networks for moving from products to solutions

The presentation of our research findings is organized on the base of the type of business networks emerging from the empirical findings. The findings yield four types of business networks, which can be named: (A) vertical after-sales service network, (B) horizontal outsourcing service network, (C) vertical life-cycle solution network, and (D) horizontal solution network. The notions *vertical* and *horizontal* describe the network structure (Möller *et al.*, 2005). Even though we classify the business networks as horizontal and vertical, very seldom are they purely horizontal or vertical. For example, horizontal networks can also contain vertically positioned suppliers; vertical networks can include value activities of competitors or auxiliary actors. We use the vertical - horizontal terminology to indicate the dominant orientation in the network. The concepts such as after-sales service, outsourcing service, life-cycle solutions and solutions capture the dominant type of solutions offered by the network. All four types of business networks represent not organically evolved networks, They rather provide empirical evidences for intentionally developed business networks (Möller *et al.*, 2005).

In the next four sections, we discuss each network type. The discussion covers the characteristics of the business network (derived from the exploratory study) and the dynamic and operational capabilities for forming and utilizing the business network (derived from the main study). Space consideration permits to illustrate the capabilities for each business networks in all details. We rather focus on the main issues.

4.1 Type A - Vertical after-sales service network

4.1.1 Network characteristics

Figure 1 illustrates the *vertical after-sales service network*. The term *vertical* suggests that the actors cover upstream and downstream activities in one specific value chain. The term after-sales service means that value activities concentrate on the product usage. Typical illustrations could be the value chain of packaging machines or mold making machines where companies such as Bosch Packaging or GF AgieCharmilles offer highly sophisticated products and services supporting the product usage.

The network includes the original equipment manufacturing company (OEM), logistic service providers, and upstream suppliers of spare parts. The OEM emerges as the focal firm of the network. The vertical after-sales service network consists of one layer, which covers clearly all specified value activities. This network is a relatively stable business system. The actors producing and delivering after-sales services are usually known and carry out pre-defined value activities. The value proposition of the whole network concentrates on the after-sales phase and/or usage of the product. The value activities performed by each actor enhance the usage of the product. OEMs offer services including spare parts delivery, repair, inspection, and maintenance services. By storing and transporting spare parts, logistic service providers support the OEMs and suppliers in the spare parts delivery processes. In case of small and medium-sized OEMs, the value network may also include distributors and external service partners. Small and medium-sized companies do not reach the critical mass to establish sale subsidiaries in various markets. Instead, they favor external service partners as distributors specializing on selling, installing and maintaining the products.

See Figure 1

4.1.2. Capabilities

Managing a service organization, and in particular enhancing technical competences and service-oriented mind-sets, are illustrations of operational capabilities through which OEMs utilize the vertical after-sales service network. The dynamic capabilities of sensing, seizing, and reconfiguring allow OEMs to deliberately form a vertical after-sales service network. Sensing opportunities are related to the exploitation of the financial potential of product usage, and seizing the exploitation of financial potential in specific service strategies and offerings. Financial potential refers to the attractive margins offered by services as well as to services that are an additional revenue stream (Cohen *et al.*, 2006). In order to exploit these financial potentials, the OEM develops service strategies around basic services such as spare parts delivery, repair, or maintenance services. The benefits of these strategies do not come for free. Instead, they require the development of complementarities with the competences of other actors, such as logistic providers, spare part suppliers, and the reconfiguration of the internal capabilities. The reconfiguration of internal capabilities is necessary in order to manage a service organization in combination with a manufacturing organization (Oliva & Kallenberg, 2003). Within the service organization, OEMs develop service delivery capabilities through enhancing technical competencies and establishing service-oriented mind-sets.

Competence complementarities with other actors such as logistic providers and spare part suppliers lead to further operational and dynamic capabilities. Operational capabilities include demand-and-supply forecasting for service interventions between customers and the OEM as well as planning and coordination of spare parts supply between suppliers, the OEM and logistic providers. Demand-and-supply forecasting for service interventions extends the range of existing customer relationship management activities.

Developing such operational capabilities at the network level requires dynamic capabilities, which aim at visioning, mobilizing, and orchestrating the value creation activities of the suppliers, logistic providers, and customers. In the case of suppliers, this would entail motivating them to rely on the OEM for coordinating and taking responsibility of the spare parts business, instead of selling and distributing the spare parts to customers themselves. Furthermore, the OEM encourages logistic providers to store spare parts close to the customers and to continuously improve their service levels. The OEM motivates customers to create a collaborative learning relationship, where the OEM’s service staff acquires knowledge as they interact with customers’ maintenance departments. Service staff learns about customers’ operational needs and gains intimate knowledge on how to link the service delivery processes (spare parts, repair, inspections, and maintenance) with customer’s operational processes.

4.2 Type B - horizontal outsourcing service network

4.2.1 Network characteristics

Figure 2 illustrates the *horizontal outsourcing service network*. The notion *horizontal* suggests that the actors cover different value chains. An outsourcing specialist represents the focal firm of the horizontal outsourcing service network. These firms focus on outsourcing services for various types of original equipments. Outsourcing specialists break into the dyadic relationship between OEMs and customers. They specialize on taking-over the responsibility of customer's operational and maintenance services. Typical illustrations could be the value chains of automation, infrastructure or paper processing equipment, in which specialized service providers such as Bilfinger Berger, Voith Industrial Services AG, or Wisag industrial services take over the responsibilities for all services supporting the product usage. As illustrated in Figure 2, these outsourcing specialists are directly engaged in upstream activities in relation with OEMs – the component suppliers. The value proposition of the whole networks aims at operating the customer's maintenance and operational processes in a more cost-efficient way than the customers themselves (Gebauer *et al.*, 2010).

Contrary to type A, the horizontal outsourcing service network consists of two layers. In the first layer, the outsourcing specialist mobilizes various actors to form a stable platform of value activities and competencies. In the second layer, the outsourcing specialist selects the necessary actors from the platform to address the customer's needs. The outsourcing specialist provides the outsourcing services and orchestrates the value activities of the selected actors. Whereas the first layer is a relatively stable system, which serves as a prerequisite for providing services, the second layer can be reconfigured dynamically according to the outsourcing needs of customers.

In this type of network, customers favor a reciprocal dependency with an outsourcing specialist when the outsourced operational and maintenance processes are not core processes (Windahl & Lakemond, 2010). OEMs are restricted to only offering basic services such as spare parts deliveries, warranty services and knowledge-intensive services such as solving complex product failures. All other activities such as inspection, repair, maintenance. modernization, and process optimization are outsourced to the outsourcing specialist. Accordingly, outsourcing specialists increase the operational efficiency of the installed base.

Similarly to type A, logistic providers support the outsourcing specialist in storing and handling spare parts. OEMs and suppliers positioned upstream in the value chain ensure the spare parts deliveries and take part in the return and repair activities. Outsourcing specialists also mobilize IT-service providers to offer platforms for remote monitoring services. Such remote services enable the outsourcing specialist to monitor the usage and the actual conditions of the installed products.

See Figure 2

4.2.2 Capabilities

The formation of the *horizontal outsourcing service network* is an alternative to the *vertical after-sales service network*. The focal firms in both networks (OEMs and outsourcing specialists) compete for accessing and exploiting service opportunities throughout the product usage. However, in type B, sensing opportunities is focused on exploiting the customer's needs to outsource their operational processes, instead of exploiting the financial potential of services.

Seizing the sensed outsourcing needs is not limited to one specific type of equipment, but captures the whole breadth of operational and maintenance processes, which are not core processes for the customers. For that reason, seizing outsourcing opportunities should acknowledge the client and other OEMs as potential competitors (Mathieu, 2001). According to the proposed value proposition, seizing specifically considers higher cost-efficiencies than costs achieved by customers or OEMs. Outsourcing specialists logically benefit from larger economies of scale (Auguste et al., 2006), because they offer outsourcing services covering both different equipment brands and the product range within a brand, whereas the OEMs maintain only their own product brands. Thus, outsourcing specialists may gain a significant learning advantage by specializing on one specific service (e.g. outsourcing services of complex technical equipment). Moreover, by relying only on one outsourcing partner for a range of equipments, the customer's coordinating costs are significantly lower than by relying on different OEMs specializing on their own equipments.

Reconfiguring existing operational capabilities precedes the process of seizing the previously sensed outsourcing needs. The reconfiguration process depends on the specific origin of the outsourcing specialists. Outsourcing specialists can either originate from OEMs that broaden their service offerings beyond their own product category (Raddats & Easingwood, 2010) or from customers setting-up their maintenance departments as a strategic business unit. Voith Industrial Services represents the case of an OEM broadening its service offerings beyond its original product categories, i.e., machines for the paper-making process (provided by Voith Paper) or turbines and generators for power stations (Voith Hydro). As an outsourcing specialist, Voith Industrial Services seized cost advantage by achieving higher economies of scale (e.g., Voith acquired ten technical service specialists between 2000 and 2009).

An illustration of an outsourcing specialist that transitioned from having solely internal maintenance competences to providing services to external customers is Lufthansa Technik. Lufthansa Technik has moved from being an internal maintenance provider for the flight operator Lufthansa to being one of the leading independent providers of maintenance, repair, overhaul, and modification services in the civil aviation industry. Lufthansa Technik gains competitive advantage by developing a collaborative learning relationship with flight operators, airplane, and air engine manufacturers, since it has an intimate knowledge of operational and business needs of each of these network actors.

To utilize the business network, outsourcing specialists build operational competences such as technical skills for the service provision, behavioral skills for performing frontline roles necessary to be a performance enabler, and customer-focused attitudes to understanding the customer's outsourcing needs. All these skills are part of managing a pure service organization offering outsourcing services.

As mentioned above, offering outsourcing services for multiple equipment categories entails competition among OEMs moving into services. Therefore, convincing other OEMs (demobilizing of OEMs) to concentrate on basic services for the installed base and knowledge-intensive services represent central issues among the dynamic capabilities. Through intensive partnering, outsourcing specialists convince OEMs to focus only on the provision of spare parts, warranty services and knowledge-intensive services to solve very complex product failures. Logistic services ensure spare part deliveries to the customer. Furthermore, outsourcing specialists motivate IT-service providers to monitor the usage conditions of the equipment. Through such information, outsourcing specialists can optimize the capacity utilization of their service staff. Furthermore, outsourcing specialists offer performance guarantees such as pay-for-performance achieved in the outsourcing process. In order to make such payments for the actual performance, outsourcing specialists collaborate with bank and insurance companies.

4.3 Type C - Vertical life-cycle solution network

4.3.1 Network characteristics

Figure 3 depicts the business network for vertical life-cycle solutions. Again, the *vertical* concept suggests that activities concentrate on one specific value chain. In contrast to type A, type C is not restricted to the phase of product usage as network activities cover the whole equipment lifecycle - starting from the development, design, and construction phases and ending with the product usage. As in type A, the OEM is the focal firm of the network. A typical illustration of this type would be Alfa Laval, which designs, manufactures, and maintains water-recycling systems. OEMs such as Alfa Laval offer services supporting the whole lifecycle of water-recycling systems as well as the integration of products and services into customer-specific solutions.

Interestingly, this network was observed to differ in their layer structure across the product life-cycle. In the design phase, the network consists of two layers. Similar to type B, in the first layer, the OEM mobilizes engineering specialists to form a stable platform of value activities and competencies. In the second layer, the OEM selects the necessary engineering specialists from the platform to address the customer's individual design and constructing needs. In the after-sales phase, the network is similar to type A. It consists only of one layer covering all specified value activities.

Similarly to type A and B, logistic providers support the spare parts delivery processes and IT-service providers offer remote services to monitor the condition and usage of the installed base. Further auxiliary service providers include engineering specialists that can offer firsthand technical knowledge.

See Figure 3

4.3.2 Capabilities

The formation of the vertical life-cycle solution network is triggered by dynamic capabilities such as *sensing* the opportunities of exploiting customer's technical and business needs along the whole product lifecycle and *seizing* the exploitation of the whole product lifecycle in terms of service strategy and offering. Seizing refers to achieving a value proposition for an outstanding performance along the whole product lifecycle. This value proposition ranges from designing customer processes around the equipments to the service support for using the equipment. Similarly to the case of vertical after-sales service network, *reconfiguration* of capabilities aims at supplementing manufacturing with service capabilities. Such sensing, seizing, and reconfiguring are managed by OEMs. OEMs apply these dynamic capabilities by visioning and mobilizing engineering specialists to form a stable platform. They also orchestrate these engineering specialists in taking an active role in creating lifecycle solutions and in participating in solving customer's process design and construction needs. Thus, OEMs start to orchestrate engineering specialists and suppliers in the provision of lifecycle solutions.

The operational capabilities necessary to utilize the vertical lifecycle solution network are similar to the vertical after-sales service networks. They also include technical competences for the service provision. Additionally, OEMs set-up behavioral competences for performing frontline roles, like acting as trusted advisers for lifecycle solutions and developing customer-focused attitudes for understanding the customer's operational needs, business needs, and technical design requirements along the product lifecycle. Similar to type A, these capabilities are part of managing a service organization for all services along the product lifecycle.

4.4 Type D - Horizontal solution network

4.4.1 Network characteristics

Figure 4 depicts the last business network type (D), named *horizontal solution network*. Similar to type B, the *horizontal* concept suggests that activities concentrate on multiple value chains. In contrast to type A and B and similarly to C, the horizontal solutions in this type already start in the development phase. Similar to type A and C, OEMs represent the focal firms of the network. A typical illustration would be Alstom transportation. Alstom transportation covers the design, manufacturing, and maintenance of transportation equipment, specifically trains. In addition, Alstom's solutions capture services for competitors' rolling stock (locomotives, railroad cars, coaches and wagons) and signaling track infrastructure.

The horizontal solution network includes a broad set of auxiliary service and product providers, which contribute to the solution with specific knowledge. Together with suppliers in the various value chains, auxiliary service and product providers as well as the actual OEMs form a new value system. The network structure here is not purely horizontal as it also consists of considerable vertical elements. Vertical elements can, for example, include strategic partnerships and alliances with experts with local market knowledge. Alstom, for example, formed a strategic partnership with Transmashholding (TMH), the main rail rolling stock manufacturer in Russia. TMH holds superior technological expertise regarding the specific needs of Russian railways. Both companies are engaged in developing a new generation of rolling stock (electric locomotives and double-decker passenger cars, especially for the medium distances) specifically tailored to the Russian market's needs.

Interestingly, the horizontal solution network consists of two layers. In the first layer, the focal firm mobilizes various actors to form a stable platform of competencies contributing to a solution. In the second layer, the focal firm selects and orchestrates the necessary actors from the platform to comprehensively address the customer's business and operational needs. Whereas the first layer is a relatively stable system, which serves as a prerequisite for providing solutions, the second layer can be reconfigured dynamically according to the customer needs.

See Figure 4

4.4.2 Capabilities

Sensing and exploring new value creation opportunities across the whole value network triggers the formation of the horizontal solution network. Once companies have sensed these opportunities, they start to seize them in value creating strategies and to reconfigure their capability base towards multi-dimensional value networks. The reconfiguration is accomplished by visioning and mobilizing actors’ contributions to the value creation strategies (e.g., auxiliary service providers, suppliers, engineering specialists, and customers). Once the network actors are mobilized, the focal firm orchestrates their value contribution. To do so, focal firms should possess the relational capabilities necessary to form solid strategic partnerships with external actors.

Operational capabilities cover technical competencies, behavioral competencies, as well as customer-focused attitudes such as in type B and C. Moreover, the focal firm develops attitudes and skills for performing frontline roles necessary to act as a trusted adviser for providing high-value customer solutions.

5 Conclusion

5.1 Theoretical implications

This paper addresses the classification of business networks in the specific field of firms moving from products to solutions. The contribution of our findings to the literature on the topic is twofold.

Firstly, by addressing the provision of solutions at the business network level, instead of focusing on single firm efforts like previous research our findings make a valuable contribution to the literature. By combining the network structure (that is the presence of vertical and/or horizontal relations among actors), and the type of products and services components integrated in customer-specific solutions, we classify four basic types of business networks. The business networks are labeled: “vertical after-sales service network”, “horizontal outsourcing service network”, “vertical life-cycle solution network”, and “horizontal solution network”. Existing research pays little attention to intentionally developed business networks (Möller et al., 2005; Ritter, Wilkinson & Johnston, 2004). In addition, the empirical evidence of business networks in the context of moving from products to solutions overcomes the existing focus on *“… organically evolved networks, basically examining their structure and, to a lesser extent, their development processes”* (Möller et al., 2005, p. 1274). However, all four types of business networks evolve deliberately and provide empirical evidences for intentionally developed business networks.

We contend that this classification captures the complexity and variety of emerging business networks when it comes to the movement from products to solutions in a more comprehensive way than previous contributions. The characteristics of operational and dynamic capabilities necessary to form and utilize each type of network are summarized in Table 2.

See Table 2

Secondly, our findings about the types of network and capabilities contribute to the discussion of the transition from products to solutions. The four business network types seem to achieve different degrees of maturity in the movement towards solutions. The vertical after-sales service network and horizontal outsourcing service network are less advanced than the vertical lifecycle solution and the horizontal solution network. The former in fact, are close to the traditional supply chain perspective on after-sales and outsourcing services (Cohen et al., 2006; Johnson & Mena, 2008). Vertical lifecycle solution and horizontal solution networks cover all the complexities of the solution offering. This, in turn, means that the network would need new and different partners and new ways of working together (Ford et al., 1998). Moving from products to solutions would start with a vertical after-sales service network or horizontal outsourcing service network. Both networks are in strong competition for the financial opportunities of the product usage phase. Whether the vertical after-sales service network or the horizontal outsourcing service network succeed depends on the presence of dynamic capabilities for forming both business networks as well as operational capabilities for utilizing them.

Once companies have succeeded in forming and utilizing a vertical after-sales service network, they can continue to move towards solutions by deliberately forming a vertical life-cycle solution network. The formation of the vertical lifecycle solution network requires an extension of the initial dynamic capabilities, whereas the move benefits significantly from the strong similarities in operational capabilities. Similarly, once outsourcing specialists succeed in forming and utilizing a horizontal after-sales service network, a further evolution of their dynamic capabilities would enable them to move towards horizontal solution networks.

However, our findings do not suggest a strict path dependency between companies succeeding with the vertical after-sales service network and the vertical life-cycle solution or between outsourcing specialists succeeding with a horizontal outsourcing service network and a horizontal solution network. Interestingly, after having adopted vertical life-cycle solutions, companies can still continue towards becoming a horizontal solution network, whereas outsourcing specialists succeeding with a horizontal outsourcing service network do not move towards a vertical life-cycle solution network.

As suggested above, our findings contribute to business network theory. Dynamic capabilities determine the formation of a specific business network and enable companies to move from one business network to another. The identified role of dynamic capabilities (sensing, seizing, and reconfiguring) substantiates recent research on sense-making in business networks (Möller, 2010). Sensing business opportunities and threats and visioning value contribution of network actors to the exploitation of business opportunities and threats are related to Möller’s (2010) notion on exploring future businesses. Seizing the sensed opportunities and mobilizing other network actors relate to focusing and selecting future business opportunities. Seizing is also closely related to constructing and communicating a business network agenda (Möller, 2010). Future research can, therefore, benefit from integrating dynamic capabilities into existing sense-making frameworks for network actors.

5.2 Managerial implications

According to our findings, managers seeking to move from products to solutions can adopt different business network approaches. The four types presented in this paper offer viable alternatives for managers attempting to navigate this movement. In addition, managers should understand that all four approaches have the potential to replace traditional vertically integrated supplier-customer relationships.

The study suggests that a vertical after-sales service network is rather common in the early stages of the move from products to solutions. Managers trying to form and utilize such a network should be aware of the competition with the horizontal outsourcing service networks. Managers should also understand the interdependencies between the adopted approach and the necessary capabilities. In this regard, managers can easily form business networks if they are able to build dynamic capabilities. Managers should understand that dynamic capabilities such as sensing and seizing business opportunities and threats in combination with network visioning and mobilizing skills are the key to new value creation in business networks. When they decide to utilize the business network, managers should also concentrate on optimizing operational capabilities.

Further managerial implications can be drawn by analyzing the evolution of the four business networks types: starting with vertical after-sales service network, firms move towards vertical life-cycle solution network, and then to horizontal solutions. Similarly, managers utilizing a horizontal outsourcing service network have the potential to move towards a horizontal solutions network.

5.3 Limitations

Despite its substantial managerial and theoretical implications, this study has its limitations. General inferences on our four business network types cannot be made. We chose case studies due to their appropriateness, rather than their representativeness (Miles and Huberman, 1994), in order to empirically derive potential types of business networks for the movement from products to solutions. The idea was to explore types of business networks and to develop an understanding of capabilities for business network formation and utilization rather than testing them. Thus, the extent to which our results can be generalized remains unclear.

An additional limitation of our study is that it focuses on the focal firms (selected via our exploratory and main study) and their perspective of business network formation. It is possible that a wider study, based on different types of actors (for instance focusing deliberately on suppliers or auxiliary service providers) in the business network could generate further insights into the interdependencies that exist between the type of business networks and capability development. It would be valuable for future research to focus on additional empirical investigations, covering larger samples and a more diverse set of companies. Such studies could contribute further to the building and testing of theories pertaining to networks supporting the move from products to solutions.

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Research process	Industry and products	Characteristics of the companies participating in the exploratory and main studies
Exploratory research	1. Compressors 2. Civil and military aircraft engines 3. Die casting machines 4. Food processing equipment 5. Graining machines and equipment 6. Milling machines and components 7. Mold-making equipment 8. Packaging machines 9. Power generation equipment 10. Production systems for the semiconductor industry 11. Manufacturer of printing equipment 12. Transportation equipment 13. Telecommunication equipment 14. Waste-water treatment equipment 15. Weaving machines 16. Maintenance specialists 17. Outsourcing specialists	• *Countries:* France, Germany, Italy, Switzerland, and United Kingdom • *Company size*: Between 800 and 88’000 employees • *Complexity of the capital goods:* Medium to high • *Position in the value chain:* Companies are positioned as Original Equipment Manufacturers (OEMs), suppliers, industrial service specialists • *Unit of analysis:* Strategic business units and companies with multiple business units, and companies function as a single business unit
	Description of the business network	Companies embedded in the business network
Main study	(1) Business network manufacturing for mold-making machines and providing after-sales service ensuring the functionality of mold-making machines	• Focal firm (OEM) and its associated customers, logistic providers, and suppliers
	(2) Business network offer solutions for waste-water treatment systems	• Focal firm (OEM) and its associated customers, logistic providers, engineering specialists, and suppliers
	(3) Business network for providing solutions on transportation equipment	• Focal firm (OEM) and it associated customers, logistic providers, engineering specialists, and suppliers
	(4) Business network for providing outsourcing services	• Focal firm (outsourcing specialists) and its associated customers, logistic providers, OEMs, and suppliers

Table 1: Characteristics of the case-study companies.

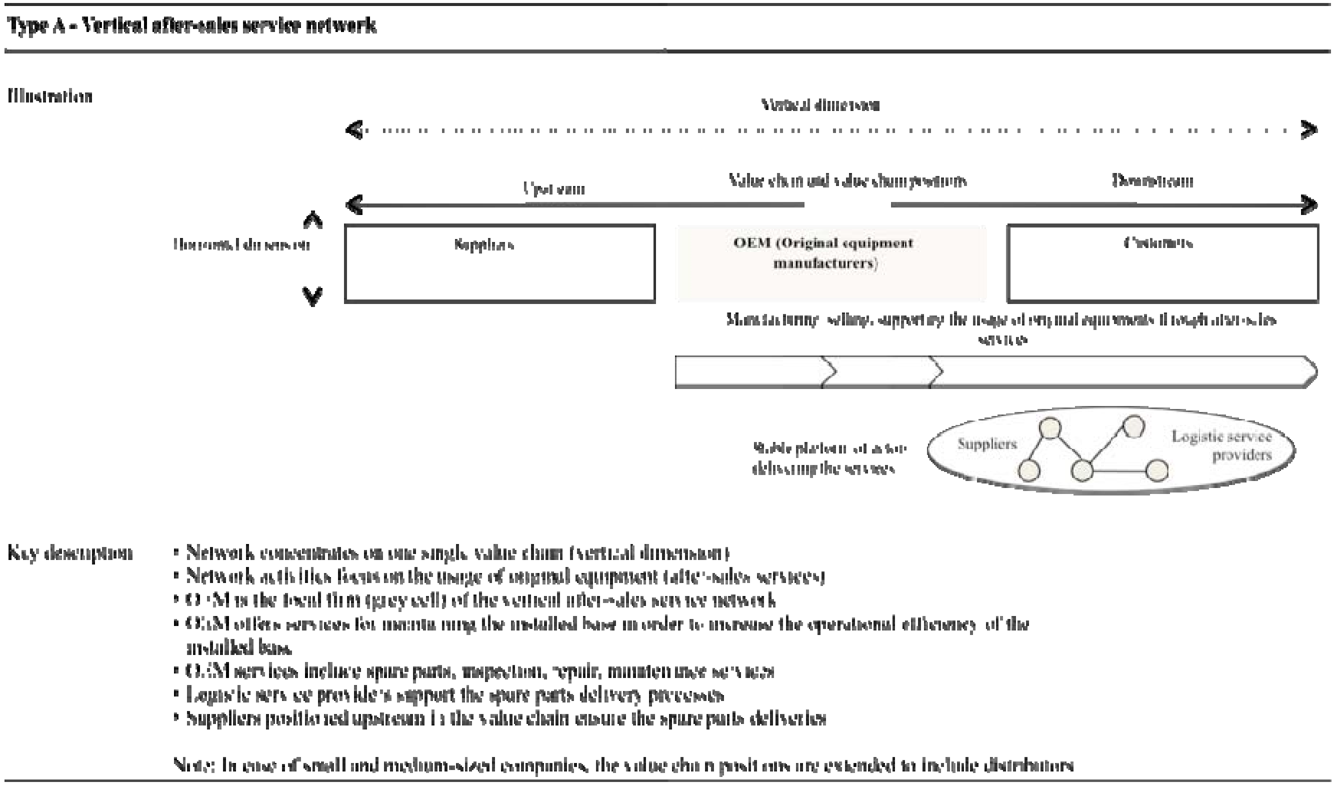


Figure 1: Type A – Vertical after-sales service network.

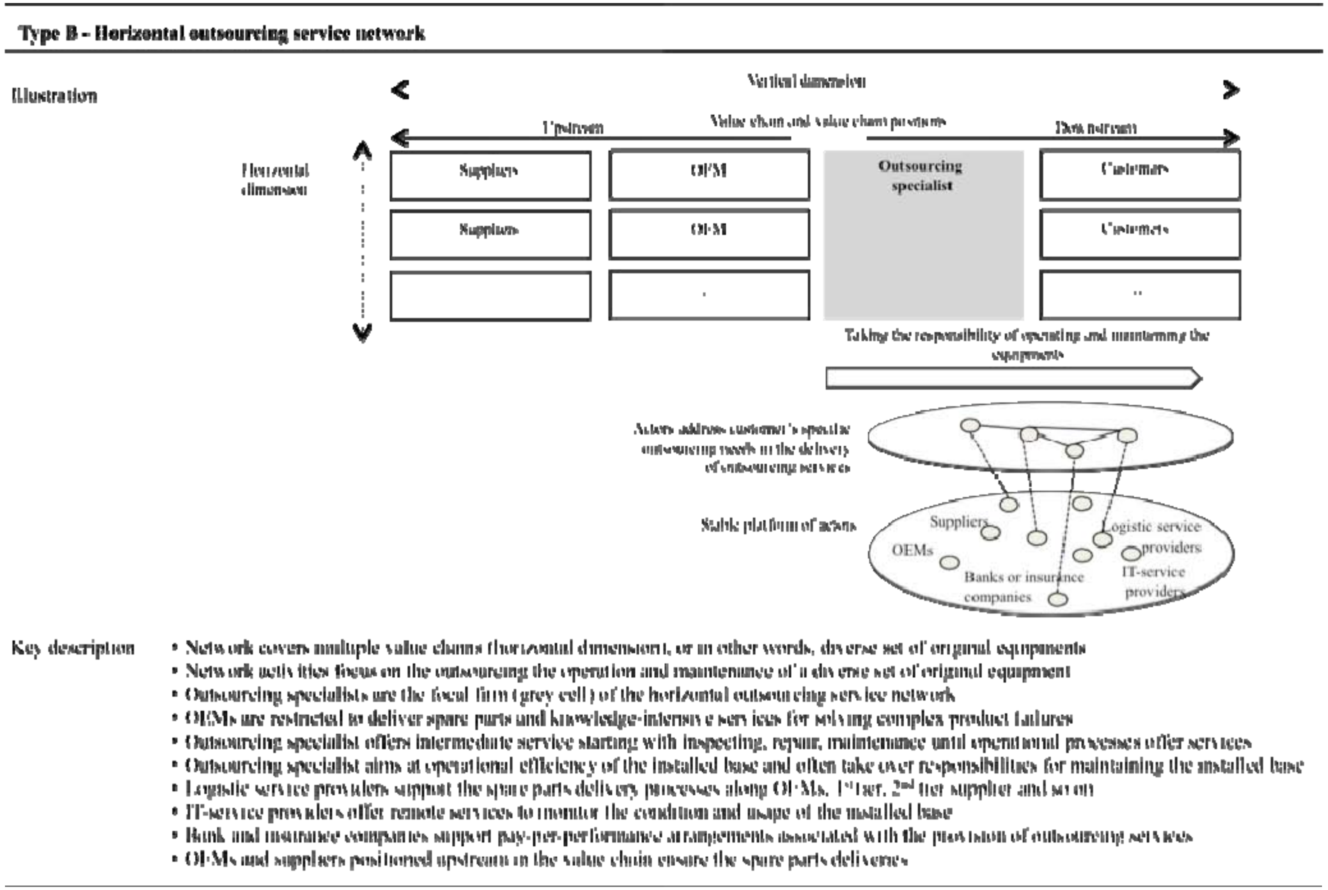


Figure 2: Type B – Horizontal outsourcing service network.

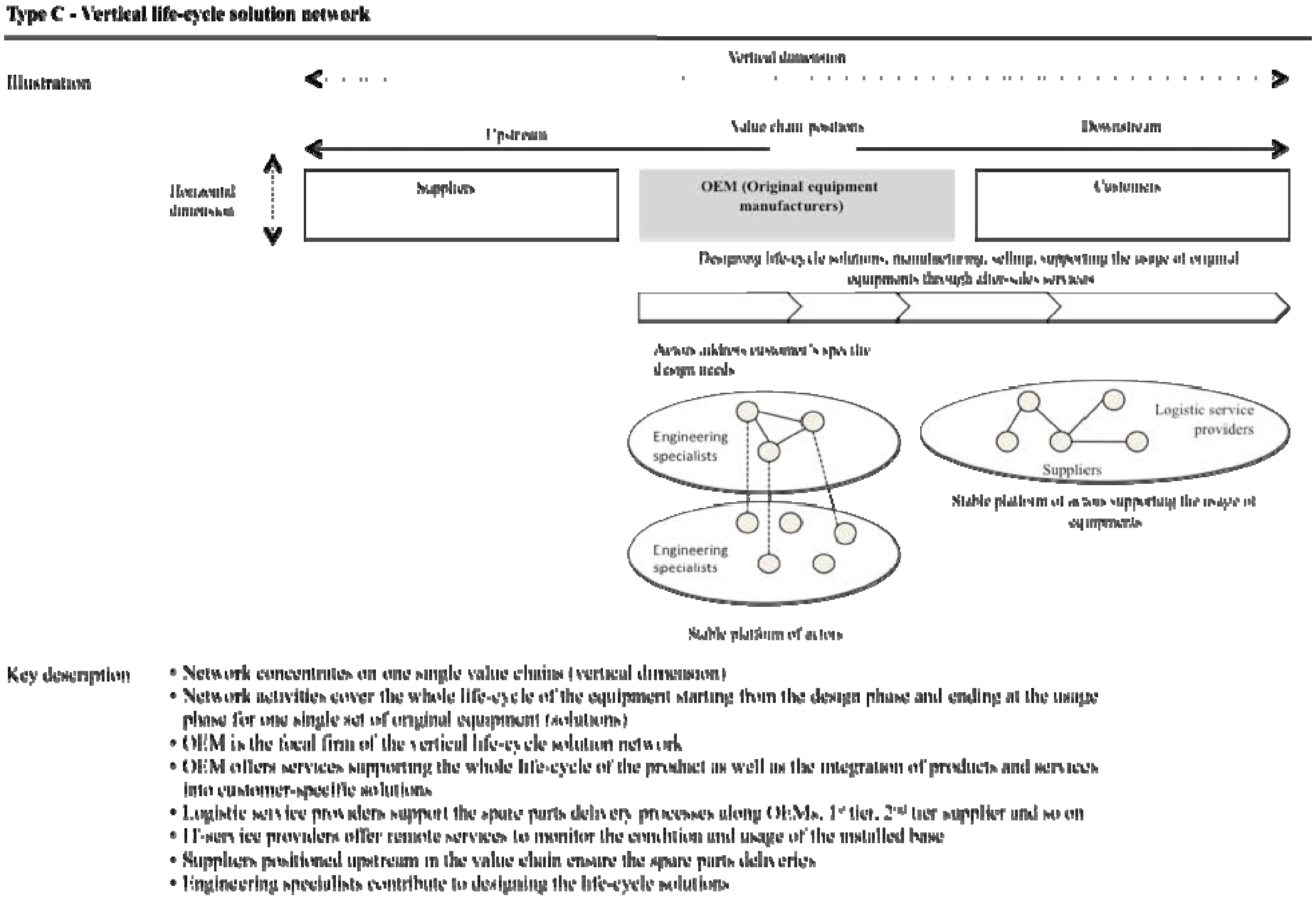


Figure 3: Type C – Vertical life-cycle solution network.

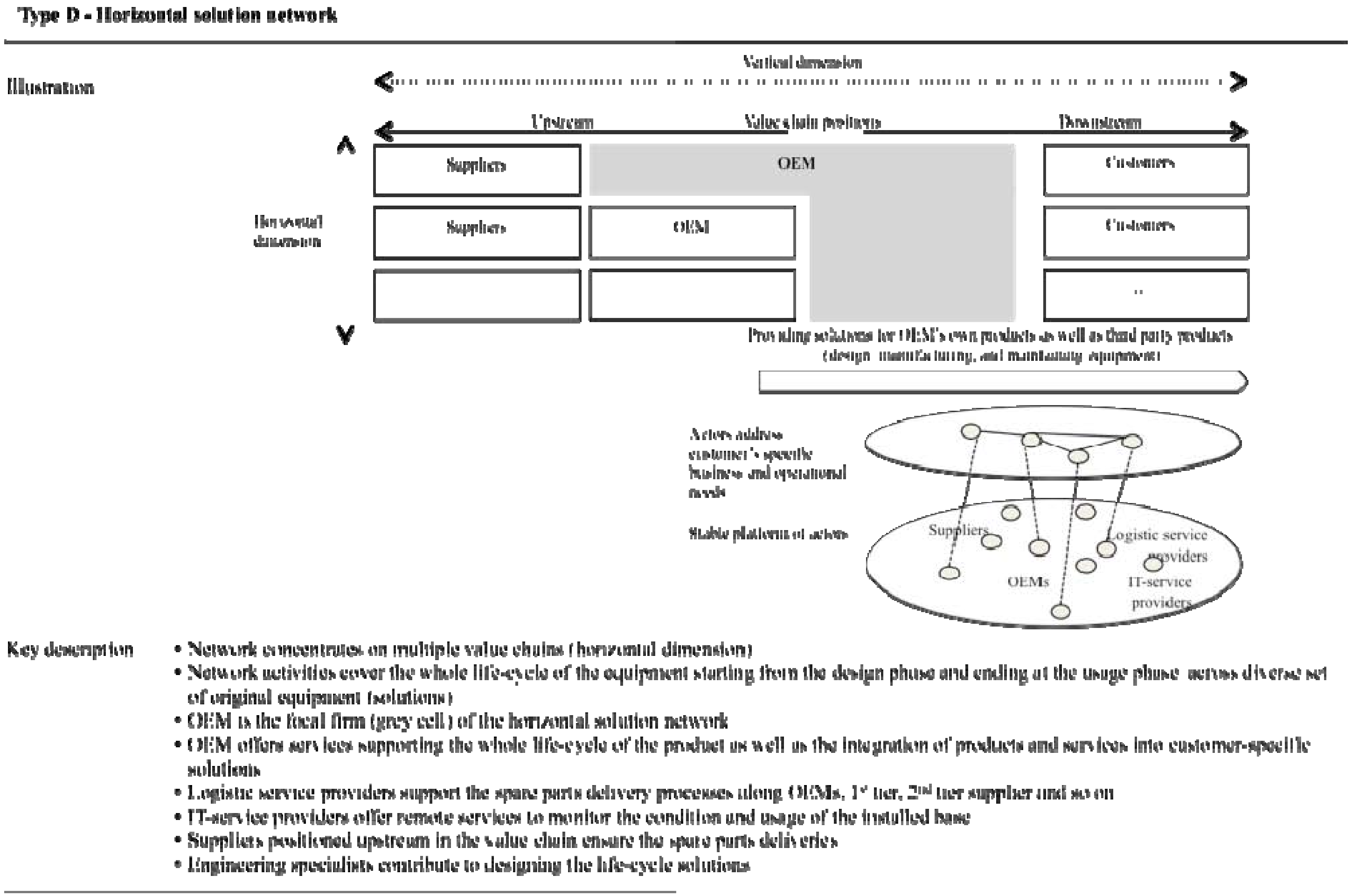


Figure 4: Type D – Horizontal solution network.

	Type A: Vertical after-sales service network	Type B: Horizontal outsourcing network	Type C: Vertical life-cycle solutions network	Type D: Horizontal solution network
Dynamic capabilities	- Sensing opportunities on exploiting the financial potential in the after-market - Seizing the exploitation of financial potential in specific service strategies and offering for the after-market - Reconfiguration of capabilities aims at the supplementation of manufacturing with service capabilities - Orchestrating logistic providers and suppliers in the spare part deliveries	- Sensing opportunities on exploiting customer's needs to outsource their operational processes - Seizing the outsourcing needs into strategies to leverage service competencies on intermediate services across different value chains and types of equipment - Continuously advancing the service competencies - (De)mobilizing OEMs to concentrate on basic services for the installed base and knowledge-intensive services - Orchestrating logistic providers and suppliers in the spare part deliveries	- Sensing opportunities on exploiting customer's technical and business needs around whole product life-cycle - Seizing exploitation of the whole product life-cycle in service strategy and offering - Reconfiguration of capabilities aims at the supplementation of manufacturing with service capabilities - Visioning customers to take an active role in creating life-cycle solutions - Visioning and mobilizing engineering specialists and research institutes in participating in life-cycle solutions - Orchestrating customers, auxiliary service providers, and suppliers in the provision of life-cycle solutions	- Sensing and exploring new value creation opportunities across the whole value network - Seizing these opportunities in value creation strategies - Reconfiguring the capability base from managing multiple value chains into multi-dimensional value networks - Visioning and mobilizing actors to contribute to the value creation strategies (e.g. auxiliary service providers, suppliers, engineering specialists, and customers) - Orchestrating the mobilized value network actors
Operational capabilities	- Running and managing a service organization in combination with a manufacturing organization - Technical competencies as the major sources of service delivery capability - Demand-and-supply forecasting of service interventions - Planning and coordination of spare parts supply and - Service and spare parts provision management - Customer relationship management	- Technical competencies for the service provision - Behavioral competencies for performing frontline role on being a performance enabler - Customer-focused attitudes to understanding the customer's operational needs - Running and managing a pure service organization - Demand-and-supply forecasting of service interventions - Monitoring condition and usage of equipment to optimize the capacity utilization of the service organization - Deep partnering the OEMs and suppliers - Partnership with auxiliary service providers (logistic and IT-specialists) - Customer relationship management	- Technical competencies for the service provision - Behavioral competencies for performing frontline roles on being a trusted adviser for life-cycle solutions - Customer-focused attitudes to understanding the customer's operational and business needs along the product life-cycle - Running and managing a service organization in combination with a manufacturing organization - Demand-and-supply forecasting of service interventions - Monitoring condition and usage of equipment to optimize the capacity utilization of the service organization	- Technical competencies for the service provision - Behavioral competencies for performing frontline roles on being a trusted adviser and a leader of a collaborative solution performance for high-value customer solution - Running and managing a solution network based on core competencies and competencies complementarities - Demand-and-supply forecasting for solution provision - Monitoring condition and usage of equipment to optimize the capacity utilization of the service organization - Cross-firm information management systems - Intensive strategic partnering capability

Table 2: Comparison of dynamic and operational capabilities for forming and utilizing the business networks.

Entry Strategy for Global players in India- People Resource and Talent pool

(Global industrial systems, changing landscapes and trajectories)

Shailendra Singh, General Manager, Materials Management,
Maruti Suzuki India Limited, India
Gurgaon, India – 122015
+91-9891358202 ; shailendra@maruti.co.in

Soarabh Pathak, Asst. General Manager, Material Engineering,
Maruti Suzuki India Limited, India
Gurgaon, India - 122015
+91-9811303421 ; Soarabh.Pathak@maruti.co.in

Abstract

People are the most important asset in any industrial system. The paper studies six states in India which are moving fastest towards industrialization and growth. The paper covers Automobile, Construction and Social sectors in India.

The model is called "Charkha" - the manual equipment used by Mahatma Gandhi to prepare thread for clothes. The "charkha" has the bigger wheel which represents Planning and systems while the smaller wheel represents operations. The thread which connects and drives the two wheels together depicts people while the thread which comes out is the products.

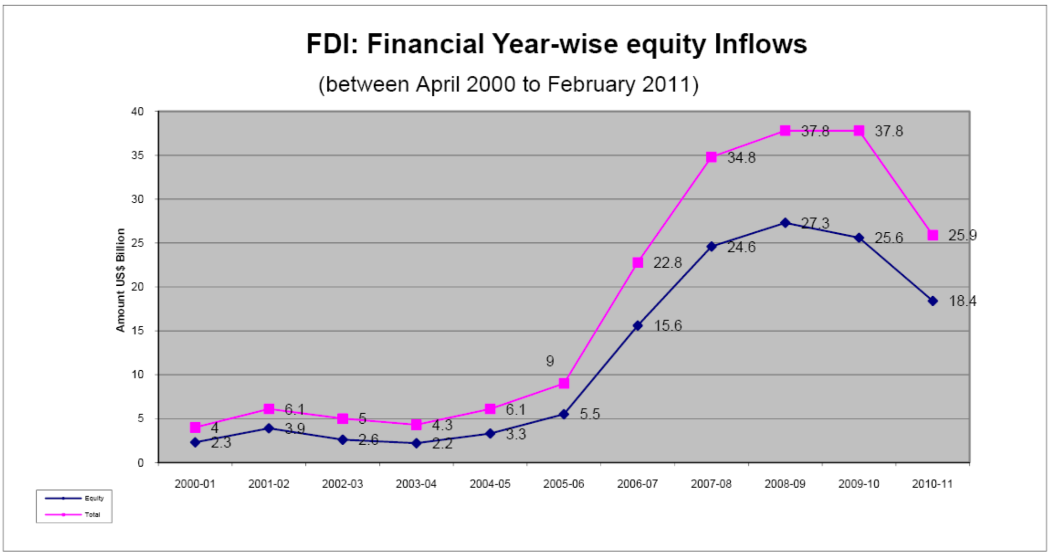
The paper studies entry strategy in line with the requirement of skills required to be employable .The comparison studies competitive advantage using five forces model of Michael Porter and how adaptation to Indian local requirements is possible using learning's from Mahatma Gandhi. It proposes a specific people based strategy over a decade for Automobile, Construction and Social sectors in India.

Key Words

Entry Strategy, India, Porter's Five Forces, Gujarat Attractiveness, Rajasthan, Gandhi, Charkha.

Introduction

India is one of the fastest growing markets in the World. With a population of 1.2 bnfavorabledemographics and socio-economic distribution, one cannot ignore the huge potential for growth and expansion despite its slowness in reforms and implementation. Analysts have argued that India is also insulated from the global economy to such an extent that the growth engine will continue to move on albeit at a slower rate than one would expect under favorable global economic conditions. Rating agencies keep revising growth rates, which range anywhere between a pessimistic 5% and an optimistic 8%.With the European economy struggling to stay afloat,India remains a lucrative destination for global players to invest in, apart from China, Brazil and Russia.A FDI inflow for the past 10 years tells the story, as does the GDP and per capita growth trends. While GDP growth has been positive and close to 9% in recent years despite slowdowns, Per capita income has breached the half-lakh mark, and is now pegged ta Rs. 53,331 per annum in 2011~12, a 15.6% increase over the previous year. However, one should not forget the fact that India is a 'developing' country, and has its own pros and cons, which should be explored in depth.



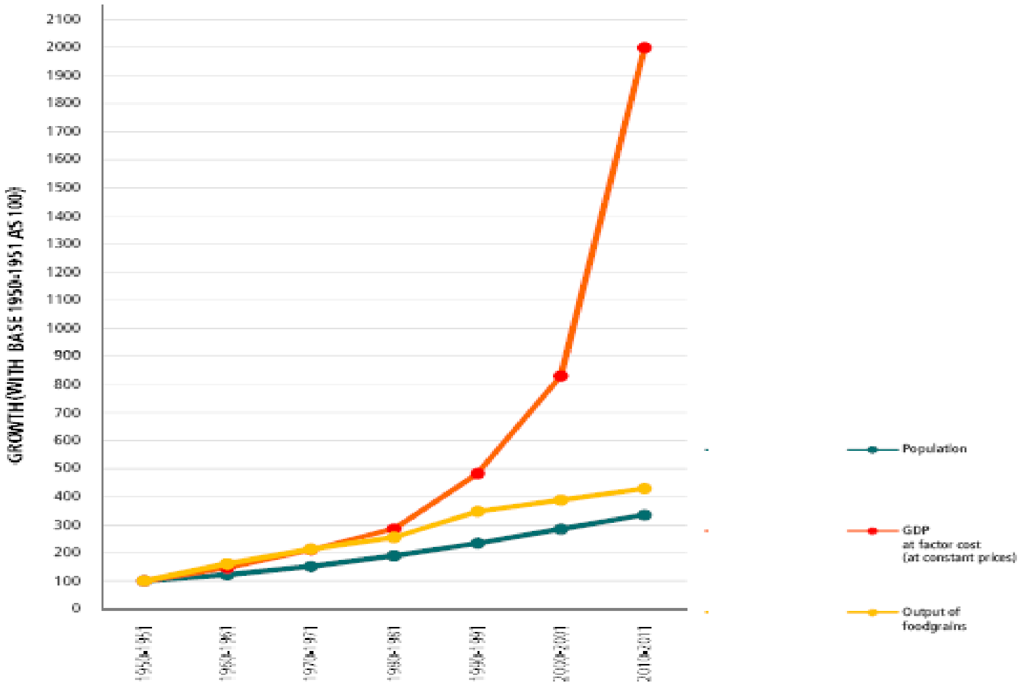
People power

India has a distinct comparative factor advantage as a vast reservoir of skilled manpower. The demographic differentials reveal that over the next 20-30 years, India has distinct advantages in a population profile concentrated in the younger age group, where many new opportunities can be fully optimized.

An important trend running concurrent with globalization is changing demographics and the effects of these changes on the global skilled workforce. In overall terms, the workforces in the Western countries have been aging along with the populations in general, the workforces in the most economically developed parts of Europe are aging and shrinking, and the workforces in most of Asia (Japan and South Korea excepted), the Middle East, and South America are growing and getting younger.

In India, from 2001 to 2026, population is projected to increase from 1.029 billion to 1.400 billion. The proportion of population in the working-age bracket of 15-59 years will increase from 57.7% in 2001 to 64.3% in 2026. India's present population is young, 54% of the population is aged 24 years and less as per Census 2001. The 15-24 age-group accounted for 19% of the population in 2001,195 million people. While the share will drop to 16% in 2026, in absolute terms, the number of people in the 15-24 age-group will increase to 240 million in 2011 and then decline a bit to 224 million in 2026.There is yet another way of looking at this. Between 2001 and 2026, the total population will increase by 371 million and 83% of the increase will occur in the age-group of 15-59 years.

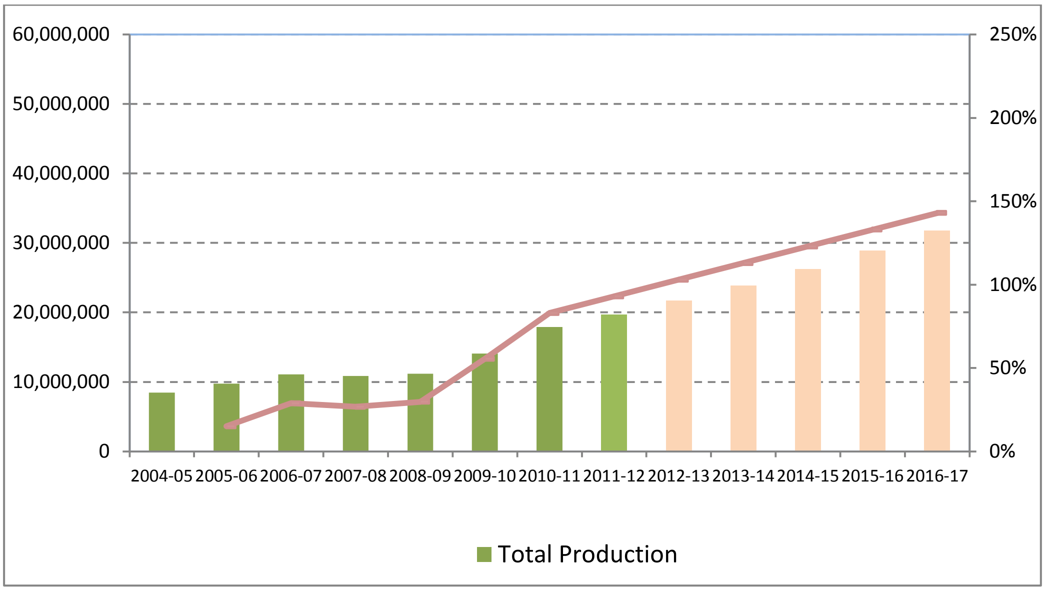
However regular fixed employment has kept up with the growth of employable work force, as contract labor has become a key ingredient on factory employment and the nature of this employment is only temporary.



This paper attempts to analyzethe “People” angle for 3 major sectors – Automobile, Construction and Social Sectors. The engagement levels as of 2011-12, along with Sector wise projections for the next decade has been considered, also forecasting the availability of workforce in terms of numbers and Quality .Probable reforms in labor and employment, education and technology have also been factored in while arriving at the entry strategy for India. The paper goes to the extent of suggesting the most suitable region within India to set up shop, for each sector, analyzing various factors including demand-supply equation of resources, influence of political volatility and regional characteristics among other factors, using the Porter’s model of 5-forces.

Automobile Sector

The Automobile Sector is one of the major industrial sectors in India. Since liberalization it has witnessed tremendous growth and is aptly described as the as the Sunrise sector of the Indian Economy. It contributes to about 5% of the GDP and 17-18 % of indirect taxes to the government. It has been growing at 14% CAGR over the last 6-7 years and is expected to grow at the rate of 10% in future. The current size of the industry is 20 million and is expected to reach 30 million by 2016-17. At present 100% FDI is permissible in the Automotive sector under automatic route.



The segments comprises of the following broad categories of vehicle – two wheel, three wheeler, passenger vehicles and commercial vehicles. Two wheelers, being the most popular means of personal transport, alone contributes for 75% of the total automobile production, while passenger vehicle contributes to 16% of the production. However, owing to lower sales realization, two wheeler accounts for only 32 % of the sales while passenger vehicle accounts for around 62 % of the same.

Geographical Distribution

In India, the auto industry growth has mainly has happened in clusters of related companies which are linked by commonalities. The major clusters are in the four major regions likeSouthern Region : Chennai – Bangalore –Hosur, Western Region : Mumbai – Pune – Nasik – Aurangabad, Northern Region : Delhi – Gurgaon – Faridabad ,Eastern Region : Kolkata – Jamshedpur, but the development in this region has been to a lesser extent than in othersThe major players in the Automotive Segment in India are

Companies	Segments
Ashok Leyland	LCVs, M&HCVs, buses
Asian Motor Works	M & HCVs
Bajaj Auto	Two and three wheelers
BMW India	Cars and MUVs
Daimler Chrysler, Fiat India, Volkswagen	Cars
Eicher Motors	LCVs, M & HCVs
Force Motors	MUVs and LCVs
Ford, General Motors, Hyundai	Cars and MUVs
Hero motor corp,Kinetic Motor, Suzuki Motor India	Two wheelers
Hindustan Motors	Cars, MUVs and LCVs
Honda	Two wheelers, cars and MUVs
Mahindra & Mahindra	Three wheelers, cars, MUVs, LCVs
Maruti Suzuki	Cars, MUVs, MPVs

Piaggio	Three wheelers, LCVs
Royal Enfield Motors	Two wheelers
Skoda Auto India	Cars
Suzuki Motorcycles, Yamaha Motor India, TVS Motor Co.	Two wheelers
Swaraj Mazda Ltd	LCVs, M & HCVSs, buses
Tata Motors Cars	MUVs, LCVs, M&HCVs, buses
Toyota Kirloskar	Cars, MUVs
Volvo India	M & HCVs, buses

The automotive value chain comprises of the OEM at the topmost tier of the Automotive Industry, with a wide network of Tier I, II, III level suppliers supporting the OEM for the end production. Manufacturing is the most important function in the Automobile segment, owing to 60-70% of the manpower engaged in this activity at the manufacturer's end.

The Indian economy has been growing at the rate of 8.2% since the last five years. The average age of the Indian population is 26 years and working population is 61% of the total population. An increased level of income and burgeoning middle class , a young aspiring population , availability of low cost finance , rapid urbanization and emergence of Tier II and non-metro cities , Government initiative etc., have been instrumental in driving demand growth in the Automotive sector.

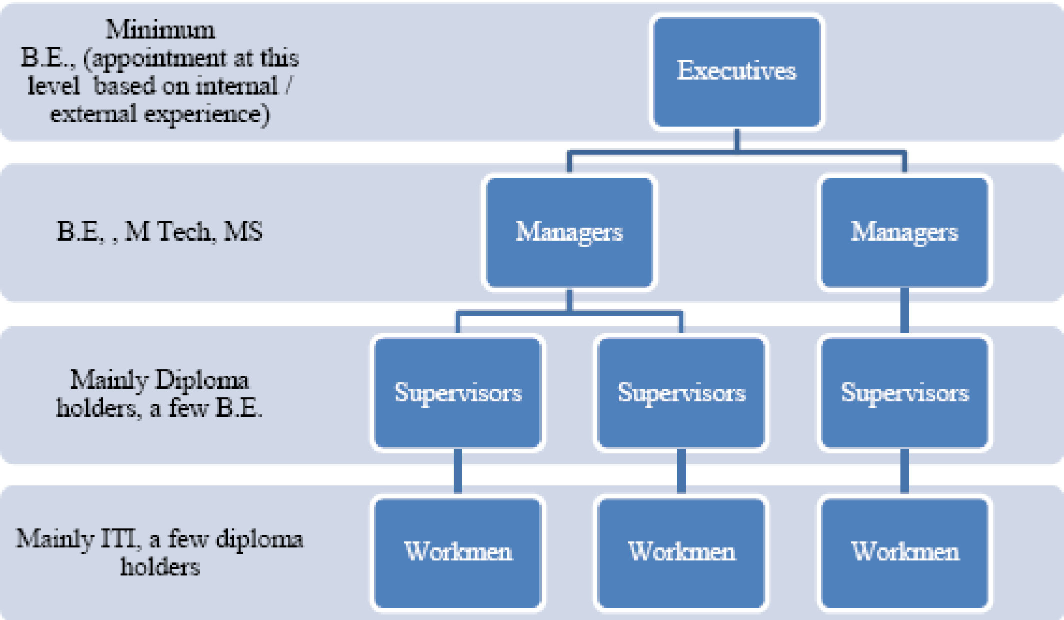
Labor Characteristics of the Automotive Industry

The Automotive Industry has considerable forward and backward linkages and employs a significant number of people. The Society of Indian Automobile Manufacturers (SIAM) has estimated that Indian Automotive Industry provides direct and indirect employment to over 13 million people. Manufacturing being the most important activity employs around 60 – 70% of the total manpower. A distribution of human resource employed at Automotive OEM and Auto Component supplier at functional level is as follows

Function	Distribution at Auto OEM's	Distribution at Large Tier I suppliers	Distribution at Small Tier I suppliers, Tier II, Tier III and lower suppliers
Manufacturing / Operations	55-60%	70-75%	80-85%
Design and Development, Production Engineering	7-8%	5-6%	1-2%
Vendor Development / Purchase	4-5%	2-3%	Minimal
Projects	1-2%	Minimal	-
Tool Room	2-3%	2-3%	1-2%
Industrial Engineering / Technical Services	4-5%	2-3%	Minimal
Sales and Marketing	5-6%	3-4%	3-4%
Service / Spares	7-8%	1-2%	1-2%
Support functions (HR, Admin, Finance, Accounts)	7-8%	4-5%	2-3%

ITI pass outs account for the maximum portion of the employment followed by graduate engineers and diploma engineers. Educational level wise and profile wise distribution of human resource in the automotive sector is shown below

Educational Qualification	Distribution at Auto OEM's	Distribution at Large Tier I companies	Distribution at Small Tier I suppliers, Tier II / Tier III and lower companies
Ph. D / CA / MBA / MTech etc.	3-4%	1-2%	-
Graduate Engineers	15-20%	8-10%	1-2%
Diploma Engineers	8-10%	15-20%	4-5%
ITI and other vocational courses	50-55%	40-45%	10-12%
Graduates (BA/BSc/BCom/others)	7-8%	1-2%	3-4%
12th Standard or below	1-2%	18-20%[13]	70-75%



Charkha frame work

Going by the sheer numbers and the importance in manufacturing, it is the workmen- mainly ITI or Diploma holders who from the thread linking the growth story of the Indian automobile industry (The bigger wheel) and the actual manufacturing plants that roll out the millions of motorized vehicles that carry people and freight across the length and breadth of the country.

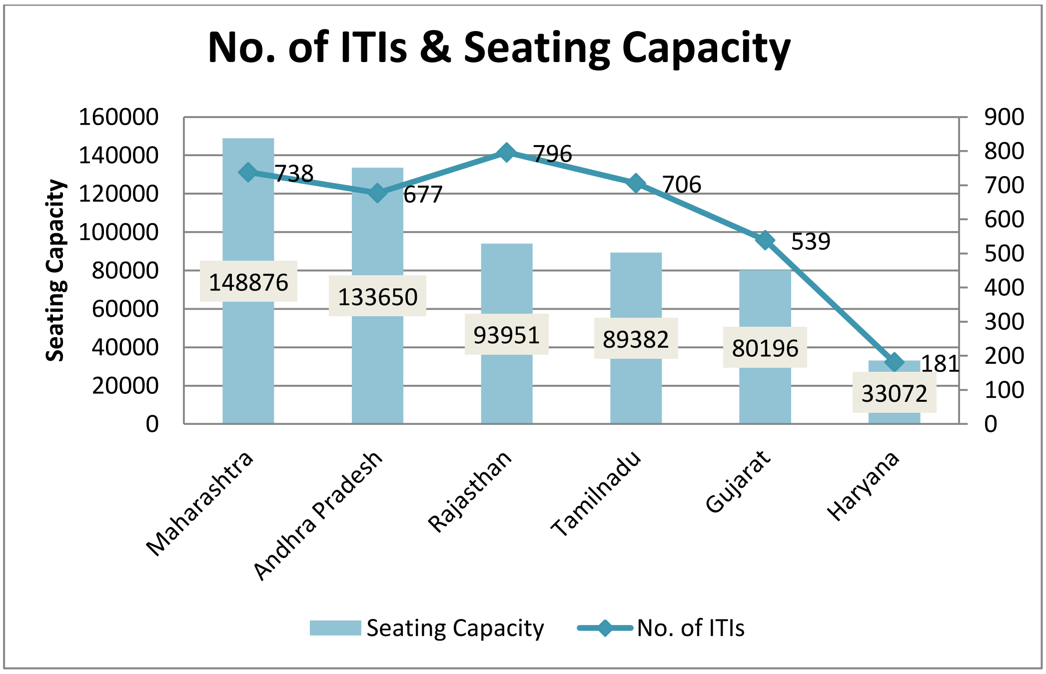
Porter's 5 forces analysis

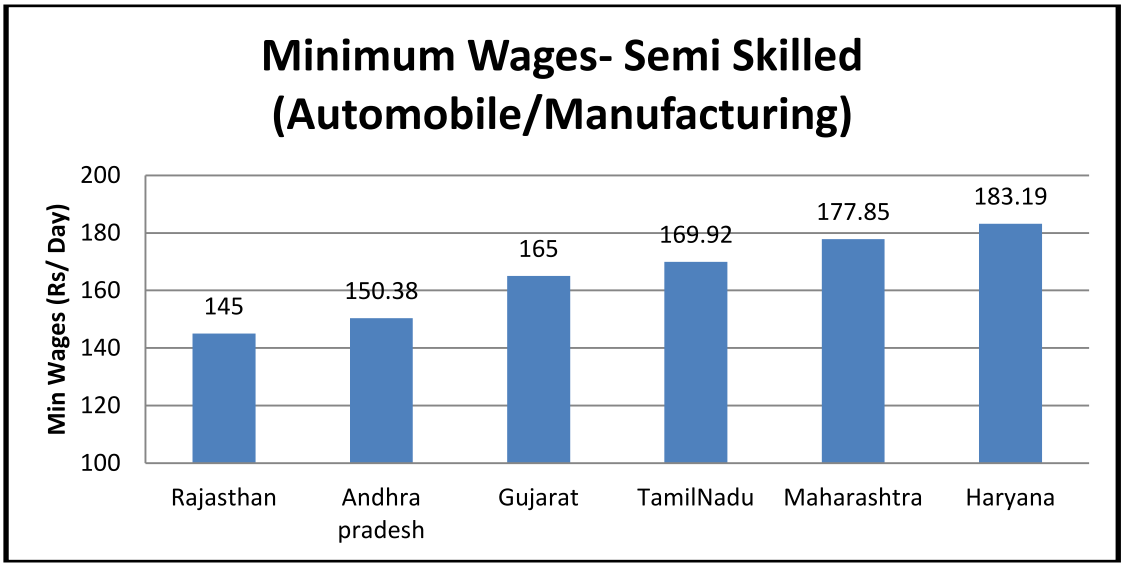
Threat of new entrants

The sector is one where huge capital is required along with designing capability. Manufacturing capacities of large scale are a must considering that India is still a growing market and the consumer segment is one that is still evolving. Gone may be the days when people clamored to own an Ambassador or a Maruti 800, but it is still the low end of the premium hatch backs, particularly those which offer a low cost of ownership that constitute the bulk of the passenger car sales. Similarly it is the fuel efficient, easy –on the wallet 2 wheelers that far exceed the niche segment of sports bikes .Going by the trend, it will be quite some time before the Indian middle class becomes a market for high margin low volume automobiles. Although FDI is fully allowed, it will be difficult for any new entrant to make a mark unless they have a very strong financial muscle, to counter the first mover and early bird advantages that other players enjoy

Supplier Power

The suppliers of the mainstream manpower for automobile sector are the various 'ITI's that churn out close to 1.3 million trained manpower every year. Southern India is the undisputed leader, holding one-third of the total seating capacity of India, with Andhra Pradesh alone contributing 10% capacities. Assuming uniform seat fill factor, one can definitely be assured of an abundance of ITI trained manpower from the South. The same holds good even for Engineering or MBA institutes too, as Andhra Pradesh, TamilNadu and Karnataka, account for 32% of Engineering and 41% of MBA institutes in the country. Although questions remain on the seat-fill factor and also the quality of institutes outside the top few, going by simple demand –supply economics, the manpower should be available at a lower cost than in other parts of India. A comparison of minimum wages indicates that Rajasthan and Andhra Pradesh fare better than the other states for the employers as the average minimum wages are lower. Higher wages in Haryana, Maharashtra and Tamilnadu may also indicate a higher demand in these states. A strong recruitment process can certainly help in identifying good quality talent, and even for low end skills, as there is a lot of choice to pick from, and hence the supplier power is low for the lower skilled job profiles, while due to strong rivalry, high quality talent is always in demand.





Threat of Substitutes

In the context of labor for automobile industry, automation is a viable alternative to a large extent, provided there are enough volumes for economies of scale. The capital expenditure is generally quite high for automation, but pays a lot of dividends if there is a shortfall of labor. However owing to the complexity and the no. of components involved assembly operations are still done manually using skilled labor. Another way substitution can be effective is by promoting migrant labor, with sufficient incentives. In the early 1990s due to lack of sufficient opportunities, there was heavy migration of labor from the South of India to North and Central India, however with now Chennai emerging as the Detroit of India and Pune also emerging has a strong hub, the earlier trend has started to reverse. It is quite possible that labor may actually come from states like Rajasthan, Uttar Pradesh and Bihar.

Internal rivalry

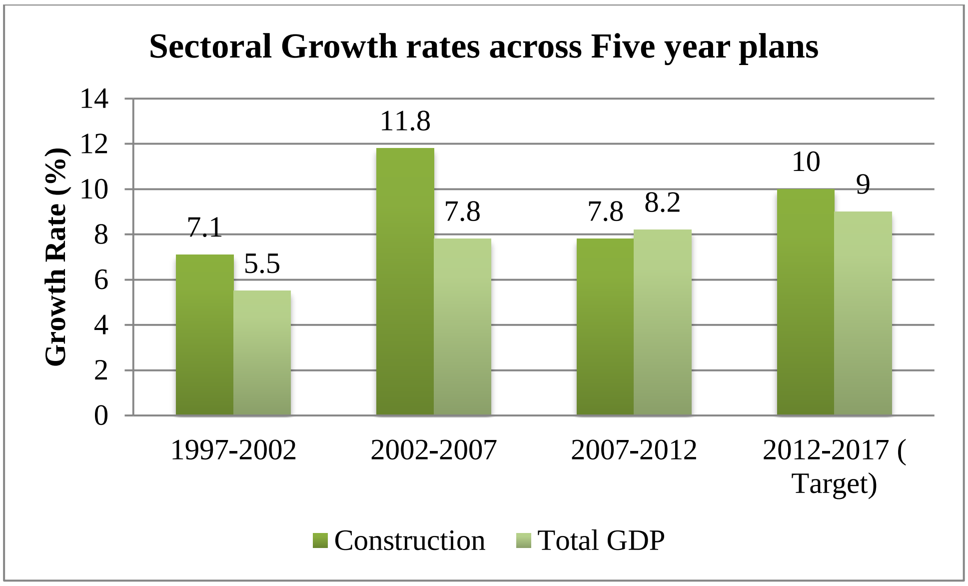
The competition is very intense in this sector, and almost every big name is in India. There is a very strong rivalry in all portions of the value chain. While poaching of top and middle management is very common, the lower strata have also become quite flexible, with opportunities available across the country for the right talent.In fact whenever there is a substantial capacity addition in any of the three major clusters there is a huge exodus of manpower back to the home state or cluster. The rivalry is pretty strong in the major clusters of Haryana, Pune and Chennai.

Recommendation for Automobile sector

While availability seems to favor the Southern Cluster, existing rivalry points towards an area other than the existing 3 clusters. Any state with favorable policies, and other factors such as growth rate, availability of land, attitude of labor, geographical constraints, proximity to market, should be an ideal choice. In this regard, we recommend Gujarat, as it fares better than Rajasthan in terms of the other factors mentioned above.

Construction Sector

This sector contributes around 9% of India's GDP, and witnessed double digit growth of 15% in the last 5 year plan (2006-12), and is likely to grow at further despite a temporary slowdown in demand especially in the real estate .The sector employs 14% of India's population , second only to agriculture. The Govt. outlay has been doubled to USD 1 trillion, in the five year plan for 2012~17, and private spend which is around one-third of the total expenditure is expected to equal Government spending in the next 5 years



(Source: Planning Commission, India)

The construction sector in India is made up of two major constituents –infrastructure and real estate. While infrastructure deals with transportation, urban infrastructure &utilities, the real estate segment is made up of residential and commercial buildings. Central and State Governments play a key role in the infrastructure sector as major projects in roadways, railways, airports and ports are integral part of the development agenda. Many states attract investment by showcasing fast growth rates in infrastructure. The real estate sector demand is driven by favorable demographics, urbanization and migration. Steady rise in disposable incomes and a burgeoning middle class, combined with easy availability of loans has contributed to a highly skewed demand –supply scenario driving real estate prices upwards.

Major factors that affect this sector are availability of labor, speed of land acquisition, procedural lead times, frequent revision of master plans and raw material prices especially cement and steel. The infrastructure which requires a high level of technical expertise is dominated by a few major names like L&T ,Gammon, Hindustan Construction Company (HCC), Jaypee group, GMR Infrastructure group, IVRCL, NagarjunaJaiprakash associates, Unitech. The real estate construction sector though is much more fragmented particularly in the housing sector, as there are innumerous agencies which take-up construction of small house-holds. However players like DLF, Purvankara, Omaxe,Unitech and Raheja do dominate organized construction of residential and commercial space.

Growth trend

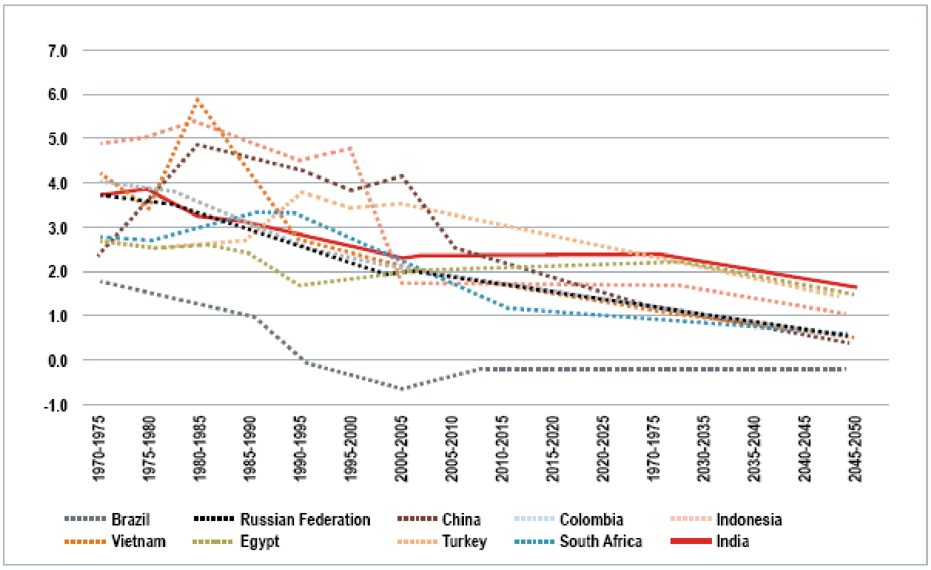
The construction sector has grown at rate of 11.1% from Rs 1084 billion in 2001 to Rs 2263 billion in 2008[1]. Growth projections range from 12% in Real estate sector to 15% in the infrastructure segment. Some estimates put the CAGR at 10% over the next decade, which is in line with the Planning commission's target of 10~11% for the Twelfth Five Year plan (2012~17). As the country's GDP grows at around 8~9%, the infrastructure needs to keep pace, and hence the Government backed projects in this sector will be key elements in India's growth story. There are also shortfalls of the eleventh 5 year plan, which are to be recovered. For instance, as of December 2011, only 54% of the targeted Road length of 55,455 km was either completed or under construction. While lime-light projects like the Golden Quadrilateral and the North-South; East-West corridors have almost been completed, other

[1] Economic Survey 2008-09 &IMaCS analysis

projects under the National Highway Development Program are delayed.A master plan for 18,637 kms of express ways has been proposed under a new National Expressway Authority of India, under the Twelfth Five year plan along with up gradation of 20,000 kms of Single lane Highways to two-lane Highways. The PradhanMantri Gram SadakYojana (PMGSY) also aims to improve rural connectivity .Similarly in rail transport too, the Dedicated Freight Corridor (DFC) is also expected to attract huge construction opportunities, most of the metros are investing heavily in metro-rail projects, with Delhi leading the way and Mumbai and Chennai following suit. Metro projects have also become operational or at kick-off stage in Bengaluru & Hyderabad.

India is the second highest in the World when it comes to Average Annual rate of Change of Urban population (Figure 1). From 28.1% in 2001 urban population has grown to 31% in 2011.This rapid urbanization will lead to large scale opportunities in real estate development especially in the cities. There was a shortage of around 25 million houses in the eleventh five year plan, at 4.8 million houses per year. Supply and absorption of Office space is also bound to increase, as is Retail Shopping space. The year 2011 saw record completions and absorption of office space – close to 37 million sq.ft and 13.8 million sq.ft of retail space across 34 retail malls spread across the top seven cities of Mumbai, Delhi, Bengaluru, Chennai, Hyderabad, Pune and Kolkata.

Figure 1: Average Annual Rate of Change of the Urban Population (BRIC and CIVETS)

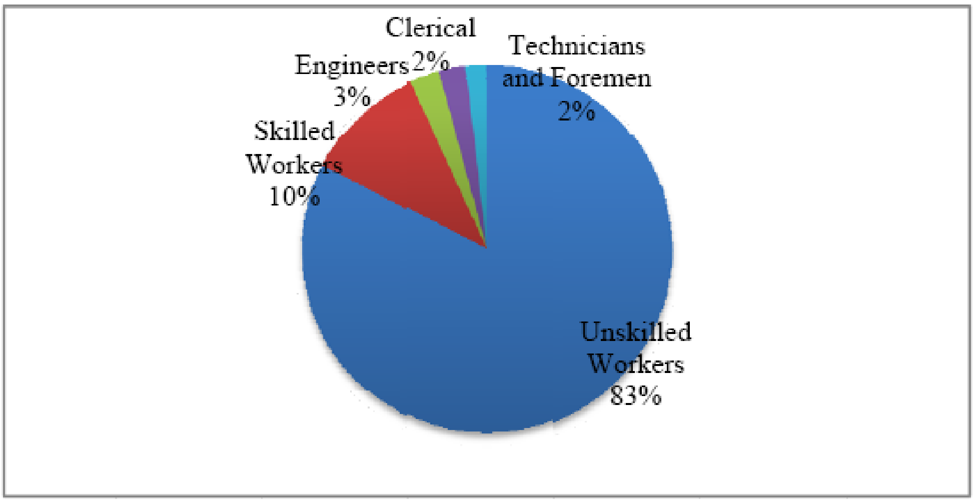


Source: World Urbanisation Prospects, United Nations, Department of Economic and Social Affairs, Population Division

Labor characteristics of Construction Industry

The Construction sector is the second biggest employer of manpower, after agriculture in India, offering direct/indirect employment to about 35 million people and isexpected to employ about 92 million persons by 2022. Thus almost 50 million additional jobs may be created in Construction in the next 10 years. Roughly 70% work in the infrastructure segment and the rest 30% in real estate segment.A majority of the employment is unskilled workers or those with minimal education .

Figure 10: Breakup of employment in Building, Construction and Real Estate sector in India – education wise



Source: Report of the Working Group on Construction for the 11th Five Year Plan, Planning Commission, Government of India and IMaCS analysis

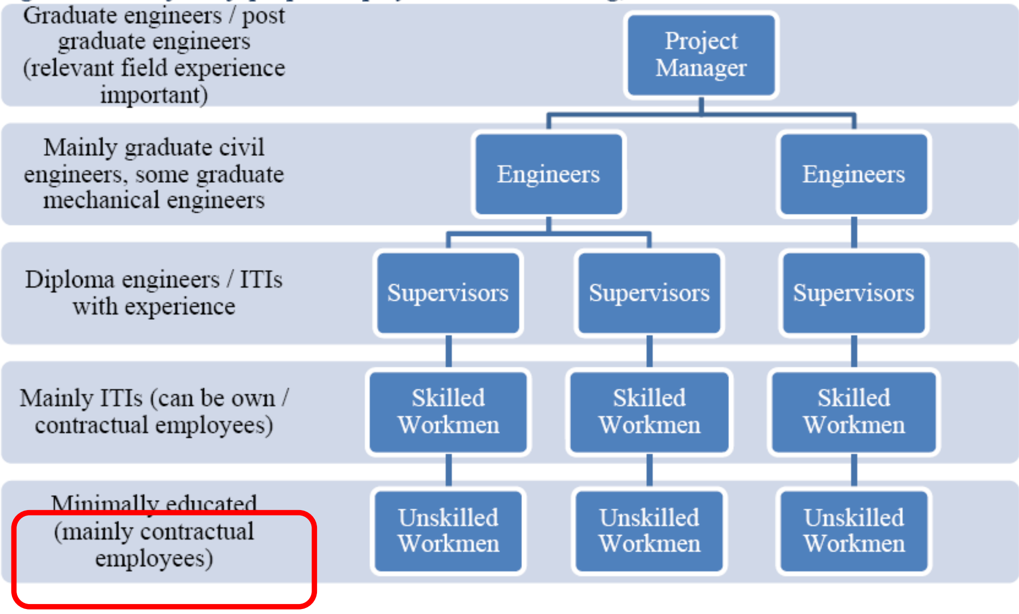
The 66th round NSSO Survey of Employment shows that the vast majority of new jobs createdbetween 2004-05 and 2009-10 was in casual employment, mainly in construction

Requirement of Human Resources for Construction (2022)

Engineers	3.72 million man years
Technicians	4.32 million man years
Support Staff	3.65 million man years
Skilled Workers	23.35 million man years
Unskilled/ Semi skilled workers	56.96 million man years
Total Manpower	92 million man years

A substantial addition (estimated about 4 millionper annum) is necessary to the workforce in coming years to sustain the growth rate of construction sector ..A look at the typical profile of a construction project employment , clearly shows that the unskilled workers constitute bulk of the workforce . It is necessary that , the industry and government should further strengthen the mechanism for providing training to this group of people. Some initiatives have been taken in this regard, e.g. National Skills Development Corporation (NSDC) is facilitating a Sectorial Skill Council (SSC) for the Construction Sector. An ambitious target of training-cum-certifying 35 million construction workers by 2022 has been fixed and the process of formation of the Skill Development Council for the construction sector is already underway.

Figure 14: Profile of people employed in the Building, Construction and Real Estate Sector



The Charkha framework

It is clearly evident that people – particularly at the lower end of the value chain – the unskilled labormostly under contract , with minimal education form the essential thread of the charka model that keeps the bigger wheel of the Charkha -the ambitious plans of the Government and the huge demands arising out of rising aspirations and the smaller wheel - the execution of these projects in a timely manner connected and thereby running the spindle that produces the flowing thread of good infrastructure and quality housing apart from other commercial space.

Porter's 5 forces analysis

Threat of new entrants

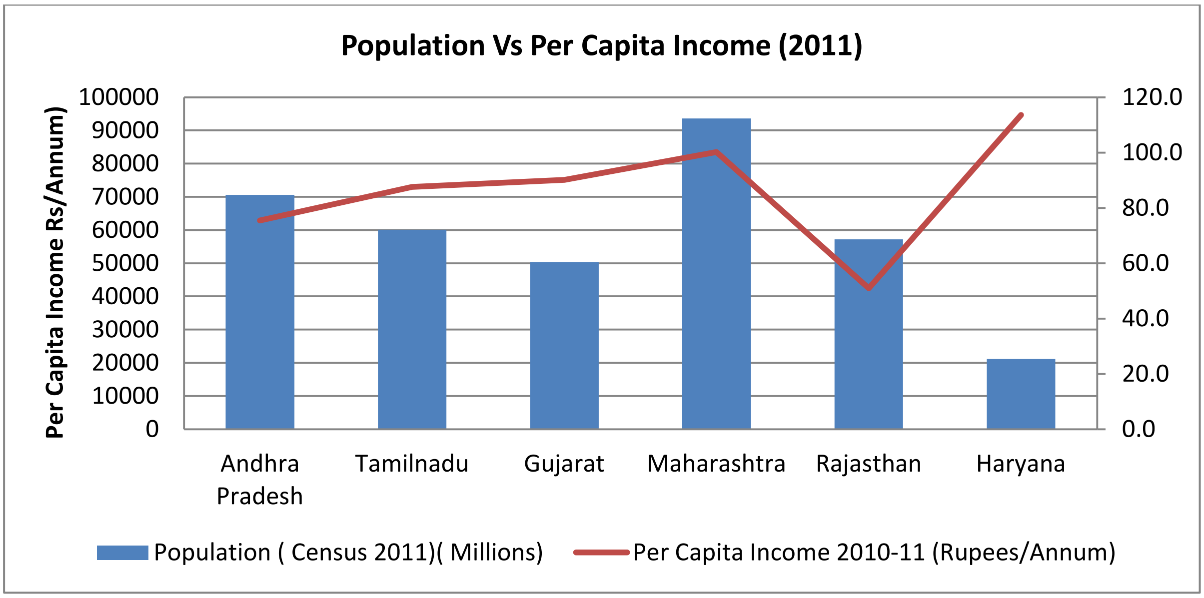
There is no major entry barrier in this sector, as there is a wide variety of options available depending on the ability to raise capital. However for major infrastructure projects which are awarded by the Govt or for big ticket commercial or residential projects financial muscle does matter .The size of a player and also its reputation play a huge role in the awarding of contracts.

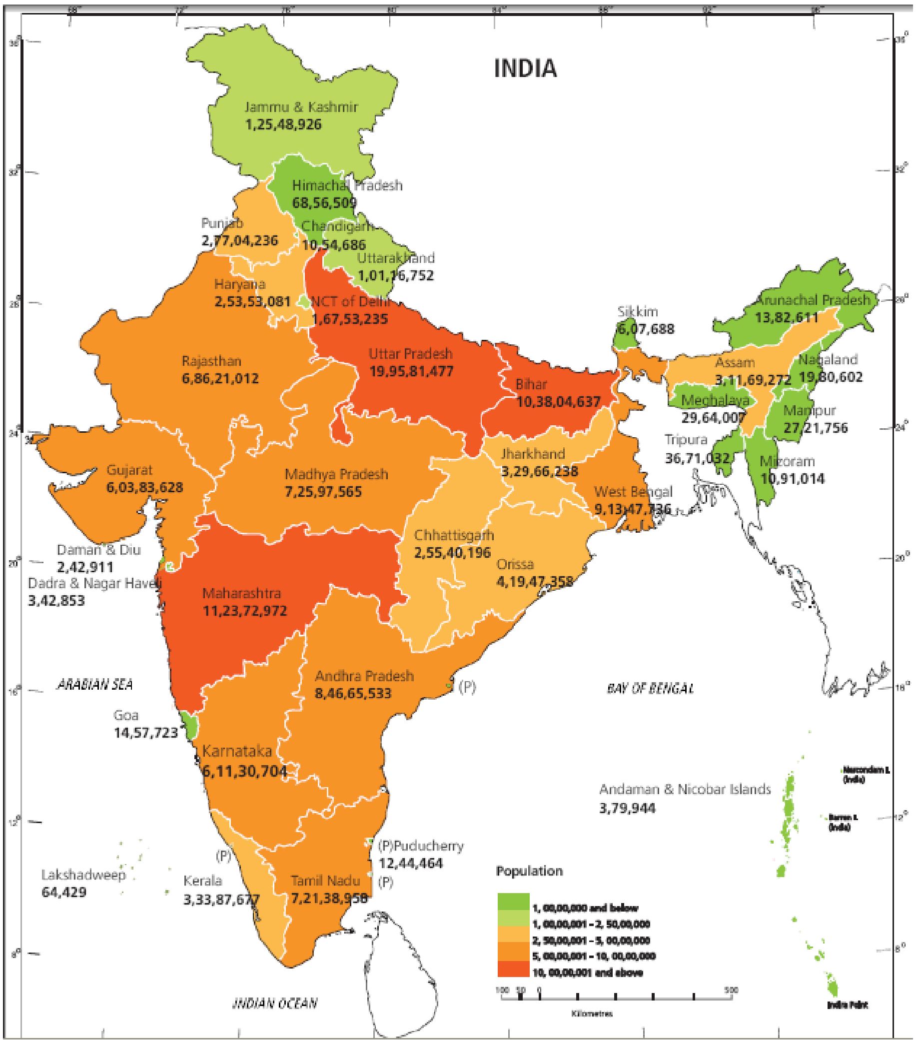
The Indian Govt has also opened up the FDI route with a view to catalyzing investment in townships, housing, built-up infrastructure and construction-development projects as an instrument to generate economic activity, create new employment opportunities and add to the available housing stock and built-up infrastructure. The Government decided to allow FDI up to 100% under the automatic route in townships, housing, built-up infrastructure and construction-development projects (which would include, but not be restricted to, housing, commercial premises, hotels, resorts, hospitals, educational institutions, recreational facilities, city and regional level infrastructure) as early as Mar-2005

Supplier Power

In the context of Construction industry, the supplies come from the population itself channeled through innumerous contractors, who offer casual labor mostly on daily wages, to either small contractor's taking housing jobs, or large construction companies executing big infrastructure projects.

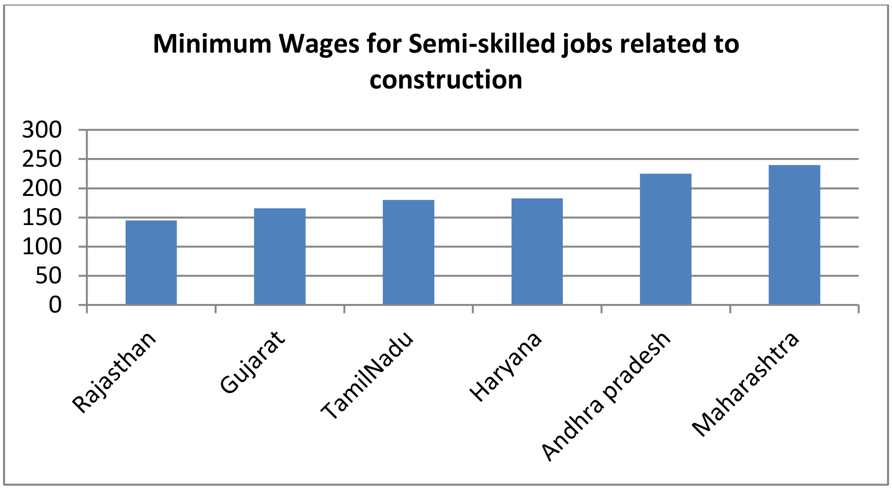
It is only logical that resources will be on offer where needy population is available. A comparison of the six chosen states , on Population vs. Per-Capita-Income shows that Rajasthan, has the best ratio, which means that there are more people, with less earnings at present, and hence the state can be an ideal supplier of manpower at the lower end of the construction value chain





Buyer Power

The buyers of the labor are the Construction companies or the individual house owners who get their projects executed .Buyers have little control over the minimum wages as they are controlled by Government. A comparison of minimum wages across the selected states again points towards Rajasthan, as Rajasthan has the lowest minimum wages for all levels of skilled jobs – from masonry to Carpentry to brick molding. When the industry is taken as a whole, buyers do not wield much power, be it the real estate sector or the infrastructure segment. The demand generally exceeds supply in the long term, and given the speculative nature of investments and the fact that real estate is one of the few assets considered to be appreciating, buyers have little bargaining power. The same is true even in the case of infrastructure, as more and projects are now PPP models where the preferred mode is BOT (Build Operate and Transfer) or similar models where the private concessionaire is given the freedom of pricing and recovering its investment or profiteering, with Yamuna express way coming as the latest example in this model.



Substitute Services

There is literally no alternative to either the constituents of construction sector, or the low-cost labor that is involved. With the population growing and the per capita income reaching newer heights every year there is no foreseeable drastic change in the trend of the growth of this sector. The same can be said about involvement of technology in construction per se. Although technological developments are bound to happen in the manufacturing of the raw materials like cement , structural steel or even brick making , the very process of construction is unlikely to see a large scale automation, barring small improvements in the process

Internal Rivalry

Owing to a yawning gap between demand and supply in this sector, there is ample cope for everybody to take part and still not bleed , unlike the automobile or aviation industries. However for infrastructure related projects there is active competition at least in the top rung with the top few names participating in the normal tendering route.

Recommendation for Construction sector

In short the resource and talent pool availability will not affect this sector in any significant manner , as the whole sector thrives on where the demand is. At present , it is urbanization which is driving the sector, and hence Delhi, Mumbai, Chennai, Bengaluru, Pune, Hyderabad, Gurgaon, Kolkata and Chandigarh are prime locations where activity is happening. When it comes to picking the migrant labor from the six states in consideration, Rajasthan seems to be the best in terms of availability as well as need for growth. Thus we recommend Rajasthan as most strategic providing best entry possibility.

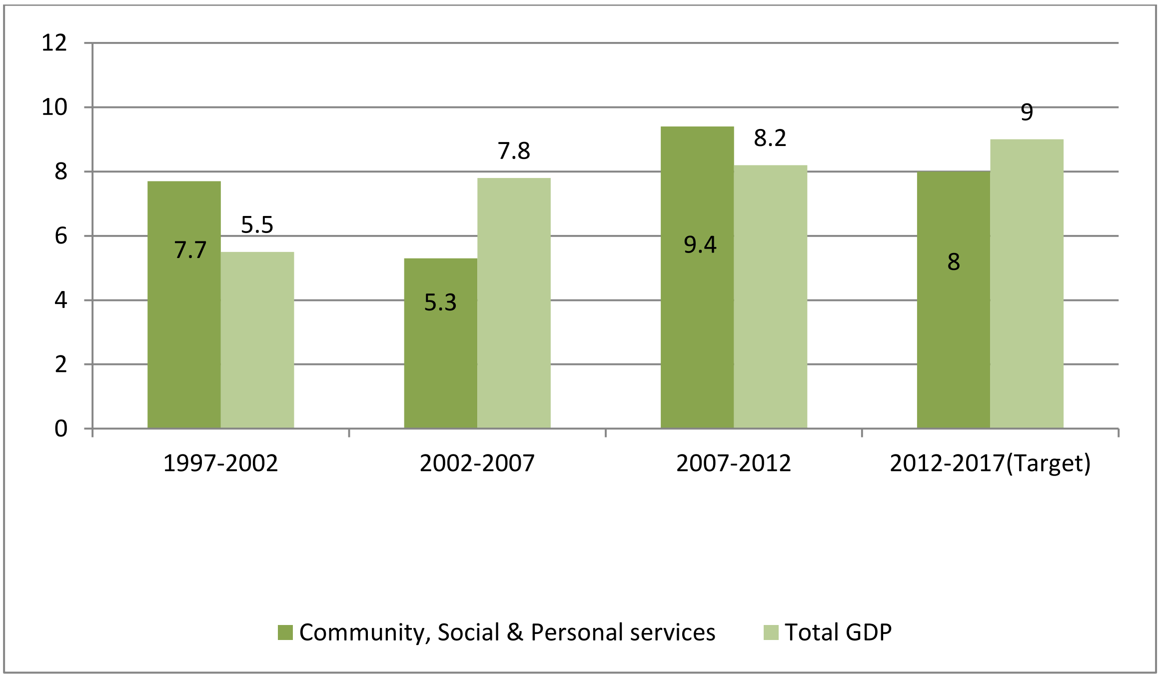
Social Sector

Social sector comprises of all those establishments which aim at the betterment of society through their contributions in the healthcare, education, nutrition, social upliftment, poverty eradication & sustainable rural employment generation. Though most the spending in social service sector comprises of government spending, which is almost 7% of the GDP, there is substantial investment coming in from charitable organizations, NGOs & nonprofit & for profit organization too in the recent years. The government recently has started pooling in for profit organizations under PPP model wherein special concessions are offered to these organizations in terms of viability gap funding or free land, etc. Even private organizations like Lijjatpapad, Aravind Eye hospital have been there for quite some time & their business models have had phenomenal success. Another private initiative which has a lot of potential is microfinance which gives easy finance access to small rural businesses thereby laying the way for entrepreneurship in these areas. We first study the govt. spending trends on this sector after which we delve into nitty-gritties of profitable models.

Trends in India's social-sector expenditures

Government expenditure on social services has consistently shown an upward trend. Expenditure on social services as a proportion of total expenditure increased from 21.6 per cent in 2006-7 to 25 per cent in 2011-12 . Expenditure as a proportion of the GDP increased from 5.57 per cent in 2006-7 to 6.74 per cent in 2011-12. On education as a proportion of GDP, it increased from 2.72 per cent in 2006-7 to 3.11 per cent in 2011-12 while on health, it increased from 1.25 per cent in 2006-7 to 1.30 per cent in 2011-12. These programs also help in the betterment of health and education of the population, besides contributing to more inclusive development.

<u>Sectorial Growth rate of Social sector across five year plans:</u>

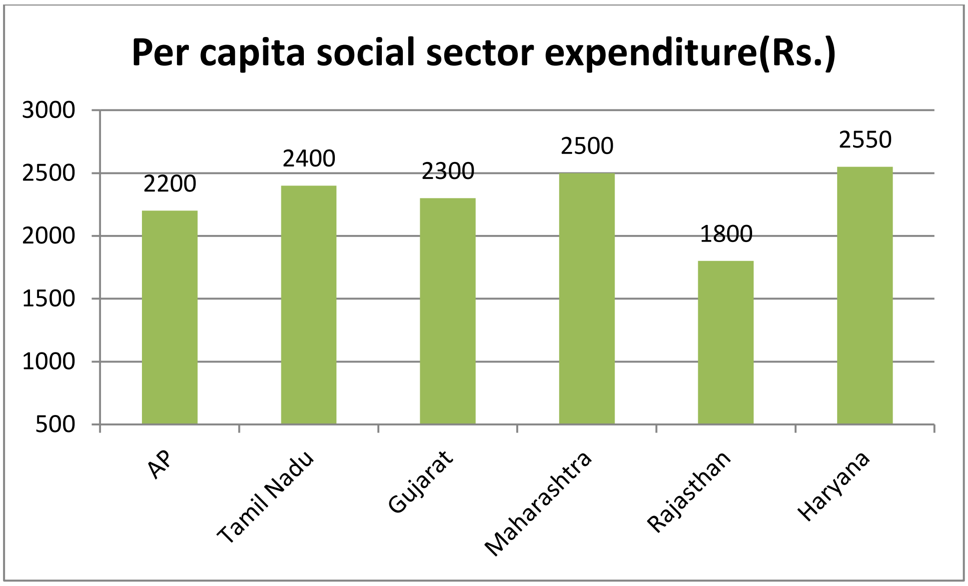


Major Government initiatives:

The following major flagship programs are operating in rural areas
(1) Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)
(2) National Rural Livelihood Mission (NFRLM)
(3) Indira AwasYojana (IAY)
(4) National Rural Drinking Water Program (NRDWP) and Total Sanitation Campaign (TSP)
(5) Integrated Watershed Development Program (IWDP)
(6) PradhanMantriGrameenSadakYojana (PMGSY)
(7) Rural electrification, including separation of agricultural feeders and Rajiv Gandhi GrameenVidyutikaranYojana (RGGVY).
(8) National Rural Health Mission (NRHM)
(9) SarvaShikshaAbhiyan(SSA)
(10) Integrated Child Development Scheme (ICDS)
(11) Mid Day Meal Scheme (MDMS).

Trends in Social services expenditure by general government	***Rs Cr.**					
Items	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
1.Social Service						
a. Education, sports, youth affairs	4.28	4.02	4.27	4.15	4.24	4.63
b. Health & family welfare	1.87	2.05	2.09	2.00	1.83	2.15
c. Water supply, housing, etc.	1.72	2.02	2.54	2.39	2.13	2.10
d. Information & broadcasting	0.25	0.22	0.23	0.20	0.21	0.20
e. Welfare of SC,STs & OBCs	0.34	0.36	0.41	0.43	0.57	0.67
f. Labor& employment	0.32	0.27	0.28	0.22	0.24	0.24
g. Social welfare & nutrition	0.85	0.82	1.15	0.87	0.90	1.02
h. North-Eastern areas	0.00	0.00	0.00	0.02	1.68	1.86
i. Other social services	-0.17	1.29	1.55	1.67	1.56	0.32
Total	**9.47**	**11.06**	**12.52**	**11.94**	**13.36**	**13.20**
2.Rural development	2.84	2.80	4.56	3.77	3.79	3.68
3.Pradhan Mantri Gram SadakYojana(PMGSY)	1.08	0.91	0.88	1.11	1.81	1.59
4. Social Services, Rural Dev. & PMGSY	**13.38**	**14.77**	**17.95**	**16.82**	**18.96**	**18.47**

Following graph shows the interstate analysis of states in terms of per capita social sector expenditure. As is visible there is marked inequality in expenditure, the effects of which are visible in social indicators like growth rate, literacy rate, infant mortality rate, etc. Even though the correlation between expenditure & social indicators exists, the govt. distribution channels are often marred by poor efficiency, private enterprises thus hold the key to increase efficiency & contribute in a big way.



Skill Development and Building Capabilities

New govt. plans aim at building retainable rural manpower to which technical skills can be imparted. This creates barefoot engineers, technicians, farm & dairy technology specialists, vets who design, execute & maintain rural infrastructure & bring economic & social independence to these areas. Also, programs like ASHA (Accredited Social Health Activist) which aim at developing intermediate medical staff are bringing awareness among villages about health & hygiene & bringing the first line of health care to these desolate areas.

Non-governmental social sector enterprises:

These include charitable trusts, NGOs, CSR initiatives of private sector enterprises as well as entrepreneurial ventures which seek to build sustainable business models around social sector. The private sector can aim for financial restructuring by offering different risks & returns to these societies & can leverage the potential of this huge untapped market. The following are some of the worldwide followed practices:

1. Loan guarantees: By offering loan guarantees instead of direct funding, the rural entities can get easy access to funds in absence of collateral as well as at low interest rates thus paving the way for further business development.
2. Quasi-equity debt: For entities that are registered as nonprofit& thus cannot hold any equity in the organizations they are supporting, the loan T&C are designed in a way which gives the management incentives to operate these entities efficiently.
3. Pooling: Third party entities form various competitive risk & return models in which urban market investors can invest. The models further provide easy funding to micro lenders.
4. Social impact bonds: These are specifically designed government bonds in which private investors can invest & returns are paid only when the social mission achieves success. This helps in private funding of government projects. These are important because it shifts the program failure risk from tax payers to investors which becomean incentive for the government to increase efficiency, failure of which would result in decline of future funding.

Tapping this huge one billion plus market at the bottom of the pyramid requires conceptualizing cost effective, scalable & replicable models which bring far reaching social changes along with returns. The cycle then becomes self-sustaining – increasing development & returns. Specialized social investors provide capital, networking, marketing and business expertise to such ventures. Fast company in their March 2010 listed "top 10 by Industry". And four of the top 10 most innovative companies in India were standalone social enterprises or have socially entrepreneurial initiatives.

Few for-profit Social Business Models

Company	**Activities**	**Impact**	**Future Plan**
VNL	Makes telecom equipment that helps mobile operators reach rural markets profitably	70 station in Rajasthan	Replicating and scaling it worldwide
Narayan Hospital India	Delivering affordable healthcare to the masses worldwide	5000 bed facility completed in phase 1	Health city with 30,000 bed facility by 2016
A little world	Empowering micro business through micro banking	Customer base crosses 3 million	Touch a billion people through innovative technologies
Barefoot College	solar energy, water, education, health care, rural handicrafts, people's action, communication, women's empowerment and wasteland development	1,000 Barefoot experts in 1,000 villages, reaches 500,000 people with basic services such as drinking water, health care, and education	10,00,000 people by the end of 2016
Childline	Country's first toll-free tele-helpline for street children in distress	9.6 million calls, 3 million children, 73 cities, 10 years	600 + districts by 2013
BASIX India	Sustainable livelihoods to the rural poor and women	Over a million and a half customer	-
CraftsBridge	A bridge bet customers worldwide and crafts persons, designers	N/A	To tap 6 million village people associated with the handicrafts sector
Arvind Eye Hospital	Eliminating needless blindness by taking its services to rural India	In last year alone 2.5 million patients were treated and over 3 lakh surgeries were performed	To replicate it in all states of India
COMAT	Empowering rural citizens by creating local economies and enabling access to information and services	Deliver Citizen records and Government benefits to over 50,000 rural citizens every day	75,000 by the end of 2011

D light	High quality solutions for families living without reliable electricity	10 million	50 million by 2015
IDE India	Providing long-term solutions to poverty, hunger and malnutrition	19 million	Ending poverty in the developing world
RangSutra	Sustainable livelihoods for artisans and farmers, by creating top quality hand-made products based on the principles of fair trade	Approximate 2500 artisans	Employ 5000 by 2015
LijjatPapad	Women Empowerment	4600 women employed	Plans to employ 6000 by 2010
Selco Solar India	Sustainable energy solutions and services to under-served households and businesses.	95,000 villages covered	Bring down the cost of solar equipment by 75% by 2012
Unltd India	Angel investor and incubator for social entrepreneurs	Each of the projects has, on average, created 1.6 new jobs in the economy	World where individuals take action to bring about positive social change
SKS Microfinance	Small loans without collaterals	5.3 Million Customers	Take Micro finance to every village
Suminter India Organics	Internationally certified organic agricultural produce	Premium crop price to more than 7000 farmers	Scale this model nationally
Vortex Engineering	Rural Solar Powered ATMs	750 ATM	One ATM/ Village i.e. 6,50,000 ATMs

Social venture funds measure their investments on social, environmental and the traditional financial returns. The fund measures returns in terms of financial, operational (internal processes and systems) and social impact (outcome and output). Output is number of people who are impacted and outcome is how it has affected them. More heartening is the fact that the mainstream venture capitalists are also recognizing this as a business opportunity. So far, VCs have invested $220 million in 77 social businesses in India. But there hasn't been a single exit. In conventional commercial ventures, VCs work with a holding period of 3-5 years. In social businesses, the holding period is longer — typically, 6-8 years.

Funds Currently Available

Acumen Fund : It supports sustainable enterprises providing the poor with critical goods and services at an affordable price. Primary focus on healthcare, housing, water, energy and agriculture Companies invested in: 12 Fund size: $40 million (approx.)

VenturEast: It builds profitable businesses that cater to under-served markets. Focuses on meeting India's domestic needs (primarily rural and semi-urban markets) by backing early-stage / rapid-growth businesses Companies invested in Over 50 (including 25 social enterprises) Fund size $250 million

Oasis Fund: It supports enterprises that develop innovative solutions that provide the poor with better access to critical goods and services. Investments generally range between $1 million to $6 million Companies invested in 4 Fund size $30 million (still raising)

Song: It supports entrepreneurs in high-growth sectors like education and training, agriculture and food, healthcare, financial services, basic utilities (waste, water, rural telecom, affordable housing, etc.) that are aligned with inclusive growth Companies invested in None Fund size $17 million

Aavishkaar India Micro Venture Capital: It creates sustainable change by increasing economic activity at the bottom of the pyramid and boosting the entrepreneurial spirit. Investments to date have focused heavily on the rural and agro technology sectors Companies invested in 17 Fund size Rs 60 crore (approx. $14 million)

Gray Matters Capital: It invests in the information, communication and technology space to bridge the urban-rural digital gap Companies invested in 4 Fund size $12 million

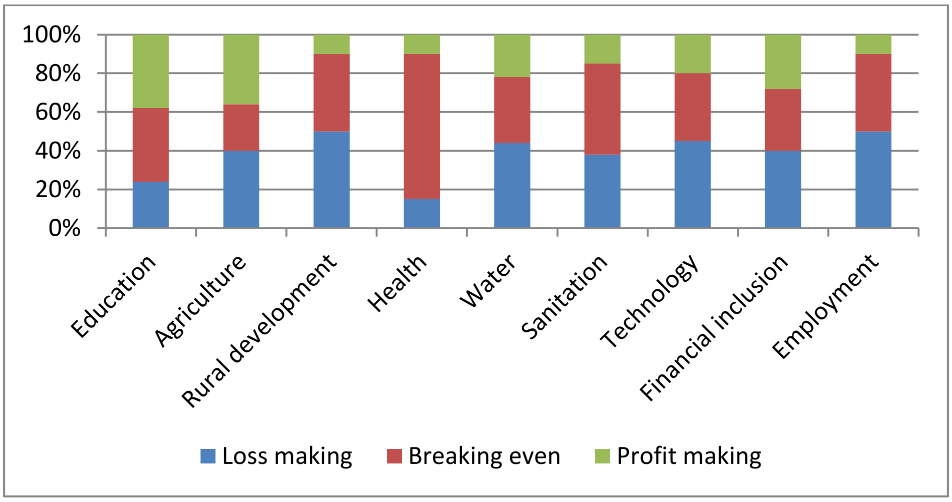
Elevar Equity II: It creates market-based solutions for poverty eradication. Focuses on sectors like healthcare, education and information Companies invested in 1 (another two in micro-finance ventures) Fund size $40 million (additional fund-raising on) .The figures simply state that there is an estimated $100 million (Rs 400 crore) chasing deals in India's social enterprise space.

But there is a divide between those that have access to mainstream and/or commercial funds and those that rely on personal connections and grants/donations to raise money. The ratio is about 50/50.

- Foreign grants: 8%
- Domestic grants: 8%
- Debt (credit loans): 11%
- Government Funding: 3%
- Charitable Organization: 5%
- Bank Loan: 13%
- Loan from Family and friends: 21%
- Equity Investors: 21 %
- Others: 10%

As per Beyond Profit survey, Forty-five percent of respondents obtained funds from commercial sources whereas 21% of respondents source their funds from personal connections such as family members and friends; another 21% rely on grants and donations from charitable organizations. Arranging finances for a social enterprise in India is still very difficult. And knowing in which sector to finance is even more difficult. In bar diagram mentioned below is a mention of profitable sectors and a trend which clearly states areas to divert funds

Sector wise profitability



Social Entrepreneurship in India – Profitable Sectors

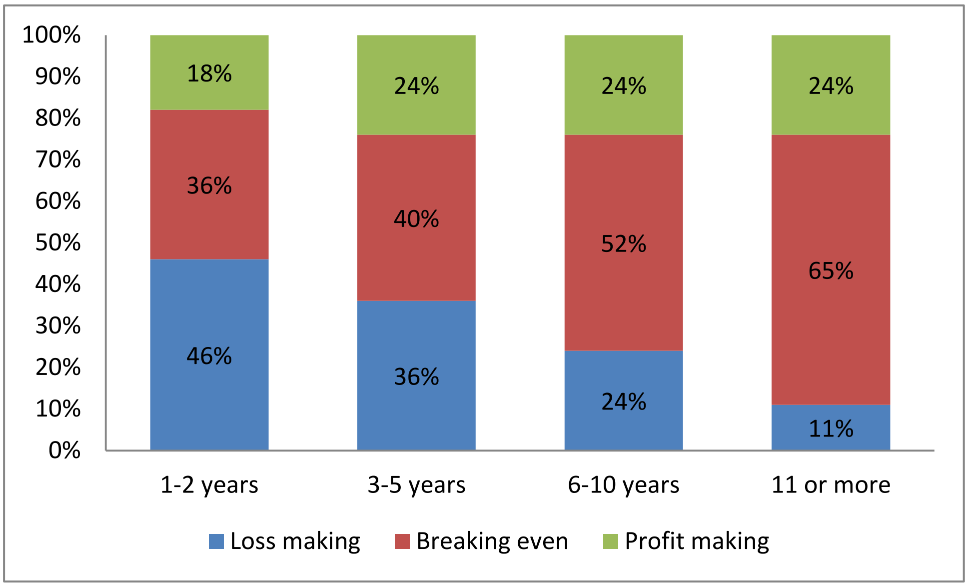
Education: Sector with a track record of profit: The Education sector has shown a marked degree of financial stability and growth potential. There are two key elements. First, the sector represents the highest number of profit-making enterprises (38%) among others, and also has one of the lowest numbers of loss-making entities (24%). Second, the observation says that there is a good growth potential; 38% of education enterprises are breaking even — which means the number of profit-making enterprises in this sector could increase in the coming years.

Health: Sector with large growth potential: Although the sector currently produces a very small number of profit-making entities, it has the lowest percentage (13%) of loss-making enterprises. Most importantly, at 73%, the Health sector has the largest segment of break-even businesses. If/when these enterprises begin to turn a profit, the Health sector could sustain a multitude of successful, profit-making enterprises.

Rural Development: Sector to watch out for future growth: Despite the fact that the largest number of social enterprises are in this field, it is the biggest loss-making sector at the moment. However, Rural Development demonstrated the largest revenue increases last year, so there could be more surprises in store.

There are more enterprises that are loss-making (34%) than those earning a profit (25%). And 41% percent of enterprises are currently breaking even. If you look at the profitability by measure of years in operation, you can clearly see that making profit through social enterprise is no easy task.

Profitability- by operational years



It is true that the percentage of loss-making enterprises steadily goes down as the companies get older. But there is virtually no disparity in the number of profit-making entities across age categories. Many enterprises stop making losses as they grow older but do not begin to turn a profit; they merely start breaking even. Surprisingly, even after 11 years or more of operations, the percentage of profit-making enterprises is only 27%.

Recommendation for Social Sector

The very nature of the sector does not lend itself to a Porter's framework for analysis of competitive edge- as it is still considered to be a non-profit sector with an evangelic cause, though sustainability comes only from a financially sound model. At the same time, it is also evident that it is the Social Entrepreneurs, who form the thread of the Charkha, with the Social causes as the bigger wheel and the different social enterprises being the smaller wheel, resulting in social up-liftment of people. Due to lack of a homogenous population or geography, the impact largely remains regional. With the current economic climate, it is very likely that social needs will increase and, consequently, the number of people committed to addressing them will increase. Definition of social entrepreneurship has changed over time. From corporate philanthropy to non-profit and now to self-sustainability, Social Entrepreneurship has evolved and will keep evolving with time and needs of the world. There is no specific region or target market which is more suitable than the other. Each state has its own case for entry of a new player. However we recommend central base from NCR Delhi primarily from impact of Government structure with six satellite branches in Rajasthan Gujarat, Andhra, Tamilnadu, Maharashtra, Haryana and. We recommend a roadmap which moves from NCR to these states in the order here for strategic reasons of government structures.

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Co-creating value across supply networks: Towards an agenda for supply chain design engineering capability development

Saikat Kundu[1]*, Alison McKay[2], Richard Baker[3], Alan de Pennington[2], Richard Thorpe[4]
[1]*School of Engineering, Manchester Metropolitan University, Manchester, M1 5GD, UK*
S.Kundu@mmu.ac.uk
[2]*School of Mechanical Engineering, University of Leeds, Leeds, LS2 9JT, UK*
A.McKay@leeds.ac.uk ; A.dePennington@leeds.ac.uk
[3]*Rolls-Royce Plc, Derby, UK*
Richard.Baker@Rolls-Royce.com
[4]*Leeds University Business School, University of Leeds, Leeds, LS2 9JT, UK*
R.Thorpe@lubs.leeds.ac.uk

Abstract
The transition to product-service systems demands co-creation of value by suppliers and customers. As a result, supplier development is becoming increasingly important because organisations cannot create value in isolation. In response, core business processes increasingly include the management and development of capabilities in supply networks.
Current practice is based on audits that assess supplier compliance with requirements. Data generated is used to drive supplier development strategies. In the future, such data might be used to support network-wide analyses of capabilities and identification of system-wide improvement opportunities. This will require supplier development strategies that embrace strategic intents of multiple organisations in a network.
This paper reports a review of literature on supplier capability and an initial analysis of an *Integrated Supplier Compliance and Capability Assessment System* from the aerospace sector. We conclude that the ability to co-create value is related to three dimensions of supply network capability: relationships, efficiency and innovation.

Keywords: Capability assessment, Service-dominant logic, Supply network, Supplier engineering capability, Value co-creation

1 Introduction

The transition from the delivery of products to the delivery of product service systems demands a change in thinking about the creation of value, from so-called "goods dominant logic" where value is created by a supplier and consumed by a customer to "service dominant logic" where value is co-created by a supplier and customer. This shift in thinking about value creation has led to the need for reframing supply chain management to a service dominant logic perspective (Lush, 2011). In sectors such as aerospace, where there is a heavy reliance on the supply network, supplier development is becoming increasingly important because organisations cannot create value in isolation; value is co-created with suppliers. For example, in the transition from *'Make to Print'* to *'Design & Make'* in the aerospace sector, prime contractors need to understand, and be able to evaluate and compare, suppliers' and potential suppliers' design capabilities in addition to their traditional manufacturing capabilities.

For this reason, core business processes increasingly include the management and development of current and future capabilities in the supply network. A key goal of these processes is to maintain supply network health to ensure the long term reliance of service and business performance. A first step in demonstrating capability is to demonstrate compliance with defined requirements. Beyond compliance, assessments based on questionnaires are used to determine the capability of suppliers. The goal of the research reported in this paper is to provide theoretical foundations for the assessment of design capability and, therefore, the instruments (such as assessment questionnaires) used to measure current and define future (required) capability, and in the formulation of improvement programmes used to achieve the future target.

Current industry practice in supplier assessment and evaluation is based on audits and questionnaires that are used to assess supplier compliance with customer requirements. These methods generate data that is used to drive supplier corrective actions to address identified areas of non-compliance. In the future, the data generated from supplier assessments may also be used to develop strategies where improvement programmes for individual suppliers, sometimes in the context of specific supply relationships, are implemented. It may also be used to support analyses of the current capabilities within an entire supply network, or part thereof, with a view to identifying system-wide improvement programmes. This leads to the need for coherent supplier (and supply network) development strategies that embrace the strategic intents of multiple organisations in a given network.

In this paper we report results of a systematic review of the academic literature on supplier capability and an initial analysis of an example Integrated Supplier Compliance and Capability Assessment System from the aerospace sector. The literature review is reported in Section 2. We conclude that a supplier's ability to co-create value with a customer is related to three dimensions of supply network capability: the building and maintenance of relationships, improving efficiency (i.e. doing more with less) and innovation (i.e. doing things better). These conclusions are used to inform analysis of an example Integrated Supplier Compliance and Capability Assessment System in Section 3. Finally, in Section 4, learning from the research is used to inform the identification of future research in this area.

2 Literature review

2.1 Method

The literature search covered 1980 to 2012 and used Google Scholar, Google search engine, and electronic resources available through the University of Leeds library.
Keywords were initially identified by considering key messages and themes of the literature surveyed and were adjusted to reflect trends that emerged from literature in the capability assessment and value engineering domains. The following keywords were used: capability; business capability; business capability measurement/assessment; capability assessment; engineering capability; service dominant logic; value; value creation; value co-creation; value engineering; innovation; innovation management; innovation in supply chain; Toyota production systems; supply chain/network relationships.

2.2 Results

2.2.1 Value in supply network and capability

Supply network activities transform natural resources, raw materials and components into a finished product that is delivered to the end customer. From traditional perspective, value is gradually added in each tier of a supply network from the end supplier to the end customer. Supply network is link to value network (http://en.wikipedia.org/wiki/Supply_chain). For these reasons, supplier capability should be assessed considering its value contribution to the customer as well as the whole/part of the supply network. In the rest of this section, we provide a review of literature on definition of value, value production and consumption, value co-creation, and value functions in supply networks.

What is value?

In their review of value, Chernatory *et al.* (2000) show that the prevalent view is to regard value as the perceived trade-off between the total benefits obtained and the total sacrifices incurred.

i.e. *Value = (Total benefits obtained) – (Total sacrifices incurred)*

Traditionally economic exchanges have been viewed and modeled from a mindset (or dominant logic) based on the exchange of physical goods or tangible resources. It is known as the *Goods-Dominant (G-D)* logic mindset and focused on tangible resources, embedded value, and transactions. However, over the past several decades, new perspectives have emerged that have a revised logic focused on intangible resources, the co-creation of value, and relationships (Vargo and Lush, 2004). These new perspectives are converging to form a new dominant logic in which service provision rather than goods is fundamental to economic exchange. In their seminal paper, Vargo and Lush (2004) formally defined this new and emerging dominant logic as *Service-Dominant (S-D)* logic. Value has different definitions in the two dominant logics: G-D logic and S-D logic.

From Goods-Dominant (G-D) logic (Vargo and Lush, 2004; Vargo, 2008)] value is:

- as produced [i.e. products are embedded with utility (value) during production];
- determined by the producer;
- embedded in operand resources (i.e. physical goods, appliances and other tangible matters);
- defined in terms of ‘exchange-value’.

On the other hand, from Service-Dominant (S-D) logic (Vargo and Lush, 2004; Vargo, 2008) value is:

- co-created;
- always uniquely and phenomenologically determined by the beneficiary;
- perceived and determined by the consumer on the basis of ‘value in use’; and
- the result of beneficial application of operant resources sometimes transmitted through operand resources.

Value production and consumption in supply network

From the perspective of goods-dominant (G-D) logic, in a supply network, value is first produced/created by the supplier(s) and then consumed by the consumer(s). In a supply network or value network, value is gradually added from the end supplier to the end customer before it is ultimately consumed by the consumers. This traditional concept of value creation and consumption is diagrammatically represented in Figure 1.

Value co-creation in supply network

From the perspective of service-dominant (S-D) logic, in a supply network, value is co-created by the suppliers and customers. In a supply network, there exist a multiple number of supplier-customer relationships. In each supplier-customer relationship, value is co-created jointly by the supplier and the customer. In value co-creation activity, the supplier can only make a value proposition and the customer harvest value out of this value proposition. For instance, a UK-based OEM can supply an aero-engine to two different types of customers- an airline operator and a FMCG supermarket. The FMCG supermarket may not find the supplied aero-engine especially valuable for their operations and so may not directly harvest value from it (or co-create value with the aero-engine manufacturer). However, for the airline operator, the aero-engine is immensely valuable for its operations. The airline operator can directly harvest value from functionalities offered by the aero-engine (or co-create value from the value proposition made by aero-engine manufacturer). This emerging concept of value co-creation by a supplier and a customer in a supply network is diagrammatically represented in Figure 2. In S-D logic, both supplier and customer are viewed as resource integrators.

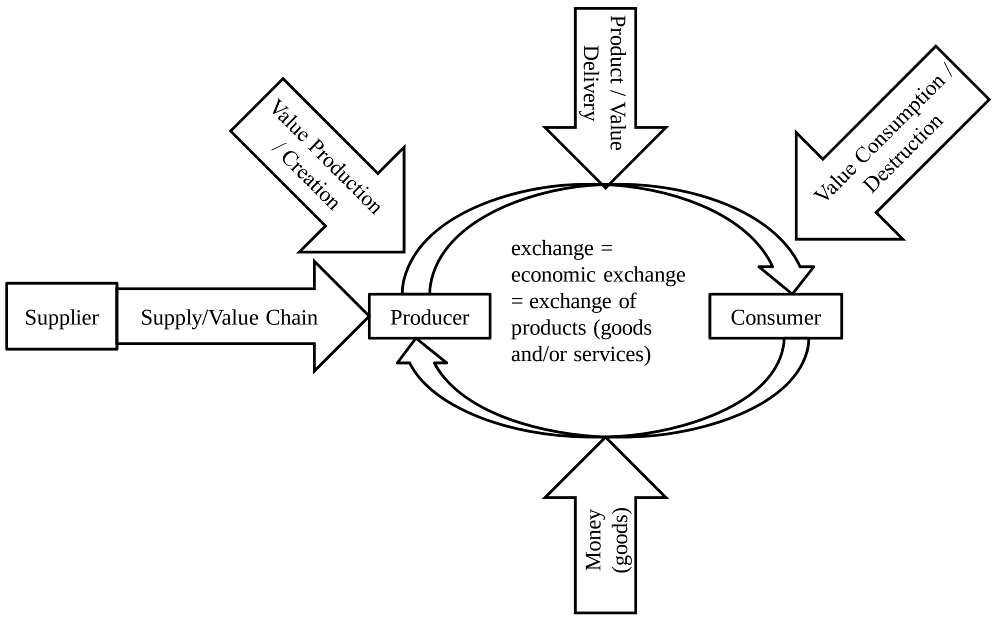

Figure 1. Value production and consumption based-on G-D Logic [adapted and reproduced from (Vargo, 2009)]

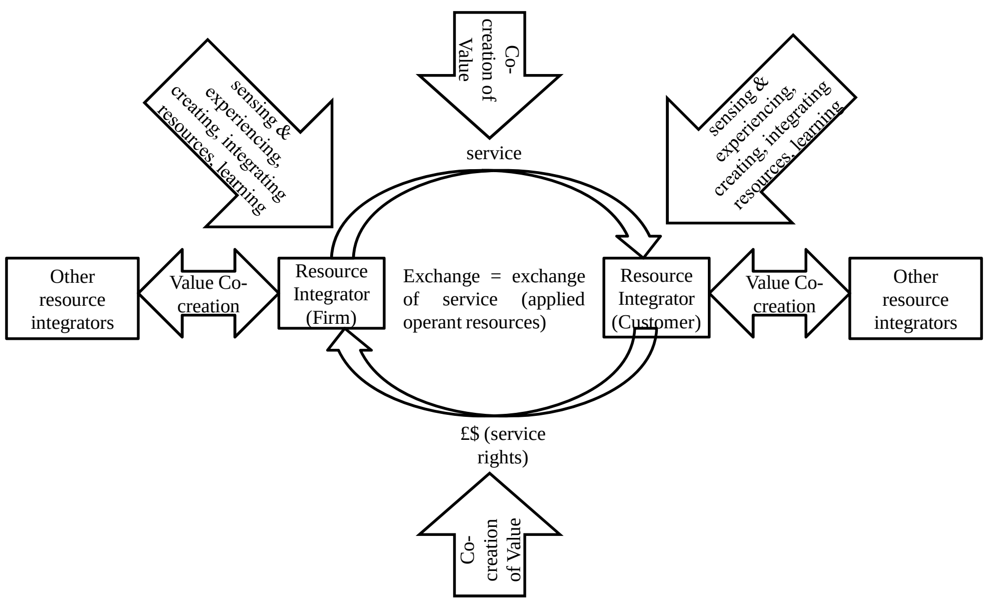

Figure 2. Value co-creation based-on S-D Logic [adapted and reproduced from (Vargo, 2009)]

Value functions in supply network

Supplier capability should be assessed considering its value contribution to the customer as well as the whole/part of the supply network. Moller and Torronen (2003) assert that in a supply network, value created through sustained joint effort is dependent on supplier-customer relationship characteristics. Functions of (supplier-customer) business relationships have been basically classified into two types: *direct-value* functions and *indirect-value functions*. Impact of *direct-value functions* is realised through immediate cost-and-revenue effects on a supplier-customer relationship (Anderson *et al.*, 1994). Impact of *indirect-value functions* is realised through linking of the supplier–customer dyad to other actors in the supply network (Ford *et al.*, 1998). Value functions are interrelated and dynamic (i.e. they evolve as functional profile of supplier-customer relationship evolves over time).
Profit function (i.e. relative direct revenue from a customer), *volume function* (i.e. volume of business generated by a customer), and *safeguard function* (i.e. possibility of 'guaranteeing' a level of business and revenue through contractual arrangements with specific customers) are examples of *direct-value functions*. These are realised within a dyadic relationship (Moller and Torronen, 2003).

Examples of *indirect-value functions* (which are realised within networks of relationships) include the following: *innovation function* (refers to the possibility of product, process or organisational innovation with a particular customer); *market function* (refers to the possibility of accruing new customers/distributors through the reference impact of a particular customer); *scout function* (refers to the market and other information that can be acquired from the working environment through a particular customer); and *access function* (refers to gaining access to relevant other actors in the working environment though a particular customer) (Moller and Torronen, 2003).

Value functions are interrelated and dynamic (i.e. they evolve as the functional profile of supplier-customer relationship evolves over time). In a supply network, supplier capability should be assessed considering a supplier's direct and indirect value functions.

Supplier value (co-)creation capability dimensions

Moller and Torronen (2003) propose that a supplier's value creation potential in a supply network could be classified into three dimensions: efficiency dimension, effectiveness[1] dimension and network dimension. They also categorized profit, volume, and safeguarding functions associated with supplier-efficiency dimension; innovation function associated with effectiveness dimension; and resource-access, scout, and market-signaling functions associated with supply-network dimension. Phillips et al. (2006), Abernathy and Clark (1997), and Johnsen *et al.* (2008) identified market linkages (or inter-firm relationships or supply relationships) and capabilities (or competencies) as two dimensions for managing innovation in firms in a supply network.

From the shift in mindset from G-D logic to S-D logic we use the term co-creation of value by supplier and customer in a supply network instead of value creation. From our survey of literature we conclude that a supplier's ability to co-create value with a customer is related to three dimensions of supply network capability: the building and maintenance of relationships, improving efficiency (i.e. doing more with less) and innovation (i.e. doing things better).

[1] An actor's ability to invent and produce solutions that provide more value to markets (customers) than existing offers

These three dimensions of supply network capability are shown schematically in Figure 3. In this paper we review literature in each of these areas and highlight future research areas

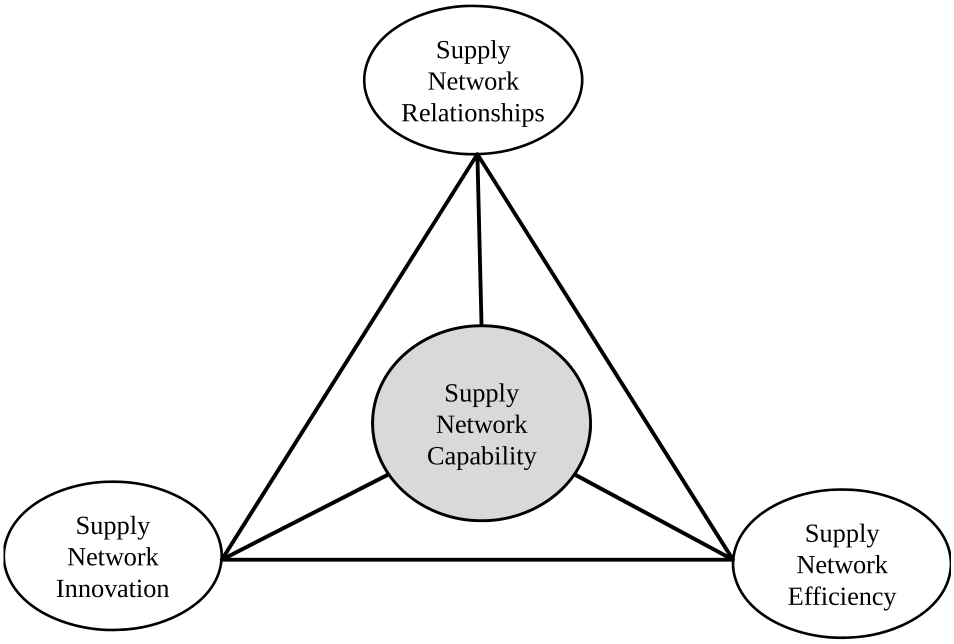

Figure 3. Three dimensions of supply network capability

2.3 Supply network efficiency

According to Moller and Torronen (2003), efficiency refers to the efficacious use of current resources that means, getting more out from the resources used. Improving efficiency (that is doing more using fewer resources) is an essential capability for co-creation of value in a supply network. It is not just efficiencies of individual firms or organisations in a supply network, but the efficiency of the whole supply network that is key for value co-creation. However, efficiencies of individual organisations contribute towards cumulative efficiency of the entire supply network. In a supply network, two typical indicators/metrics used for stating efficiency are cost and time (or lead time). For example, a gain in efficiency results in lower production/transaction costs and /or shorter lead time. In a supply network, improvement in efficiency can be achieved by fine-tuning and re-engineering the operational activities and operational strategies of the suppliers and customers, and the exchange processes linking them (Moller and Torronen, 2003). In a supply network, efficiency is the major underlying factor affecting direct-value functions (such as profit, volume, safe-guard functions of business) (Walter et al., 2001). In addition, supply network efficiency can be influenced by the other two capability dimensions – supply network innovation and supply network relationships and vice-versa. For example an innovation in operational processes in a supply network and development of strategic alliances between the members of a supply network could lead to improved supply network efficiency.

Over the years, a major proportion of research had been devoted towards improving and managing efficiencies of supply networks. These result in formulation and development of some of most influential operational management philosophies of the twentieth and twenty-first centuries such as mass production systems, lean systems (or Toyota production systems), agile systems, lean-six-sigma, and lean-agile systems. In the domain of each of these management philosophies, several tools and techniques had been developed for improving efficiencies of organisations in a supply network. In this paper, we are not repeating them.

2.4 Supply network innovation

Innovation is an important capability for an organisation for co-creation of value with other organisations in a supply network. In a supply network context product/service innovation (i.e. what is offered by a firm) and process innovation (i.e. ways in which a firm creates and delivers its offerings) are two key facets of innovation (Bessant *et al.*, 2005). Phillips *et al.* (2006), and Abernathy and Clark (1997) assert that in a supply network, managing innovation by an organisation is closely linked with its ability to build and maintain relationships with other organisations within and across a supply network. Also, innovation can influence the supply network efficiency dimension, as innovative product/service and/or processes could lead to improving efficiencies in supply network operations and strategies. In this section, we provide an overview of definitions of innovation and different types of innovation pertinent to a supply network context.

2.4.1 Definition of innovation

Innovation is regarded as a major source of an organisation’s competitive advantage. McKeown (2008) describes innovation as a change in thought process for doing something, or the useful application of new inventions or discoveries. Goswami and Mathew (2005) report an extensive survey of literature on definitions of innovation. They observe that both research communities and industries use multi-perspective approaches to define innovation. However, most of the widely used definitions of innovation focus on novelty and newness.
Galli (2011) and Roberts (2007) define innovation as the commercial exploitation of new ideas or inventions. By this definition an innovation process ranges from the *generation of an idea or invention* (Front end of innovation) through *idea realisation & development* to *commercial exploitation of idea or innovation* (Commercialization).

In an organisational context, Baregheh *et al.* (2009) describe innovation as ‘the multi-stage process whereby organizations transform ideas into new and/or improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace’. Innovation can be linked to performance and growth through improvements in efficiency, productivity, quality, technology, competitive positioning, and market share. It is needed for survival in a competitive environment. Innovation typically adds value to an organization and its stakeholders but involves risks. In an organizational context, innovation is often found in what is being offered by a firm (product/service innovation) and/or in the ways in which a firm creates and delivers its offerings (process innovation) (Bessant *et al.*, 2005).

2.4.2 Types of innovation

In terms of degree of innovativeness (or pace of change), innovation may refers to either an ‘incremental/steady-state emergent’ (i.e. continuous) or a ‘radical and revolutionary’ (i.e. discontinuous) change and development in thinking, products/services, processes, or organisation.

From the perspective of partnership and control strategies adopted for innovation management, innovation can be of either a ‘closed’ or ‘open’ type (Chesbrough, 2003). The underlying premise for closed innovation models is that successful innovation requires control and ownership of the intellectual property. In closed innovation, an organisation itself controls and manages its innovation activities such as idea generation, idea realisation & development, and commercialisation (including marketing, distribution and financing). In open innovation, an organisation carries out innovation activities by forming risk/reward sharing partnerships with other external and internal organisations. The open innovation paradigm assumes that firms can and should combine internal and external ideas as well as internal and external paths to market to advance the development of new technologies, products or services (Chesbrough, 2003).

From another perspective, innovation can be regarded as science-based, technology-based (technological innovation for product/process/service development), or experience-based (innovation for product/process/service development and organizational operations) (Floricel and Dougherty, 2007). Science-based innovation leads to flows of new technological principles based on new scientific paradigms and discoveries; technology-based innovation leads to new applications and functions as well as growth of performance in core technologies; and experience-based innovation leads to steady cost/lead-time reduction, higher market penetration and reliability, and new applications of standard capabilities.

Floricel and Dougherty (2007) assert that activities relevant to innovation can be broadly classified into four broad categories, sometimes seen as sequential stages in the flow of innovation activities: scientific, technology development, product/service development, and operational. The outputs of one type of activities enable and trigger other types, typically downstream. For example, the results of technology development enable the development of new products, which, in turn, enables production and commercialisation.

2.5 Supply network relationships

An essential capability of an organisation for co-creation of value is the ability to build and maintain relationships within and across supply networks. In a supply network, an organisation's capability to build and maintain relationships with other organisations could affect the other two capability dimensions (i.e. supply network innovation and efficiency) and vice-versa. In this section, we provide an overview of supply network relationships, their nature, different types of supply relationships, and supply relationship characteristics.

Supply network relationships group organisations entering into business relationships in order to secure supply and demand as part of a market dynamic (Lambert and Knemeyer, 2004).

2.5.1 Nature of supply relationships

Relationships amongst firms in a supply network can be either of competitive, cooperative or co-opetitive in nature.

Competitive relationship: Competition describes contests or rivalries between two parties and units. For example, in a supply network competition between firms can be for resources, capabilities and market shares. In a supply network, competition amongst firms can be both direct (e.g. where products/services which perform the same function compete against each other) and indirect/substitute (e.g. where products/services which are close substitutes for one another compete).

Cooperative/Non-competitive relationship: Cooperation is the process of working or acting together, which can be accomplished by both intentional and non-intentional agents. In terms of relational states, cooperative relationships are the opposite of competition (Contractor and Lorange, 1988).

Co-opetition relationship: The term 'co-opetition' was introduced by Brandenburger and Nalebuff (1996) in game theory by bridging competition with cooperation. In supply networks, a co-operator could suddenly become a competitor. It is sometimes possible to get co-operation from a long-standing competitor. In supply networks, two firms can co-operate (e.g. in the form of partnership or collaboration) in one project or area while competing in other projects or areas at the same time.

2.5.2 Types of supply relationships

Wagner and Boutellier (2002) present a classification of supply relationships that are cooperative/non-competitive in nature. They are based on the duration of a business relationship (i.e. short-term, medium-term, long-term), the frequency of business interactions (i.e. one-time, infrequent, frequent, ongoing/continuous), the type of business exchange (i.e. discreet or relational), and the degree of joint commitment between firms in a supply network. An adapted version [from (Wagner and Boutellier, 2002)] of different types of cooperative supply relationships and their key attributes are presented in the Table 1.

Table 1. Different types of cooperative/non-competitive supply relationships and their key attributes (adapted from (Wagner and Boutellier, 2002))

	Transaction (one-time - repeat)	**Coordination**	**Collaboration**	**Alliance**
Firms in relationship are in ...	Market-based competition	Selective competition	Selective partnership	Strategic partnership
Duration of business relationship (Relationship lasts for ...)	Duration of transaction (short-term)	Duration of contract (medium-term)	Duration of project / product / service series lifecycle (long term)	Duration of project / product / service lifecycle and beyond (very long-term)
Frequency of business interactions	One-time – very-infrequent	Infrequent – medium-frequent	Frequent	Ongoing / continuous
Intensity of relationship	Low	Medium	High	Very high
Type of business exchange	Discreet	Relational	Highly relational	Very highly relational
Strength level of business relationship	Operational	Operational / Selectively Tactical	Tactical / Selectively Strategic	Strategic
Degree of cooperation / joint commitment	Low	Medium	High	Very high
Degree of alignment and/or integration	Firms are neither aligned nor integrated	Firms (may be) aligned to some extent but not integrated (or integrated to a very limited extent)	Firms are aligned and (may be) integrated to a limited extent	Firms are aligned and several departments/units of both firms (may be) formally integrated
Know-how is usually...	Kept internal within firm boundary	Kept internal within firm boundary	Kept within firm boundary but may be shared / jointly built with the partner	Shared / jointly built with the partner
Level of firm's capabilities needed to manage relationship	Low	Medium	High	Very high
Amount of firm's resources needed to manage relationship	Small	Medium	Large	Very large

Table 2. Supply relationship characteristics and their indicators (adapted from (Johnsen *et al.*, 2008))

Relationship Characteristics	Definition	Indicators
Mutuality	Extent to which two actors demonstrate their interest in the well-being of one another and how they seek common goals or interests	– What is our level of concern in the well-being of the other party? – Do we pursue common goals or interests? – Are we willing to relinquish individual goals in order to increase the positive outcomes for other party, and thereby our own well-being (win-win)?
Particularity	Direction, uniqueness and commitment in a relationship, when compared to other relationships of the companies, or the extent of standardization / adaptation of interaction	– What is the extent of dedicated individual efforts of one party (e.g. production processes or designs) of suppliers geared towards our specific needs? – To what extent is the other party committed to us in comparison with other relationships in its portfolio? - Levels of adaptations, or asset specific investment that one party makes to the other
Co-operation	Extent of working together towards a shared aim or direction for the relationship	– To what extent is the relationship characterized by co-operative rather than contentious interaction?
Conflict	Extent of perceived differences between parties, causing friction and disputes, but also potential for creativity	– What is the extent of disagreement or disputes over e.g. specifications, or nature of orders or agreed designs?
Intensity	Extent of contact and resource exchange between firms in a relationship	– What is the number of staff or groups involved in relationship? – How frequently do we meet face-to-face? – What is the extent of senior manager involvement in this relationship?
Interpersonal Inconsistency	The personal expectations and individual interests influencing interaction and the extent of perceived variation in other actor's approach to interaction between individuals or departments	– Are there great differences between how individuals or departments interact with other party? – To what extent do we send or receive mixed messages from different parts of company or different individuals?
Power/ Dependence	Extent to which an actor - implicitly or explicitly - can get another actor to do something that they would not otherwise have done Dependence is the obverse of power as the more dependence of one party on another the less power the former has within that relationship	– What is our ability to persuade other party to do something they do not want to do? – Are we in a position to influence decisions and actions of other party? – What is the proportion of our business with other party? – To what extent are we reliant on other party's technology or knowledge e.g. where other party's technology or capability is unique or unmatched?
Trust	The expectation held by one actor about another that the other responds in a predictable and mutually acceptable manner	– Are we confident that other party will adhere to the contract? – Are we confident that other party will perform tasks in excess of agreed terms and conditions? – Are we confident that other party has competence to be able to produce what contract requires?

Complementary supply relationships: When two products or services go together simultaneously or complement each other, there exists a relationship called a complementary relationship - a kind of business symbiosis. For example, automobile and its fuel or computer hardware and software are complements. From a product development perspective, Munksgaard and Freytag (2011) define complementors as development partners ‘whose outputs or functions increase the value’ of a company's own innovations. A complementor is a firm typically outside a given industry or supply network that has a significant influence on the success of that industry or supply network (Coleman, 2001). When businesses enter new markets, attention to complementary firms and organizations is critical (Power, 2004). Without key complementors, the market may never take off.

2.5.3 Supply relationship characteristics

Johnsen *et al.* (2008) present a set of supply relationship characteristics and their indicators as part of their supply *Relationship Assessment Process (RAP)* model and *Supply Relationship Evaluation (SRE)* model. These relationship characteristics are basic elements of relationships between firms in a supply network. They can help in understanding relationship mechanisms that are in place with a supply network and can act as an important tool to evaluate and manage those relationships. Table 2 presents an adapted version of the relationships characteristics compiled by Johnsen *et al.* (2008).

3 Case study: example Integrated Supplier Compliance and Capability Assessment system

Table 3. An example integrated supplier capability and compliance scorecard

Question No.	**Functional Applicability**				**Question**	**Contract Reference**	**Assessor Comment**	**Compliance Y/N**	**Capability (0-5)**	**Capability Score**
	Qual	Ops	Logs	Eng						
12					Does the supplier have a process to detect Foreign Object Debris (FOD)?	SGR 7.5.1.5				
13					Does the supplier ensure that all incidents of actual or potential FOD are reported and investigated?	SGR 7.5.1.5				
14					Does the supplier have appropriate FOD management/leadership?				0 - FOD focal point not assigned 3- FOD focal point assigned but limited accountability 5 - FOD focal point assigned with appropriate authority from senior management	
16					Does the supplier have a process for measuring FOD occurrences and providing feedback?				0 - No metrics exist 1 - Metrics are used in areas to measure performance 2 - Management proactively use metrics to improve performance.	

The case study used in this research was an integrated supplier compliance and capability assessment system used by an UK-based OEM (Original Equipment Manufacturer) in the aerospace sector. Traditionally, for the selection and approval of suppliers, the UK-based OEM assesses compliance of each supplier to contractual requirements; these requirements are derived from the OEM's internal and external stakeholders. The OEM performs questionnaire-based audits to assess suppliers' compliance to these requirements. Increasingly, the OEM is finding it important to assess the capability of their suppliers in addition to compliance. This has led to the development of an *Integrated Supplier Compliance and Capability Assessment* scorecard. A small fragment of this scorecard is presented in Table 3. It can be seen that the questionnaire is designed to assess both compliance with explicit references to clauses in the OEM's contract and capability requirements.

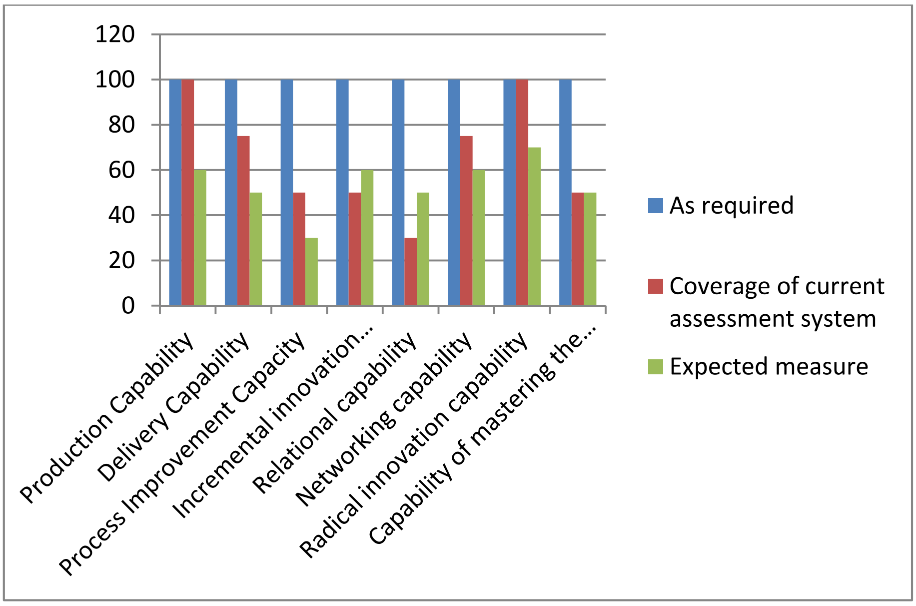

Figure 4. Results from a study on how Moller and Torronen's (2003, pp. 115) list of supplier value-production capabilities can be applicable in practice for assessment of suppliers of engineering commodity in aerospace sector

Moller and Torronen (2003, pp. 115) present a list of value-production capabilities of a typical engineering supplier and the example indicators for each of these capabilities in the list. The supplier value-production capabilities included in Moller and Torronen's (2003, pp. 115) list can be categorised using the three supply network capability dimensions depicted in Figure 3. For example efficiency dimension (production capability, delivery capability, process improvement capacity, and capability of mastering the customer's business); innovation dimension (incremental innovation capability, and radical innovation capability); and relationships dimension (networking capability, and relational capability). In this research, we investigate how Moller and Torronen's (2003, pp. 115) list of value-production capabilities can be exploited in practice by using a case study on the assessment of engineering commodity suppliers by a UK-based OEM in the aerospace sector. Early results obtained from this study are presented in a histogram shown in Figure 4.

4 Discussion

Zhang and Gregory (2011) propose a framework for managing global network operations along the engineering value chain. Their framework covers the whole engineering value chain from idea generation to disposal. This research, however, focuses on network structure and external relationships from a design perspective. Specifically, the research takes a strategic perspective on the development and management of relationships in design engineering value chains. In contrast to of the assessment of manufacturing value chains, where the unit of assessment is usually a physical artefact with an unambiguous specification (often in the form of engineering drawings), the unit of assessment in a design value chain is the less tangible capability to respond to design briefs. From the literature, key indicators of suppliers' value production capabilities were identified. These categories of capability were applied to a sample group of design suppliers to a UK-based OEM. Early results have led to the following questions:

(i) How can capability profiles be articulated across supply networks?

(ii) How can required capability profiles be determined?

(iii) How can profiles of given suppliers be measured?

(iv) How can the assessment process contribute to supplier capability development?

Current practice is through audits and questionnaires that are a core part of an OEM's supplier selection and development processes. The research is informing the development of a design engineering capability assessment system that will support the definition and evaluation of supplier improvement programmes.

5 Conclusions

It is important for customer organisations to define their capability requirements and measure suppliers against them. From an understanding of capability requirements, a customer can specify them for a particular task, and so measure capability in addition to compliance. In the future, these measurements could inform the definition and deployment of capability development programmes.

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Role of Policy in enhancing Manufacturing Competitiveness of India

Dr. Amit Kapoor
Honorary Chairman
Institute for Competitiveness, India
E-Mail: amit.kapoor@competitiveness.in

Anshul Pachouri
Senior Researcher
Institute for Competitiveness, India
E-Mail: anshul.pachouri@competitiveness.in

Dr. Tomas Harrington
Senior Research Associate
Institute of Manufacturing
University of Cambridge, UK
E-Mail: tsh3@cam.ac.uk

Abstract
The rising debt, slowing growth and increasing unemployment has seriously affected the Indian economy in recent times. Indian economy is predominantly driven by Service sector which contributes to more than half of its GDP. On the other hand, the contribution of manufacturing in India's GDP has remained stagnant to nearly 17% and contribution of India in world manufacturing has increased by merely 1% in past two decades. It is very recent that India has started counting big on manufacturing.

Business environment, in which manufacturing sector operates in India, differs among various states due to state-level policy interventions, availability of resources, and geographical factors. India has a huge diversity in terms of manufacturing growth and stage of economic development among its states. For instance, two states Maharashtra and Gujarat alone contributes 34% in total Gross Value Added in the manufacturing sector in India. It clearly implies that to find out the various factors which affect the manufacturing competitiveness of India, it is very important to understand the state-level interventions.

This paper aims to bring out different state-level policy initiatives which have led to high growth in the manufacturing sector in their region. The paper discusses the key aspects of State Industrial Policy and explores its role in enhancing the overall manufacturing competitiveness of India in global economy.

Keywords: *Policy, Manufacturing, India, Competitiveness*

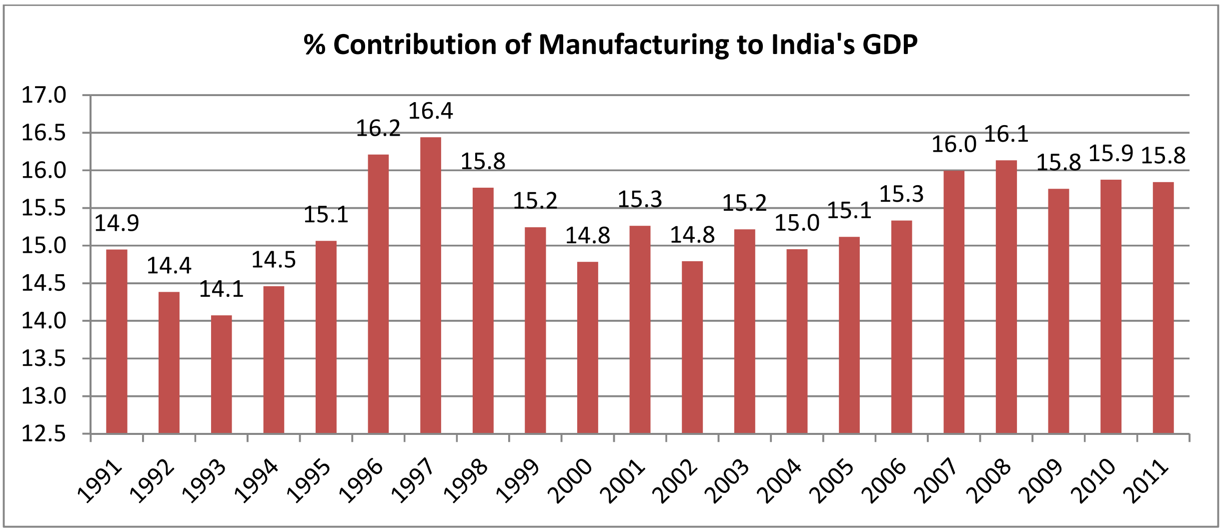
1. INTRODUCTION

Manufacturing sector is seen as a remedy by policymakers and industry to restore the growth story of India. It is considered as the backbone of the economy which has the potential to create 100 million jobs by 2025 due to its multiplier effect as declared in the National Manufacturing Plan of India, prepared by the Government of India. The importance of the manufacturing sector can also be understood by the fact that it employs around 11% of the total labor force of the country which is estimated to be around 49 million.

With the change in global dynamics, India is now seen as a new sourcing destination for manufactured products which involve design and precision. This new image coupled with huge domestic market promises a good future for the Indian manufacturing sector. However, there are many bottlenecks like shortage of skills, absence of advanced technology, capital constraints and lack of supportive business environment which adversely affects the manufacturing competitiveness of India in global economy.

The contribution of the manufacturing sector in India's GDP has remained nearly stagnant to 17% for the past two decades as shown in Figure 1. It implies that India's manufacturing hasn't improved in real terms as compared to overall economic situation of the economy.

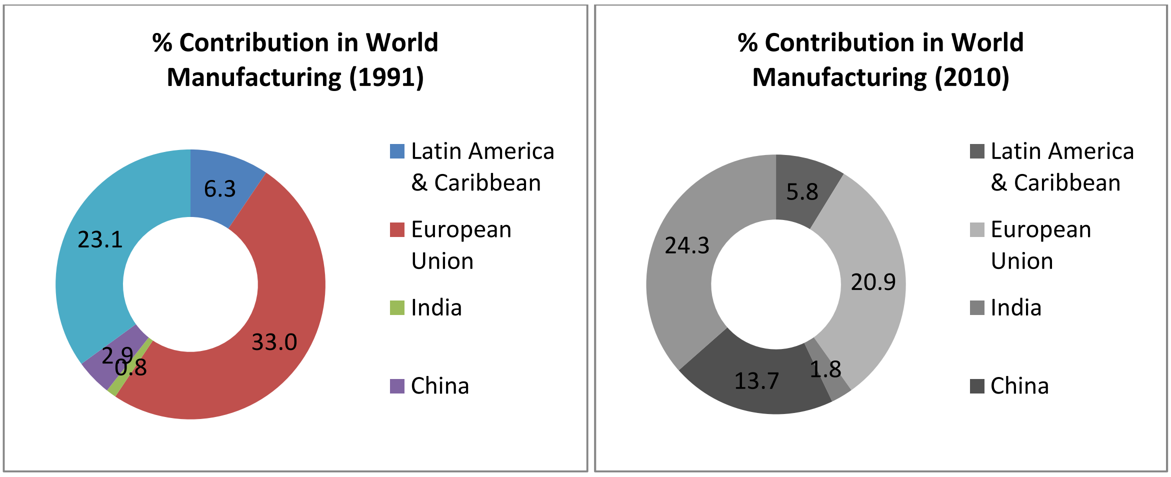
Figure 1: Percentage Contribution of Manufacturing in India's GDP



(Data Source: Central Statistical Office)

The contribution of India's manufacturing in world manufacturing was just 0.8% in 1991 as compared to 2.9% of China. Twenty years later in 2011, the share of India's manufacturing in world's manufacturing has improved by merely 1% while in China case it has improved by over 10%. It can be said that the increment of China's share in world manufacturing comes at the cost of European Union whose share in world manufacturing has declined from 33% in 1991 to 20.9% in 2011.

Figure 2: Percentage Contribution in World Manufacturing



(Data Source: World Bank)

India is a combination of 28 states and seven union territories. The complete list of states and Union Territories of India is given in Appendix 1. Each state of India is significantly different from other in terms of its culture, traditions, natural resources and more importantly business environment. Business environment of a state is highly influenced by the state's industrial policy. The Industry policy sets the guidelines and rules with which the industrial and manufacturing units are governed in the state. It also sets the various incentives and schemes given the state government to the Industry. The Industrial policy of the state is revised from time to time.

The detailed study of Industrial policy of all the states is being done to find out state-level policy interventions that affect the manufacturing competitiveness. The state-level policy initiatives are divided into eight sub-sections/heads to study the policy interventions at the deeper level as mentioned below.

1. Land and Infrastructure Support
2. Exports Promotion and Marketing Assistance
3. Technology and Quality upgradation
4. Power
5. Tax Benefits and Subsidies
6. Investment Promotion and Cost of capital
7. Skills Development and Labor issues
8. Doing Business Conditions
9.

These above eight parameters are identified as the most important factors that shape the business environment of any region from the literature. The subsequent sections of the paper discuss the state level policy initiatives based on these parameters.

2. LAND AND INFRASTRUCTURE SUPPORT

Land is the primary requirement for the growth of the manufacturing industry. Due to the delay in the implementation of land reforms in India, it is not very easy for the companies to acquire a land. According to Doing Business Report 2012, it takes 44 days to register a property, and 227 days to deal with the construction permits in India. It clearly shows the difficulty level faced by the companies in resolving the land issues.

Different initiatives are taken by different states of India to tackle the issue of land acquisition, and infrastructure development in their region. The first and foremost in this is the development of industrial estates, industrial parks and special economic zones, etc., which are dedicated only for the industry. It is found that every state in India is focusing on development of these dedicated industrial development zones. The modes of development of these industrial zones are either through public investments and inviting investments from the private sector under 100% ownership by the private sector or Public-private partnership model.

The state governments are taking various initiatives for developing the supportive infrastructure like roads, water-supply, electricity, and telephone connectivity, etc. to attract more manufacturing units in their region. Certain States like Rajasthan, Punjab, and Madhya Pradesh, etc., have developed a land bank system in which land is identified and reserved for the development of Industrial parks/ estates or new manufacturing units. Their land bank aims to streamline the land acquisition process, use surplus and wasteland, and develop clear & effective land acquisition law. A larger area of land has still remained with the agriculture sector in India which makes land availability difficult for opening of new manufacturing units. States like Karnataka and Andhra Pradesh are easing the process of land use conversion from the agriculture to Industry by partially or fully removing the land use conversion charges. Many states have a scheme for the reservation of land for SMEs in industrial parks/estates, for promoting local entrepreneurship and employment. Other incentives like rebate in land cost for SMEs have also been introduced across many states.

It is observed more than half of the states are giving subsidy on the purchase of the land through reimbursement of partial or full stamp duty. Dedicated Industrial development corporations have been formed in some states to prioritize the development of infrastructure and attract private investments in this sector. Some states like Gujarat, Tamil Nadu and Uttaranchal have adopted sector specific infrastructure development approach by developing dedicated Automobile Industrial Estate, Textile parks, etc. in parallel to overall industrial zone development strategy.

There is a lot of attention given to the states on improving the transportation infrastructure and facilities in their region. Many states are trying to implement inland container depot facility for fast movement of manufactured goods from one place to another. Other initiatives like development of dedicated logistics parks and freight corridors have also now been taken both by state and central government with the help of the private sector. One example of the same is undergoing development of Delhi-Mumbai dedicated freight corridor, which is Indo-Japan joint mega project with the expected cost of 90 billion US $. The corridor encompasses overall length of 1483 Km and passes through six states namely Uttar Pradesh, Delhi, Maharashtra, Haryana, Gujarat and Rajasthan. The aim of this ambitious project is to make Delhi Mumbai Industrial corridor as "Global Manufacturing and Trading Hub" (DMIC, 2012).

3. EXPORTS PROMOTION AND MARKETING ASSISTANCE

India's population of 1.2 billion people makes it a very attractive market for manufactured products. But with the reduction of tariff barriers, imports from China have affected Indian manufacturing industry in a very negative manner. Moreover, if India wants to increase its share in world manufacturing, which is just 1.8% approx at present, it has to focus on exports promotion and marketing assistance given to the domestic manufacturing units. Realizing the importance of export in the development, most of the states have adopted new schemes to promote exports and provide marketing assistance to the manufacturing industry.

The most common form of incentive given by various states is the support in the development of the dedicated exports parks and zones. The incentives for establishing these zones, comes in the form of capital subsidy, power incentives, interest rebates, etc. and varies from state to state. The state of Haryana aims to set up a clear-cut policy of setting up Special Economic Zones which can be a major boost to increase the exports. Few states like Uttar Pradesh, Uttaranchal and Bihar are trying to establish permanent display-cum-convention centers for showcasing export-oriented products with the help of private sector. There is an increased importance given to display the textile, apparel and products of Village & Khadi industries in these convention centers. One good example is the effort to establish Urban Haats by the states of Bihar and Maharashtra.

Many States are trying to organize trade-fairs and road-shows to connect entrepreneurs/manufacturing enterprises with global markets. Adequate support to SMEs and manufacturing units is also being given by some states to attend trade fairs and events outside India. These support mechanisms will help the states in a positive manner to increase exports from their region. States of Keraka, Karnataka, and Uttaranchal are encouraging common branding and marketing efforts for artisans and village & khadi industry products. This new innovative mechanism has a big potential to revive this sector, but how much successful it would be, is still the question mark. Apart from above, states are encouraging the development of new value added products by weavers which can compete both in national and international markets. It is observed that most of the states are introducing various schemes for the promotion of village and *khaadi* industries in their region which can also be seen as traditional manufacturing sector. Most of the states are found to give more preference to local small scale units in government procurements. In Himachal Pradesh, to avoid uncertainty in operating environment, the provision is discussed in which workers need to give 14 days prior notice before going to strikes in export oriented units. Relaxations in certain labour laws, like allowing hiring of workers on contracts and working of women in night shifts, is given under certain conditions. Certain states, like Tamil Nadu, are also developing trade portals in collaboration with industry bodies to connect manufacturing units directly with importers. With the establishment of export promotion council, some states are improving the service of market intelligence, product information, export documentation and financing support. Support and subsidies to obtain international certificates like Conformity Europenne and China compulsory certificate is also given in the state of Karnataka. Freight subsidy in the import of raw-material to be used in manufacturing export products is also given in state of Uttar Pradesh.

4. TECHNOLOGY AND QUALITY UPGRADATION

Technology plays a very vital role in the manufacturing sector today. The demand is shifting towards hi-tech manufactured goods in the world, which has given new direction to the manufacturing practices and production techniques. It is a well established fact that technology up gradation is closely related to the quality of product and productivity of a manufacturing unit. The Indian states are taking various steps to facilitate the adoption of latest technology by manufacturing units especially in the MSME sector.

Many states have introduced 50-100% support mechanisms to manufacturing units to get patents and quality certifications. These support mechanisms come in the form of capital subsidy, information and help in filing applications for patents, quality certifications, and legal help, which varies from state to state. The maximum amount of money, which companies get in the form of capital subsidy to get patents and quality certifications also significantly varies from INR 0.2-0.5 million.

The states of Tamil Nadu and Haryana aim to establish center of excellence to undertake quality research on specific manufacturing sectors like Automobile in collaboration with the private sectors. These centers can be leveraged in developing low cost high-tech production methods for better design, quality, and productivity. Several states are also focusing to improve the research facilities in existing industrial research centers and laboratories. The scheme of contractual research for industry in research centers and academic universities is also been discussed and encouraged.

There is an extensive incentive and support mechanism by various states like Maharashtra, Odisha, Uttaranchal, Arunachal Pradesh, Punjab, Manipur, Jammu and Kashmir, etc. for upgrading the technology and quality of the manufacturing units. These support schemes cover capital and interest subsidy on the purchase of the equipment and technical know-how assistance taken from approved research institutions; installation of testing equipment and setting up of laboratory in the plant. All of these schemes vary from state to state. Few states, like Karnataka, are one step ahead and giving capital subsidy for installing rain-water harvesting technology, waste-water harvesting technology and zero discharge process to promote green manufacturing and reduce pollution levels. On the similar lines of Karnataka, the states of Punjab and Rajasthan are encouraging the establishment of carbon credit mechanism and introducing the scheme of assisting companies in earning more carbon credits.

5. POWER

Power availability is one of the key drivers of industrial and manufacturing growth in a region. Good availability and reliable supply of power ensures that manufacturing units need not to be dependent on the expensive captive power sources which in turn reduces the costs of operations. On the other hand, non-adequate power supply can result in high operating costs which negatively affect the competitiveness of the manufacturing sector.

It is seen that most of the states are giving power subsidy in the form of rebate in power cost per unit. This power subsidy is given for a limited number of years from the date of commencement of the commercial production and actual rebate per units vary from state to state. The power subsidy varies significantly in the same state itself in the case of Chhattisgarh depending on the development status of the area in which unit is operating and Industry it belongs to. For instance, a manufacturing unit in the priority sector operating in economically backward area gets more rebate than a unit in priority sector operating in economically developed area.

Most of the states are facing the problem of energy deficit in India. According to Central Electricity Authority, Government of India the energy deficit in the month of July 2012-13 is 8.1%. To tackle this problem, states like Gujarat and Rajasthan are encouraging the establishment of new power plants by the private sector by providing them land in a time bound manner and subsidy on stamp duty. Many states have also encouraged the establishment of captive power plants and allow them to sell the surplus power to nearby manufacturing units. The states are focusing to provide reliable power supply to the industry sector and permanently remove the energy deficit.

The efforts have also been strengthened to improve the plant load factor and increase private sector participation in power transmission and distribution as well. In northeastern states of Manipur and Assam, capital subsidy is given to the manufacturing units to link the main power line to the factory shed when power supply is not available in any area. Few states like Uttar Pradesh has introduced the scheme of providing continuous power supply to manufacturing units with high fixed investments in the region through dedicated feeders.

However, due to recent slowdown in economic growth, problems in the availability of coal, and huge losses incurred by state electricity boards, it is skeptical that how states will be able to provide uninterrupted and reliable power supply to the manufacturing sector. Another big concern is that more than half of the power in India is generated from thermal power plants which are again dependent on timely supply of coal and a non-renewable source of energy. The state of Gujarat is becoming successful to increase the installed capacity of electricity generation with fresh private investments in renewable sources of energy and sets an example for other states.

6. TAX BENEFITS AND SUBSIDIES

India is ranked 147 in paying taxes parameter in Doing Business Rankings 2012 by World Bank. According to Doing Business Rankings, the total tax in India accounts for 61.8% of the profits as compared to 44.4% in South Asia and 42.7% in OECD countries. It implies that India has one of the highest tax rates in the world. The total tax need to be paid by any firm varies from state to state. Certain taxes like corporate income tax is levied by central government, while value added tax is levied by state government.

The state governments are trying to reduce the over-burden of taxes in a rationalized manner. Many states have taken positive step of reimbursing partial Value added Tax and central sales tax levied by them to companies. The actual amount of reimbursement and number of years for which tax benefits are given to companies from the government varies from state to state. The amount of reimbursement is also dependent on size of the manufacturing firm that is whether it belongs to small scale enterprise, medium scale enterprise and large scale enterprise.

Few states, like Bihar also give exemptions in various other taxes like luxury tax, market fees, and electricity fees for limited number of years to manufacturing units under certain conditions. The state of Chhattisgarh reimburses 50% of the mandi fees (form of market fees) on the purchase of raw material from Krishi Upaj Mandi under following conditions. Few states are also giving partial or full exemption from central excise tax and entry tax on purchase of raw-materials and inputs used in the production process for limited number of years. The states are also trying to ensure free movement of goods among each other by reducing the tax barriers to the minimum or completely removing all the taxes levied on transportation. The states are also holding periodic reviews to continue tax benefits given to the Industry and manufacturing sector. To give boost to the food-processing industry, state of Jharkhand has exempted mandi fees on the purchase of agriculture produce procured by the processing units.

The states of Uttar Pradesh and Maharashtra give support to buy machinery in form of capital investment or interest rate subsidy to new manufacturing units. Many states give financial assistance to manufacturing units to prepare their project report which needs to be submitted to the government for availing loan facility. The actual amount of project report subsidy varies considerably from state to state, and depends on the size of the manufacturing unit. The state of Goa has introduced an employment subsidy scheme for small scale manufacturing units under which it gives additional financial support to workers.

The north-eastern states of Meghalaya and Tripura give a very high transportation cost subsidy on the transportation of raw-material and finished goods from their region due to their lower integration with the rest of the country. In continuation of this, the states of Punjab and Manipur also give partial air freight and sea freight subsidy on exports of products to other countries. Few states also gives exemption from stamp duty paid in respect of loan agreements, mortgages and other deeds executed to avail loan from the government.

7. INVESTMENT PROMOTION AND COST OF CAPITAL

India is ranked 40th among the world in the area of "Getting Credit" in Doing Business Rankings 2012. It implies that India is far behind many countries in terms of making easy availability of the credit to entrepreneurs.

The most common form of investment promotion scheme introduced by the states is the investment subsidy on the fixed capital investment made by a manufacturing unit. The actual percentage of subsidy on fixed capital investment, and maximum amount of subsidy significantly varies from state to state. Apart from investment subsidy, interest rate subsidy is also given in many states on the loans taken by the manufacturing units to establish new plants. It is found that interest subsidy on fixed capital investment also significantly varies from state to state.

Few states, like Goa and Haryana, have set-up state-level investment promotion board to attract investments from the private sector. These investment promotion boards are responsible for timely approval of investment proposals and tackling of issues raised during the process. Some states like Odisha have set-up a permanent Industry promotion cell in Delhi (Capital of India) to attract businessmen and investors to invest in their region. These promotion centers or Industry cells of various states organize business meetings at regular intervals, and acts as an information provider & facilitator to entrepreneurs who wish to invest in their states.

The states of Rajasthan, Maharashtra, and Odisha are trying to form a separate entity to attract foreign direct investment from investors and National Foreign Residents of India (NRIs) and address the issues and concerns of this community. Goa and Gujarat are assisting SMEs in getting equity support from the investors which can certainly solve the problem of financing to a certain extent. The state of Maharashtra has started seed fund facility for unemployed educated youth by giving financial support in form of 10-22.5% of the total project cost subject to the maximum limit of INR 1 million. Few state governments are paying attention and taking steps to avoid any problem of shortage of money for lending to industry by state development corporations and financial institutions.

Tamil Nadu has started giving case to case incentives for the expansion of new manufacturing units and expansion of existing units with fixed capital investment of more than INR 25 million in the state. It is observed that many states are giving case based incentives to mega manufacturing projects in their region. These mega projects are given high priority and given faster clearances and approvals from all concerned government departments. Some states like Tamil Nadu, Maharashtra, Sikkim and Rajasthan are giving sector specific incentives to give boost to the development of particular sector like textiles, handlooms, agro, and food processing in their region. This cluster based investment promotion approach seems to be more effective rather than overarching investment promotion incentives for all sectors. Few states are also found to tailor investment promotion subsidies and schemes based on the potential of a particular manufacturing unit to create local employment.

8. SKILLS DEVELOPMENT AND LABOR ISSUES

There is a huge skill demand and supply gap in developing economies like India. The literacy rate of India is estimated to be 74%, and combining it with lower enrollment ratio in secondary education creates a void in the skill availability in the country. To address the challenge to skills availability in developing economies, it is very important to solve the root cause of the problem, i.e. low quality and availability of secondary education. Unless and until, people don't have basic elementary and secondary education, it is next to impossible to imagine the skilled workforce in a country. Vocational training is seen as an effective way to supply skilled labor pool with more than 4200 Industrial training institutes in India. However, Vocational training face challenges of the quality and its relevance for the industrial sector.

Many states are taking initiatives and putting their efforts for the upgrading of the vocational training institutes. Positive steps like the participation of Industry in the design of course-curriculum, nominating members of the industry in the governing council of the training institutes and providing internships to the students in the manufacturing units are being taken. The state governments are pursuing private sector to establish new vocational training centers through 100% private sector ownership or PPP mode to fill the gap between industry requirement and academic teaching. Under certain cases, state governments are also willing to provide land to the industry to open the vocational training institutes.

Goa has introduced production oriented training in the vocational training centers and steps are being taken to revamp the tools training center by introducing advanced precision and quality testing tool as per the industry requirement. Many states have started giving subsidy on the training of the employees by a manufacturing unit in the form of financial assistance to cover training costs. Few states, like Himachal Pradesh and Maharashtra, are considering the establishment of labor market information cell which compiles information on labor markets needs, skills availability, etc. and, introducing labor reforms like reducing the number of inspections required in the plant related to labor issues to the minimum.

The states of Uttaranchal, Meghalaya, and Rajasthan are giving financial assistance for the training to young artisan from established craftsmen to solve the problem of skills availability in villages and *khadi* industry. Several other initiatives like training on soft skills, entrepreneurship, inter-personal skills, and teamwork, etc. have also been taken by many states, but the effectiveness of these initiatives is still tough to judge as they are still not present on a large scale. More importance is now being given to the cluster development approach for skills development and set-up of sector specific vocational training centers with the help of renowned international institutions, academia, and industry. Tamil Nadu has started giving case to case budgetary support and incentives for skills development initiatives of various organizations which aims to work at the grassroots level. The state of West-Bengal and Tamil Nadu have started the scheme of partial reimbursement of amount spent on the employee insurance and provident fund to the manufacturing units to improve their investment climate.

9. DOING BUSINESS CONDITIONS

India is ranked 132 in Doing Business Rankings 2012 which shows that India is not a friendly nation for doing business. The number of procedures required to be followed in India are twelve as compared to the seven in South Asia and five in OECD nations. Most of the states are focusing on strengthening or implementing the single window clearance system for timely approvals of the proposals for setting up manufacturing units. It is a widely known fact that the most critical issue in opening a manufacturing unit in India is the large number of permissions and approvals which need to be taken from different concerned departments. With the implementation of the single window clearance system, a manufacturing unit just needs to make a single application online or offline which would be forwarded to various concerned departments. It is also mandated by the many state governments under single window clearance system that concerned departments should give approvals or raise issue if required in a time-bound manner.

Many states like Gujarat, Maharashtra and Chhattisgarh have taken a step forward and formed district level committees to address the concerns in doing business conditions of the manufacturing and industrial units. With the enhanced use of Information Technology in E-governance, several applications which need to be made by manufacturing units are made online with the facility of tracking the progress of the application. The steps have been taken for the computerization of payment of various taxes and land registration for better e-governance. Many of these initiatives are still under nascent stage or under observations through various pilot projects, but once they are implemented, the conditions of doing business in the manufacturing sector will be greatly improved.

Few states like Tamil Nadu, Haryana and Punjab have streamlined the process of environmental clearances which take a lot of time in the past and have introduced the provision of giving approvals in a time-bound manner. Much importance is given to improve the inter-departmental co-ordination within the government for effective functioning and timely approvals to set-up new manufacturing units and industry. The state governments have realized the fact that manufacturing sector is overburdened with regulations and inspections. To address this problem, many states have started the facility of self-certification and reduced the inspections of Industry inspectors to the minimum.

The state of Assam has introduced the scheme of land allotment to the manufacturing units in 30-60 days depending on the area required for setting up the plant. Many states have also introduced grievances addressal systems and industry courts for implementing effective dispute settlement mechanism to resolve complaints of the manufacturing units and industry. The state of Himachal Pradesh has taken a very important step of checking the truck unions from time to time so that they don't raise the price unevenly and prevent the free control over logistics industry. The states are also taking few steps forward to revive the sick industries and support them in their rehabilitation by waiving off their taxes and restructuring their loans.

10. CONCLUSION

There is no doubt about the fact that India is counting big on manufacturing sector to revive its economic growth. The state governments have taken various effective measures and initiatives to boost high growth in the manufacturing sector. The problem of land availability of timely acquisition has also remained a big problem, which is now being addressed by the government. Initiatives, like land bank system and allowing conversion of agriculture land into industrial land can solve this problem to a great extent.

India has a big domestic market to cater, but export growth of the manufacturing sector is also very important to increase the revenues of the firms. The state governments have taken some positive steps to assist manufacturing units to explore global markets, but these efforts are not sufficient considering the competition from China in international market. With global manufacturing giants setting up their production facilities in India, the penetration of sophisticated manufacturing techniques and advanced technology has increased in the country. The states are focusing high to improve the technology standards of the domestic manufacturing firms by giving subsidies on technology up gradation, getting patents and quality certifications.
Power availability is one of the bottlenecks in the India's manufacturing growth. The recent power crisis in 2012 which has left many states of India without electricity showcases the problem of power crisis currently going on in India. The decision to allow setting up of captive power plants and selling the surplus power is a good initiative taken by the states, but certainly increased the cost of doing business in the country. The corporate tax rate of India is one of the highest in the world. There is a lot of debate going on to reduce the current tax rate in the country and some states have taken a step forward to do so. But still, major chunk of the taxes are levied by the central government which remain unaltered. Under these circumstances, the taxation system of India is affecting competitiveness of the manufacturing sector in a very negative manner.

The capital and interest subsidy on the fixed investments is definitely going to help the entrepreneurs to set up manufacturing units. This current support mechanism to reduce the cost of capital and setting up of state investment promotion boards should be continued. India is struggling with huge demand-supply gap of skills in the manufacturing sector. The establishment of new vocational training under PPP mode will certainly solve the problem to certain extent. The different initiatives taken by the states need to be implemented more effectively on the ground and there is urgent need to improve the quality of primary and secondary education as well.

India needs to focus high on improving its doing business conditions as a whole. There are certain exemptions of states like Gujarat and Maharashtra which have done exceptionally well to give supportive and competitive business environment to the manufacturing sector. The implementation of single window clearance system, timely approvals from all departments to start a manufacturing plant and availability of capital are the main factors that distinguish these two states from the rest.

It is still very difficult to answer that how much promising the future of Indian manufacturing would be in the global marketplace. But looking at the several initiatives taken by states of India combining with recent high manufacturing growth of the Indian economy, it can be concluded that if the current trend continues India can certainly improve its share in world manufacturing in next 3-5 years.

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APPENDIX 1: LIST OF STATES AND UNION TERRITORIES OF INDIA

States	**Union Territories**
Andhra Pradesh	Andaman and Nicobar Islands
Arunachal Pradesh	Chandigarh
Assam	Delhi
Bihar	Dadra and Nagar Haveli
Chhattisgarh	Daman and Diu
Goa	Lakshadweep
Gujarat	Pondicherry
Haryana	
Himachal Pradesh	
Jammu and Kashmir	
Jharkhand	
Karnataka	
Kerala	
Madhya Pradesh	
Maharashtra	
Manipur	
Meghalaya	
Mizoram	
Nagaland	
Odisha	
Punjab	
Rajasthan	
Sikkim	
Tamil Nadu	
Tripura	
Uttarakhand	
Uttar Pradesh	
West Bengal	

APPENDIX 2: MANUFACTURING GDP AND TOTAL GDP OF INDIA

(Rupees in Crores)	Manufacturing GDP	Total GDP
1991	161979	1083572
1992	158094	1099072
1993	162979	1158025
1994	176982	1223816
1995	196133	1302076
1996	226458	1396974
1997	247975	1508378
1998	248101	1573263
1999	255872	1678410
2000	264114	1786525
2001	284571	1864301
2002	291803	1972606
2003	311685	2048286
2004	332363	2222758
2005	361115	2388768
2006	499011	3254216
2007	570436	3566011
2008	629052	3898958
2009	655775	4162509
2010	713428	4493743
2011	772960	4877842

Future development and motives of manufacturing offshoring among firms operating in Finland

Harri Lorentz (corresponding author)
Turku School of Economics at the University of Turku, 20014, Finland
+358 50 502 7087, harri.lorentz@utu.fi

Tomi Solakivi
Turku School of Economics at the University of Turku, 20014, Finland
tomi.solakivi@utu.fi

Juuso Töyli
Turku School of Economics at the University of Turku, 20014, Finland
juuso.toyli@utu.fi

Lauri Ojala
Turku School of Economics at the University of Turku, 20014, Finland
lauri.ojala@utu.fi

Abstract

Facing tight international competition and high production costs at current contexts for operations, companies may have to redesign their supply chains in terms of the locations for manufacturing and sourcing. This paper sheds light on the phenomenon of manufacturing offshoring, and backshoring, by reporting the perceptions of Finland based manufacturing firms on medium-term future production capacity adjustments in the home market and the so called low cost countries. We also report the firms' main motivations for moving production capacity from Finland. The descriptive results draw on the survey data collected by the authors for the Finland State of Logistics 2012 –report. The findings contribute to the literature on manufacturing offshoring and backshoring, provide a cross-sectional view on the phenomenon in Finland, and help policymakers to orientate for the design of strategies that aim to maintain a domestic manufacturing base, which remains an important foundation for economic prosperity.

Keywords: manufacturing, offshoring, backshoring, low cost countries

1. Introduction

Currently, many advanced economies experience the reality of industrial restructuring as manufacturing firms face high costs and as demand fluctuates in concert with the business cycles. With the closing down of factories and the relocation or outsourcing of capacity to the so called low-cost countries manufacturing jobs and capabilities are lost from the economy. This trend threatens competitiveness of countries, as for example Pitelis and Antonakis (2003) have found that the extent of manufacturing in the economy has a positive and significant impact on competitiveness. They conclude simply that “manufacturing matters”. On micro level, Pisano and Shih (2012) argue that the exodus of manufacturing from the U.S. has seriously eroded the capabilities of domestic companies to turn inventions into high-quality, cost-competitive products. They claim that there is no empirical evidence in support of the suggestion that advanced economies should not be engaged in manufacturing, and that such claims are in fact “dangerous folklore“. Denning (2011) has taken a similar position, and claims that with the changing economies in outsourcing, emergent technologies, and better measurement of the total costs of such arrangements, a tipping point may have been reached in the manufacturing offshoring phenomenon.

For Finland the above described phenomenon is very current. Forest industry has been closing down factories for several years already, leaving vacant facilities for server farms of such companies as Google, however, with much less of an employment impact. At the time of writing this article, Nokia, the Finnish mobile phone manufacturer with competitiveness problems, is in the process of closing down its lead factory in Salo, with major local and national level employment implications. The offshoring phenomenon, be it captive or outsourcing related (Olsen, 2006), has also been discussed in several reports, and some anecdotal evidence of backshoring (i.e. once offshored manufacturing capacity returning to home base; Kinkel and Maloca, 2009) has also been presented in the business press.

In order to help policymakers to orientate for the design of strategies that aim to maintain a domestic manufacturing base, which remains an important foundation for economic prosperity, as well as to contribute to the literature on manufacturing offshoring and backshoring, we provide a cross-sectional view on the phenomenon in Finland. Our research questions are as follows:

RQ1: What is the relative attractiveness of low-cost countries for manufacturing offshoring?

RQ2: What are the main motivating factors for manufacturing offshoring?

We address both of these research questions from the perspective of manufacturing firms operating in Finland. The extant research suggests that back in 2009, production offshoring was a relevant phenomenon in Germany, although with decreasing importance (Kinkel and Maloca, 2009). The same study indicates that reduction in labour costs was the most important motive for production facility offshoring activities of manufacturing firms. Second and third most important motives (with much less prominence in comparison to the first one) were market opening and capacity bottlenecks. Interestingly, Kinkel and Maloca (2009) conclude that every fourth to sixth offshoring acivity was countered by backshoring in the following 4-5 years. Main motives for backshoring were loss of flexibility and ability to supply through international pipelines, as well as quality problems at the foreign locations. More recently, Porter and Rivkin (2012) concluded that over half of the surveyed location decisions were about potentially moving existing activities out of the U.S., and that the most important rationale for moving business out of the U.S. was lower wage rates in the destination country. The second and third most important rationales (again with much less prominence in comparison to the first one) were proximity to customers and better access to skilled labour. The results of Roza *et al.* (2011) suggest that the size of the firm serves as a determinant of offshoring motives, i.e. in the allocation of different priorities for cost, resource and entrepreneurship strategies, and that small firms are as likely to relocate as large ones.

Interestingly, Denning (2012) suggests that foreign outsourcing can be compared to performance enhancing drug use, i.e. once you start using them it is difficult to stop. We also know that several psychological biases affect the decision making of managers, resulting in some levels of path dependency in manufacturing offshoring decisions. For example, the *confirmation bias*, i.e. the seeking or interpreting of evidence in ways that are partial to existing beliefs, expectations, or a hypothesis in hand (Nickerson *et al.*, 1998), may bring rigidity to the process of shifting views over competing hypotheses, such as that offshoring increases or decreases competitiveness of the firm. Furthermore, the path dependency may result from *escalating commitment*, i.e. the managerial tendency to increase investment even in the face of poor and declining performance (Duhaime and Schwenk, 1985, p. 291).

We proceed to elaborate the methodlogy of the research, followed by the descriptive results on relative attractiveness of low-cost countries from manufacturing point of view, as well as on the motives for manufacturing offshoring. Discussion and conclusions bring the paper to a close.

2. Methodology

The empirical data analysed in this research comes from a sample of manufacturing companies and was collected during the Finland State of Logistics 2012 -survey in early 2012. An invitation to participate in the survey was sent to personal email addresses of all the non-student members of the Finnish Association of Purchasing and Logistics (LOGY) and the Federation of Finnish Enterprises and regional Chambers of Commerce. The language of the web-based survey was Finnish.

In total, 2,732 responses were received, with response rate at 7.0 per cent. For this research, we limited the data to manufacturing companies (a sub-sample of the total sample from the survey), effectively excluding all trading and service companies. 20 per cent (n = 551) of the sample were manufacturing firms. The number of responses analysed in this research, due to exclusion of micro-sized firms and missing values, ranges from 115 to 362.

Background questions or control variables in this study included firm size (in terms of turnover) and the percentage share of production capacity across eight regions (or countries) of the world, namely Finland (home), Northern / Western / Southern Europe, Eastern Europe, USA and Canada, South and Central America, Middle East and Africa, Developed Asia (e.g. Japan, Korea, Australia), Developing Asia (e.g. China and India).

In the questionnaire, respondents were asked to continue the statements: ”By year 2015 our production capacity in Finland / in low-cost countries will …”, by selecting the most appropriate alternative from amongst the following: 1 – decrease significantly, 2 – decrease, 3 – not change, 4 – increase, 5 – increase significantly, 6 – no response. One should note that we did not specify high or low-cost countries, but let the respondents consider the statements by taking into account their case specific motivations. Relative production costs in countries vary by industry and production type, and the perception on whether a specific country is low-cost or not, cannot be expected to be similar across firms from various industries.

For the analysis of these particular questions, we limited our sample to large, medium, and small firms, essentially excluding the micro sized firms from the analysis. Out of 180 firms, 115 answered both of the questions on future capacity changes. After comparing the respondent and non-respondent groups for these questions, it can be said that large firms, those with higher geographic dispersion of production across the world (measurement according to Stock et al. 2000), and those with larger share of low-cost country production capacity of total (including Eastern Europe, South and Central America, Middle East and Africa, and Developing Asia; based on USDL, 2011)., were more likely to provide answers. More precisely, for respondents, the average share of low-cost country capacity out of total was 12 per cent, compared with 1 per cent for the non-respondents (4 per cent for the 551 sample firms). 49 per cent of the respondents had production capacity in the low-cost countries, whereas 20 per cent of the non-respondents had production capacity in the same regions (19 per cent for the 551 sample firms).

Additionally, we asked the respondents to assess the significance of nine factors in their possible decision to relocate/outsource production abroad from Finland. The range of factors, partly based on the factors identified by Kinkel and ja Maloca (2009), were asked to be evaluated on a range from 1 to 5, where 1 was ”extremely minor” and 5 ”extremely major”.

317 respondents from large, medium, small, and micro-sized firms, out of the 551, answered every one of the nine questions. After comparing the respondent and non-respondent groups for the questions on motivating factors, it can be said that large firms, those with higher geographic dispersion of production across the world (measurement according to Stock *et al.* 2000), and those with larger share of low-cost country production capacity of total, were more likely to provide answers.

Based on the above elaborations, the respondent groups for both of the question areas are biased towards large firms and those with previous manufacturing capacity investments abroad and in low-cost countries.

The data analysis methods used in this paper are mainly descriptive, as averages and percentages across respondent categories are reported. We also employ simple statistical tests for determining between-group differences.

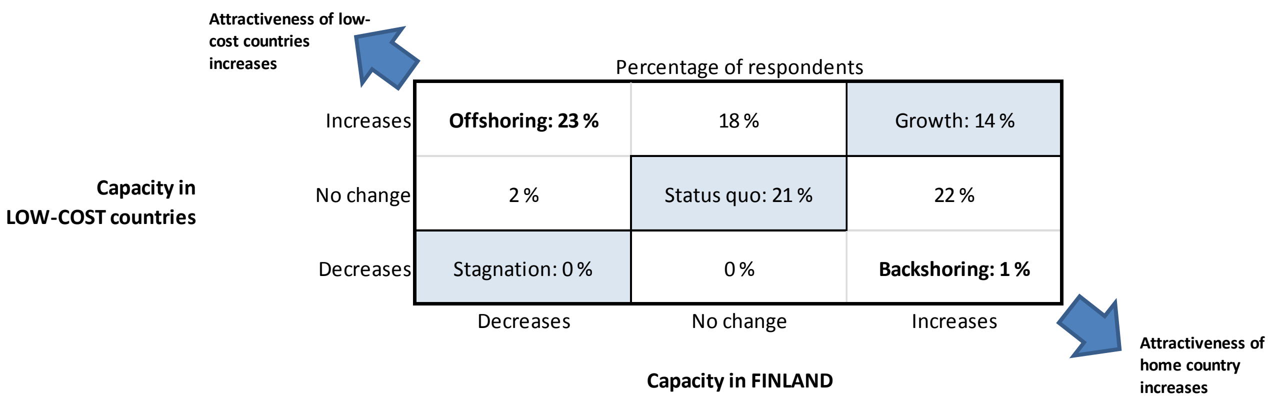
3. Results

3.1 Relative attractiveness of low-cost countries

In the following analysis we consider the future development of in-house manufacturing capacity in Finland and low-cost countries. We limit our analysis to large, medium and small manufacturing firms, excluding micro sized firms.

Figure 1 presents the percentage share of respondents in a two-dimensional matrix, where X-axis represents future capacity change of the firm in Finland, and Y-axis represents future capacity change of the firm in low-cost countries (simplified scale: decrease – no change – increase).

Figure 1 Change of in-house manufacturing capacity in Finland vis-a-vis low-cost countries by 2015



The manner of presentation in Figure 1 allows us to conclude that 23 per cent of the respondents (N=115) plan to decrease capacity in Finland and at the same time to increase capacity in low-cost countries by 2015. This category in the matrix has been named as offshoring. At the other extreme, 1 per cent of the respondents plan to increase capacity in Finland and at the same time to decrease capacity in low-cost countries by 2015. This category in the matrix has been named as backshoring. Additionally, we can conclude that on one hand a significant share of firms (18 per cent) plan to increase capacity in low cost countries and keep the level of capacity in Finland unchanged, while on the other, 22 per cent of the respondents plan to increase capacity in Finland with low-cost country capacity unchanged. Respondents (14 per cent) in the so called growth-category, plan to increase capacity in both areas, while relatively large number of firms will increase capacity neither in Finland nor in low-cost countries (status quo).

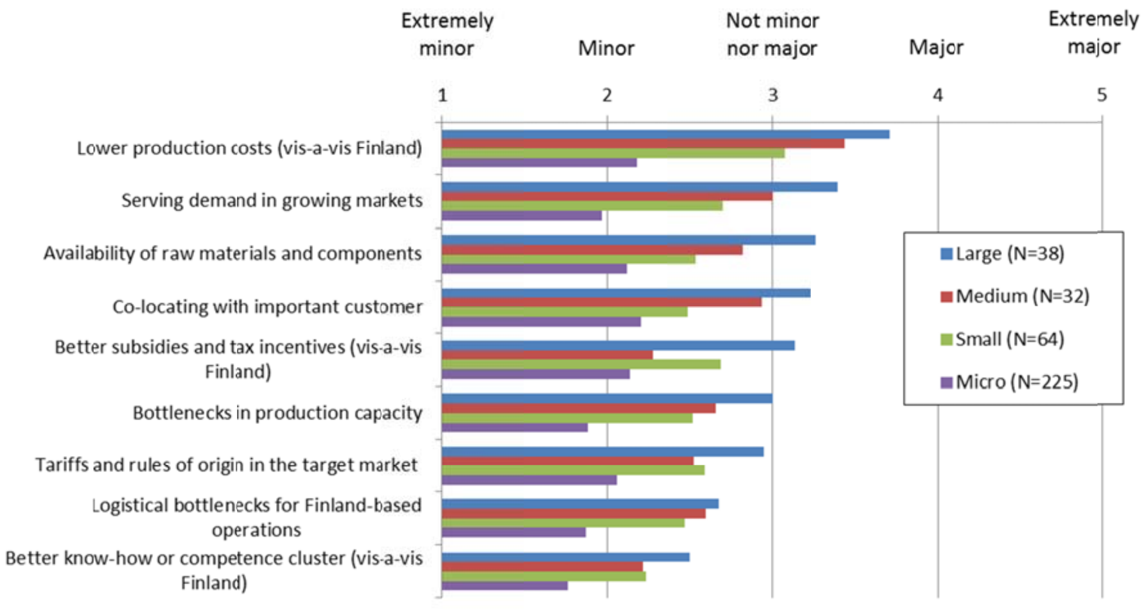
We conclude that low-cost countries seem to be more attractive on average for manufacturing capacity increase in comparison to Finland. The three matrix cells nearest to the upper left hand corner represent positions where the attractiveness of low cost countries is relatively higher, and the three cells in the lower right-hand corner represent positions where the attractiveness of Finland as the manufacturing location is relatively higher. Comparison of these two clusters of cells (23 % + 18 % + 2 % = 43 % vs. 1 % + 22 % + 0 % = 23 %), is the basis for our conclusion on the relatively higher low-cost country attractiveness by 2015.

Based on cross-tabulation, we observe that on average large companies seem to perceive low-cost countries as relatively more attractive manufacturing capacity locations. Based on ANOVA test we also observe that existing manufacturing capacity does not have an effect on how respondents on average perceive the relative attractiveness of low-cost countries in comparison to Finland. Furthermore, 50 per cent of the respondents who perceive low-cost countries as relatively more attractive are manufacturers of metal products, electronic devices, machines and equipment etc. (i.e. incumbents of the so called Technology Industries). These particular companies seem to be subject to severe international competition, as recently expressed in the business press, hence the pressure to adjust supply chains.

3.2 Motivating factors for manufacturing offshoring

The analysis moves on to the motives of relocating or outsourcing manufacturing abroad. In Figure 2, we present the results by firm size. Reported Ns are minimum, as the number of missing values varied across factors.

Figure 2 The significance of factors in decisions to relocate/outsource production abroad from Finland



Based on visual examination of Figure 2 and ANOVA tests, we conclude that the larger the firm, the higher the significance of the factors, and the higher the probability of offshoring-decisions (i.e. there are statistically significant between-group differences in means across firm size categories). However, only the motive ”Lower production costs (vis-a-vis Finland)” gets close to the value of 4 (major significance), and this among large firms. The aggregate response from all firms (N=362), with a significant portion of micro sized companies, points out the following top three motivating factors for relocating or outsourcing manufacturing from Finland:

1. Lower production costs (vis-a-vis Finland),

2. Co-locating with important customer, and

3. Availability of raw materials and components.

In aggregate terms, the respondents are much cost focused, however, for micro-sized firms, co-locating with important customer is the most important motivating factor. The third ranked factor may reflect the recent supply context, as after the first cycle of the ongoing economic crisis, Finnish electronics and machine-building industries experienced severe component shortages. This took place due to that fact that the Asian manufacturers and the supply chain as whole could not ramp up production fast enough to keep up with the increasing demand. This is a good example of the situation, where location nearer the suppliers may offer better negotiation position and level of attention from suppliers in the context of material shortages.

The results also suggest that know-how outside Finland or logistical bottlenecks for Finland-based operations are not on average the most influential motivating factors for manufacturing off-shoring.

4. Discussion and Conclusions

Several conclusions can be made from the research results described in this paper. First, the relative attractiveness of low-cost countries as a manufacturing location, vis-à-vis Finland, seems to be greater for manufacturing companies operating in Finland. This is particularly so for large firms, and the so called Technology Industry incumbents, which generates some 60 per cent of Finnish exports and 30 per cent of employment, and appears to be subject to severe international competition. Prior engagements in low-cost country manufacturing do not seem to affect relative attractiveness, i.e. we have no indication of path dependency for manufacturing offshoring. Nor can any kind of widespread discontent be detected among the respondents with prior low-cost country capacity investments that would result in a rush to bring home manufacturing capacity. These results are in general terms aligned with those of Porter and Rivkin (2012), as their results suggest that many companies in the U.S. seem to consider relocation abroad.

Second, the dominant motivating factor for manufacturing offshoring seems to be the level of production costs in Finland (most important factor for large, medium, and small firms), a finding that is also aligned with the extant research from the U.S. (Porter and Rivkin, 2012) and Germany (Kinkel and Maloca, 2009). The second most important factor, i.e. serving demand in growing markets for large firms and co-locating with important customer for all firms (the latter was the most important factor for micro-sized firms), are also aligned with previous research, as similar motivations, namely proximity to customer (Porter and Rivkin, 2012) and market opening (Kinkel and Maloca, 2009) have been identified as the motivations next in line. Therefore, while a push-factor dominates (high costs in home country), a pull-factor (generally market potential in host country) comes second.

Our results support the findings of Roza *et al.* (2011), as they suggest that offshoring motives vary by firm size. In our sample, larger firms seem to pursue cost strategy, whereas micro-sized firms also seem to emphasise a seemingly entrepreneurial strategy (co-locating with customer). However, somewhat in contrast to Roza et al. (2011), our results suggest that the larger the firm, the higher the probability of relocation (measured as the significant of motivations in the decisions), potentially due to the greater amount of resources available to undertake such an ambitious project. The difference may be explained by our focus on manufacturing capacity, as it may be relatively more challenging to relocate manufacturing capacity in comparison to the other functions of the firm.

The policy implications of this research are as follows. Stakeholders interested in maintaining a manufacturing base in Finland should focus on how to reduce production costs for manufacturers, as the decision makers seem to be very much cost focused. The measures taken may include controlling for labour cost increases, but also making sure that the logistics costs of manufacturing firms do not escalate due to infrastructure deficiencies, labour market disturbances, and emission taxation. Anecdotal evidence from successful Mittelstand manufacturers in Germany suggests that aggressively employing automation and aiming for extreme flexibility in production (such as the ability to produce short notice batches of one) can make local manufacturing in high labour-cost context competitive with the distant and low-cost Asian rivals. The labour market may need to adjust to the need for higher flexibility.

Furthermore, companies should be encouraged to focus on measuring the total costs of the offshoring decision over time (such as in line with total cost of ownership concept). The extant literature suggests that for example low cost country sourcing is plagued by indirect, induced (Arvis *et al.*, 2007), unexpected (Weber *et al.*, 2010) or hidden costs (Holweg *et al.*, 2011), which are partly due to an increased administrative burden, or uncertainty and complexity in general, and are felt across the supply chain organisation in a company (e.g. Choi and Krause, 2006). These costs, due to the difficulty of measurement, are often overlooked in decision making (Porter and Rivkin, 2012). Implementation and improvement of systems for cost data capture should therefore be a priority. Further research may focus on designing and implementing dynamic cost models that take into account both short and long-term direct and indirect costs of manufacturing offshoring (Porter and Rivkin, 2012). Greater understanding of the dynamics in exogenous factors and firm resources and capabilities is a basis on which these models may be built on.

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Sourcing factors affecting production localisation decisions

Jessica Bruch, Monica Bellgran, Jayaprakash Lakshmikanthan, Godfred Tabiri

Div. of Product Realisation at the School of Innovation, Design and Engineering,
Mälardalen University, Box 325, SE 631 05 Eskilstuna, Sweden
Corresponding author +46 16-153219, jessica.bruch@mdh.se

Abstract

Many factors affect the production localisation process of global manufacturing companies. An area of great impact is the strategy for how to source material and components for a new production location. This paper presents a review of the main factors affecting the overall decision of localising production to a new site, and seeks to identify whether the sourcing and supply base development was considered during the decision process or not and in which way. The paper is based on interviews within four global manufacturing companies. The results of the theoretical and empirical studies indicate that the two most important factors affecting the production location at the studied companies were cost and proximity to markets/customers, verifying the expected reasons, while the impact of the sourcing factors was only considered to a less extent when making a location decision.

Keywords: Production localisation, localisation factors, localisation decision, sourcing, supply base and sourcing parameters

1. Introduction

An important decision in today's transnational manufacturing environment is the localisation decision. Selecting the most suitable location for the manufacturing of a product is critical since the right location can offer economic advantages and superior operating conditions and thus plays a powerful tool in creating a competitive edge (Schmenner, 1982). However, making location decisions had become increasingly complex with the large number of interdependent activities, as well as increasingly uncertain with direction of changes becoming more difficult to predict. As a result, the ability to manage international networks is an essential task for managers (Ferdows, 1997a; Vereecke and Van Dierdonck, 2002). Hence, it becomes clear that new knowledge regarding the management of international operations is required as the research on international issues in manufacturing has evolved from local production, through global sales and marketing, into global manufacturing (Rudberg and Olhager, 2003).

Although research is made on comprehensive manufacturing footprint strategies and how location decisions should be made, there is still more to be done. The Manufacturing Foundation (The Manufacturing Foundation, 2006) points out that location decisions are carried out in an unstructured way and without appreciating the overall impact on the manufacturing company. Consequently, there is a need for research to help international manufacturing companies to adopt a holistic perspective to identify the most appropriate production location (Chandraprakaikul, 2008).

Since localisation decisions do not only affect the manufacturing company and its immediate environment but also sourcing issues, the strategy for how to source material and components for a new production location is one important area to consider when making the localisation decision. Here, a number of strategies could be used in order to source material, from the extreme one end of full utilization of existing supply base to the other extreme of developing a complete local supply base. However, supply networks structures are often complex, including resources and suppliers in different combinations (Gadde and Håkansson, 2001). Thus, considering sourcing issues in the localisation decision is not an easy task and needs special attention. The objective of this paper is to review the main factors affecting the overall decision of localising production to a new site, and seeks to identify whether the sourcing and supply base development was considered during the decision process or not and in which way.

2. Theoretical frame work

2.1 Manufacturing location decisions

Manufacturing footprint refers to the manufacturing network design and stresses that the number and location of the company's facilities can be a key to profitability (Shorten et al., 2005).Companies need to revise their manufacturing footprint in different situations such as the expansion of manufacturing capacity, entering a new market, introducing a new product or relocating a facility. In order make a suitable decision it is important to have a clear understanding of the characteristics of the different types of localisation decisions (Pongpanich, 1999) as each type of decision has different implications on the suitable alternatives. However, it has also been argued that although each type of decision has different implications, the way the localisation decision is approached remains the same (Vos, 1991).

In general, the process of making a localisation decision can be divided into several distinct phases comprising all the necessary activities (e.g. Hoffman and Schniederjans, 1994; Kodali and Routroy, 2006). In a study of 11 manufacturing location decisions, Pongpanich (1999) developed a method in four stages for making manufacturing location decisions; investigation, identification, evaluation and selection as described in Figure 1.

Figure 1. Stages of decision making process (Pongpanich, 1999)

The principle stages guides the progress towards a localisation decision. Stage 1, the investigation, is about getting a better understanding about the manufacturing company's current industrial situation. This is made with extensive data collection involving identification of project members, identification of current information about the company's business including the plants, products, suppliers, markets, the examination of markets and competitors and their trends and also the making of a SWOT analysis to scrutinize the company's business strategy and manufacturing objectives. Stage 2, the identification, aims to identify a list of possible options starting by examining the company's manufacturing operations for every product types by using the "location matrix", estimating the characteristics of "location appropriateness" and "capabilities" of every manufacturing location leading to the identification and evaluation of course if action. In stage 3, the evaluation, the identified possible options in stage 2 is examined. Financial evaluation and non-financial aspects of the manufacturing company are evaluated and location visits to develop the first-hand knowledge of the proposed option is conducted. Finally, stage 4 implies selecting the most favourable option for a manufacturing location.

When making the localisation decision, companies do normally have at least one driver to consider in the location problem. Ferdows (1997b) presented the drivers behind global spread of production which classified location factors into six categories: government policies, market, skill and knowledge, risk, competition and production and logistics cost. The suitability of a specific production site for proposed facility operations depends largely on what location factors are selected and evaluated, as well as their potential impact on corporate objectives and operations. Therefore, to reach the right location decision, it is most important to select, analyse and evaluate the right location criteria (Yang and Lee, 1997). Already early research, see e.g. Schmenner (1982) classifies location factors in to “musts” and “wants”. Beneath “musts” involve factors important for site location such as cost and market; while “wants” are factors preferably to be taken into the consideration.

Further, location factors can be measured from the angle of qualitative and quantitative categories (Yang and Lee, 1997). In the quantitative numerical values are measured such as cost of lands and tax incentives while the qualitative types combines both non-quantifiable factors that impact on the ease of doing business in a particular area, such as labour attitude, business climate, and quality of life. Such factors cannot easily be expressed in numerical values and evaluated by quantitative models. Location selection problems become more difficult when qualitative factors are taken under consideration, because subjective judgments must then be adopted.

Apart from differentiating between qualitative and quantitative factors, it is clear from the literature review that there are a large number of location factors, which should be considered in the localisation decision. For example, Goetschalckx *et al.* (2002) classified location criteria from seven published strategic logistic models into four categories: stochastic features, taxation and cash flow features, non-international features and trade barriers. Farahani *et al.* (2010) categorised location factors on the criteria used in multi-objective into six groups: cost, environment risk, coverage, service level and effectiveness, profit and other criteria. Further, Bergeron et al. Bergeron et al. (2005) classified factors in a site selection model into four groups: geography and culture, environment, workforce and cost and ROI. While Hoffman and Schniederjans (1994) differentiate between country factors but also factory specific factors. Country factors refer to the general environment (consisting of technological, political, economic, physical and social factors) and the task environment (consisting of potential customers, suppliers, competitors and regulatory groups), while country site factors are important for the evaluation of the manufacturing site and includes aspects such as price per square foot, renovation requirements, options for expansion, etc. Product life cycle stage has also been addressed as criteria to categorise factors that are in the early stage, companies often start producing products in the head quarter or research and development section. In contrast, at the end of product life, companies often locate the facility close to the market (Yang and Lee, 1997).

2.2 Sourcing parameters

Sourcing can be described as a procurement practice intended at finding, evaluating and engaging suppliers of goods and service. The sourcing decision involves an organization deciding whether to source a product, process or service internally or purchase it from an outside supplier (Balakrishnan and Cheng, 2005). Different approaches have been applied when making a sourcing decision and companies aim at finding the right balance between outsourcing and insourcing, i.e. right-sourcing. Right-sourcing refers to the combination of both insourcing and outsourcing actively in a strategic manner to be competitive now and in the future (Hägg et al., 2004). With the changing trend and increased competition it is more important than ever to act strategically, hence apply right-sourcing. Examples of parameters to consider when making sourcing decisions are e.g. cost calculation, capacity, choice of supply, competitive priorities, core competence analysis, qualitative and quantitative analysis, risk analysis and the logistics aspects (Hägg et al., 2004). McIvor (2000) suggests a sourcing model that helps manufacturing firms in making the sourcing decisions based on three main concepts; the value chain perspective, core competency thinking and impact of the supply base. How the supply base and the sourcing parameters affect the actual production localisation decision needs to be investigated further.

Sourcing of services and production to various locations across the world has become more evident today. In respect of this, more research needs to be directed towards the identification of risk associated with sourcing, especially for international B2B in different countries. In sourcing one evident risk is becoming over dependant on your suppliers (Wasner, 1999). Being over dependant on suppliers will result in loss of critical skills according to Hilmer and Quinn (1994). It will be difficult to insource such activities back when there is over dependant on the external supplies since companies from time to time change their core competence, the risk is also that the supplier builds up expertise and becomes a competitor learning the key skills and the company's core competence and further exploiting it. The supplier always works with the option to sell knowledge obtained through the outsourcing process to a competitor. During outsourcing it is important to note that these results are dependent on the employees and their skills. High transaction cost is also a risk during outsourcing (Nellore and Söderquist, 2000). This cost involves the time and effort needed to manage partnership between the parties involved including set up cost, trading cost and competitiveness cost.

3. Research design

A multiple case study was selected as a research strategy, as it seemed feasible to provide a rich understanding (Yin, 2009) and inclusive assessment of the complexity of the factors in production location decision making process, sourcing decisions and the sourcing decision models, which affect production location decisions. In-depth, qualitative data was collected from four global manufacturing companies (henceforth referred to as Company A, B, C, D).

In total seven interviews were conducted ranging from 50 to 80 minutes, with an average of 60. The interviews were conducted with managers and employees responsible for production localisation decisions; see Table 1 for a detailed overview over the respondents of the interviews. The interviews were semi-structured and each interview was conducted by two interviewers, one observing and taking notes. All interviews were recorded and transcribed. During each case, more than one person was interviewed from different functions and levels of the organization. Thus, it was possible to get complementary views on the research variables. In addition, the respondents were given the possibility to read the case description and comment on it. In order to complete an interview successfully, the people interviewed had the chance to study the questions before the meeting. Before framing the interview questions, a deep literature study was made in the related area.

Table 1. Overview of the semi-structured interviews

Company name	Respondents position	Venue and nature of interview
Company A	Vice President Industrial Strategy	Video-conference and e-mail
	Manager Global Production Support	Face -to-Face
Company B	3 Buyers	Telephone, e-mail and video conference
Company C	Global sourcing Manager	Telephone and e-mail
Company D	Supply Manager	Telephone and e-mail

4. Empirical findings

4.1 Company A

Company A was a global manufacturing company within the automotive industry, manufacturing components and whole products.

Decision making process. In Company A, production localisation decisions were carried out by top management and the decision making process was described as complex. The production localisation process was supported by a strategic decision model including checklist, guidelines and methods. However, the available support was not followed strictly; rather it was adjusted to the respective decision to allow some degree of flexibility. When relating to the product characteristics, Company A used the combination of both new products and the matured existing core products for their new facility location. The main reason was if the company located manufacturing for example in India, then they needed to have a redesign in their core products to meet the Indian market needs and the customer requirements.

Factors affecting production localisation. The main factors affecting the company's production localisation process were cost, proximity to markets/customers, capacity, legal issues, labour competence and supply chain factors.

Sourcing process and parameters. When locating production, Company A used both existing and new suppliers depending on selected production location. The suppliers needed to have the knowledge, experience and the possibility to meet the demands of the company. In performing the operations within the company, long term-relationship with the suppliers was maintained to achieve the right product with the right quality. Suppliers were evaluated based on a systematic approach where cost, quality and capacity were analysed. Company A made their industrial strategy decisions based on two axis namely; footprint thus where they wanted to be located depending on the market, and vertical integration, i.e. what they wanted to do internally and what they had to outsource. In Company A, on the average 70% of the components were outsourced and 30% produced internally. If the local suppliers did not satisfy the quality demands for the company, they made the decision to source the components from existing suppliers for the new production plant. A make or buy strategy was used to select suitable suppliers. The purchasing and supply chain department were responsible for carrying out the sourcing decision process and there was a cross functional decision between operations and R&D. The parameters that affected choice of new suppliers for the new site were cost, quality, core competence, capacity, volume and deliverability.

How the supply base and sourcing parameters affected production localisation decision. In Company A, the supply base and related sourcing parameters played a major role in their production localisation process. From the interviews conducted it can be inferred that the supply base and sourcing parameters are equally important as other localisation parameters, i.e. in localisation decisions sourcing factors will be weighted to the same extent like any other factor identified as important. In general, Company A tried to localise products within their existing manufacturing footprint to be able to apply the already existing supply base because localisation decisions become much easier. Contradictorily, if Company A wants to localize the production completely on a new site, a pre-study phase is performed to identify the supply base and if they don't find the good supply base then the localisation is denied for that selected location. This confirms the effect the supply base and sourcing have on their production localisation decision.

4.2 Company B

Company B was a global manufacturing company with a worldwide manufacturing footprint and a leading provider of services.

Decision making process. Decision making was made on a top down management level. When making the decision to localize the total cost of ownership and the technical feasibility of the product had a major impact on where to locate manufacturing. Further, the market demand was critical in the localisation decision process. In general, localisation decisions were made concerning both new and matured products.

Factors affecting production localisation decision. The main factors affecting the production localisation in Company B were costs, proximity to markets/customers, supply chain factors, labour, capacity and legal issues. The main driving factor for revising the manufacturing footprint was maximizing profit through cost reduction. Whenever they wanted to localize a new production an intensive cost evaluation was carried out in order to estimate the profitability of the relocation. The next factor was the closeness to the market since being close to the customers enhanced good customer relationship and improved the ability to meet the market demand. Supply chain factors such as the current supply base, supplier capability and transportation cost were also considered in a localisation decision. Logistics cost had a significant impact on the total costs, hence minimizing supply chain costs was critical. Resource availability, capability and transportation were other factors that were thoroughly investigated before the final decision was taken. Finally, legal issues were emphasised to ensure that all regional regulations were met. The potential production location needed to be politically stable to enable efficient manufacturing operation.

Sourcing process and parameters. When locating production to a new site, Company B applied both existing and new suppliers. The decision of selecting an existing or new supplier depended on the complexity of the products. A source plan was published every year based on the performance of the current supply base and future requirements. Company B used the Six Sigma Strategic Sourcing Process as the strategy in sourcing decisions. This standard tool defined the six sigma methodologies and comprised the standard supplier selection process. The suppliers were evaluated under the QCLDM (Quality, Cost, Logistics, Development and Management) score card and if the suppliers met the required QCLDM score, then they were selected in order to meet the right quality, right products at right time (3R's). However, to decide on suppliers for products of low complexity, only a simple supplier evaluation process was carried out. The sourcing decisions were executed by the Product Managers. Initially, the product manager presented the product specification and a cross functional discussion including the purchasing management took place when selecting the supply base.

How the supply base and sourcing parameters affected production localisation decision. The supply base and sourcing parameters were of high importance and affected the localisation decisions as all necessary analysis and calculations concerning sourcing and supply base were taken into consideration when making a decision of where to locate the production. This was done mainly to make sure that costs of poor quality or late delivery were minimized in order to decrease the total costs of operations and satisfy the customers. In cases where the potential supply base in a country did not meet the demands of the company, the neighbouring country's supply base was studied. It was emphasised that a suitable production location also had to have potential suppliers in and around the selected region; otherwise it was deemed difficult to realize cost-effective production.

4.3 Company C

Company C was a global supplier in the automotive industry and had currently ten production sites and three distribution centres.

Decision making process. In Company C, the production localisation decision was carried out by cross-functional top management group comprised representatives from sales, product management, purchasing and logistics. However, when making the localisation decision to standardised process was applied nor was any kind of guidance in form of checklists, models or documentation recognised. The decision making was considered as flexible and depended mainly on the market support and the customer demands, while other factors concerning human resources, the production system and financial aspects did not have any real impact on the localisation decision.

Factors affecting production localisation. To minimize cost, easy access to market and maximization of the effectively for the distribution centres were identified as the main drivers for Company C in localisation decision. The main factors affecting the production location were costs, Proximity to markets/customers, legal issues, supply chain factors, capacity and labour. As focus was on maximising profit through cost reduction, costs were identified as the most important factor. Thus, to ensure a high profitability when making a localisation decision, a cost analysis is made. But also geographical nearness to consumers played a significant role in the decision process. Increased market share, a better understanding of the demands placed and improved customer support were mentioned benefits that can be accomplished by being located close to the customer. Further, the company emphasised the importance of considering legal issues and supply chain aspects when making a localisation decision. The former one is important as it may have an impact on the product design, while supply chain factors referred to the ability of finding suitable suppliers in the new region. Capacity and labour played only a minor role low in the decision making process.

Sourcing process and parameters. The product and the marked had an effect on if current suppliers were also used at the new production site or new suppliers were selected. To identify suitable suppliers, Company C applied a rigorous supplier selection process and an audit system. The comprehensive supplier selection process was important in order to meet the high requirements placed on the suppliers as failure in product functioning could had a significant impact. Currently there was no sourcing model that was followed; rather sourcing decisions were made by an informal process. In line to the localisation process, the sourcing decisions depended on the market and the complexity of the product, although had a make or buy strategy that supported the decision making. The parameters the company considered when making sourcing decisions were cost, market, volume, complexity and supply base.

How the supply base and sourcing parameters affected production localisation decision. The supply base and the sourcing parameters of Company C did not have any direct impact on the production location decision. This is mainly because the company made location decisions based on cost and the market and once the decision is made, supply base and the sourcing parameter were considered. On the other hand Company C considered the supply base as one of the important parameters in the sourcing decision process. The main problem faced was that the company had too many suppliers. As a result, it was difficult to find the right suppliers to produce quality products at the right time.

4.4 Company D

Company D was a global manufacturing company and was represented in around 100 countries.

Decision making process. The decision making concerning production localisation was carried out by the top management and followed a standard process, which was supported by, methods, guidelines and checklists. Proximity to customers is seen as the most important factor for making a suitable localisation decision, but also the volume of the manufactured product may have an impact on the decision. Both matured and new products were when deciding on the production location. However, location decisions concerning mature products were often related to an increased need of capacity. In the case were the current manufacturing plant could not satisfy the customer demand, the company aimed at achieving an increase of production capacity close to the customer demand.

Factors affecting production localisation decision. The main objective of the localisation decision was to maximize profit through cost reduction and to enhance the growth of the business by being located close to the customer. Legal issues, labour aspects (competence, attitude & availability), supply chain factors and capacity were also mentioned as factors that were considered before the decision to localize is finally taken in the production location decision. With regard to the supply chain factors the supply base, specific suppliers and other logistics factors were generally considered. However, since cost reduction was the main aim, particular emphasises was placed on the logistic costs due to their high impact on the total production costs.

Sourcing process and parameters. When relocating to a new manufacturing site, Company D used both existing and new suppliers. The selection process was guided by the sourcing strategy and consisted of four steps: (1) Evaluate the existing supply base; (2) Evaluate the supplier requirements; (3) Find out if the supply base meet the requirements; and (4) if there is any miss match regarding the quality, lead times, delivery performance, price levels etc. then search for a new supply base. Further, the companies used a supply base rationalization in order to maintain the right number and quality of the suppliers. Collaboration between supply managers at the local manufacturing plants and consolidation of volumes was also used to maintain low number of suppliers with closer cooperation.

The commodity manager was responsible for the overall selection process and provided a list of preferred suppliers for different regions. This list was made available to all supply managers within the company. Then the final decision concerning suitable suppliers was made by local supply managers. In Company D, on the average 60% of the components were outsourced and 40% produced internally. The parameters that influence their sourcing decisions are cost, complexity, quality, core competence and capacity.

How the supply base and sourcing parameters affected production localisation decision. The supply base and sourcing parameters had a major influence on the where to locate production. Before relocating production, the company demanded that there had to be a large part of local suppliers in the region. This is because one of the main aims of localising production was to reduce the logistics cost lead times. When it was not possible to guarantee a good local supply base, the company did not localize in the selected region. Based on the experiences of emphasising a reliable local supply base, Company D had accomplished several benefits such as a more reliable production, minimized risks concerning poor quality and assured good investment.

5. Analysis

5.1 Decision-making process

In general, production location decisions were made by a small team comprising managers on the corporate level of the manufacturing companies. The production localisation decision is a part of a complex long-term investment decision (Hayter, 1997), which may explain why only top management is involved in the decision. Further, the results reveal that the production localisation decision making process is highly complex. But despite its complexity, not all companies use a standardised process or any kind of support such as checklists, documents or tools when making the localisation decision. The companies argued that they did not adhere to a structured process to remain flexible in the decision making process. However, most manufacturing companies use structured ways of working in many of their processes such as the make or buy process or the production development process without fearing a lack of flexibility. Instead of spending time on structuring activities and thinking of the appropriate order of the activities, what factors to consider etc. the decision makers can concentrate on finding the most suitable production location. Further, it will be easier for people outside of the decision making group to understand the decision rational.

Somewhat unexpectedly, the results of the case study showed that all four case companies used both matured and new products for their new facility location, i.e. the manufacturing location decisions are not limited to mature products. Therefore, the findings of the studied companies challenge previous reserach suggesting that that companies often start producing products in the head quarter or research and development section (e.g. Yang and Lee, 1997). The findings indicate that it is the demand of the customer and the competitive situation at the market which decides on if new products are also introduced to new facilities.

5.2 Critical factors

The importance of the localisation factors are summarised in Table 2. The importance of the production localisation factors were measured on a six point scale. “1 and 2”indicated that the factor was not at all important for the localisation decision, “3 and 4” that the factor was of intermediate importance and “5 and 6” that the factor was of high importance when making a production localisation decision.

Table 2. Major factor affecting production localisation

No	Factors	Company A	Company B	Company C	Company D	Cumulative Scores
1.	Costs	6	6	5	6	23
2.	Proximity to markets/customers	5	6	3	5	19
3.	Supply chain	2	5	5	5	17
4.	Legal Issues	4	3	6	4	17
5.	Labour characteristics	1	5	5	4	15
6.	Capacity	1	4	4	2	11

The analyses show that cost is ranked highest among all major factors but also proximity to market is of high significance in the production location decision process. This is in line with earlier research (e.g. Levine, 1991; Vereecke and Van Dierdonck, 2002) who argue that the major motivations for companies to relocate manufacturing are the opportunity to lower production costs and to gain access to markets. Manufacturing companies seek to increase their profit margins by reducing the cost of operations and hence an intensive cost analysis is carried out before making a localisation decision in order to ensure that the new manufacturing location will be profitable. The profitability of the production site is also influenced by the proximity to markets since being close to the market improves the responsiveness, delivery time to the market and relationship with their customers. In addition, it is easier to identify and react on regional trends, i.e. the specific demands may differ between the markets, which require a detailed understanding of the specific needs of the customer.

Supply chain, labour, legal issues and capacity were of intermediate importance highlighted in decreasing order. It is apparent that the rating for supply chain, legal issues and labour characteristics are very close to another, while capacity seems to be of minor importance in the decision making process. This can be explained by the fact that localisation decisions are often made by the top management, which only may have limited knowledge about the consequences and impact of unutilized or lack of capacity on the performance. However, Bruch *et al.* (2012) point out that it is important to understand these consequence in order to make localisation decisions that will be sustainable. Therefore, it would be beneficial to include also people in the decision making who have been involved in relocation project earlier as well as have operation knowledge and can describe these consequences. In addition, lack of capacity is often one of the key drivers for revising the actual manufacturing footprint. That is if the current manufacturing site cannot satisfy the demand, companies often localise additional production facilities close to the market.

Another interesting aspect was that the importance of the supply chain factor when making a localisation decision varied considerably among the case study companies. Company B, C and D considered supply chain factors, i.e. the supply base, sourcing and other logistics factors as highly important, while Company A rated that the impact of the supply chain factors in the decision making process was of low importance. The rating is somewhat conflictive to the results of the interview study, where the respondents at Company A highlighted that when supply chain factors were considered they were equally important, i.e. weighted to the same extent as any other factor in the production location decision process. However, it was not seen as a “Must” factor which, needed to be considered in every location decision.

In line with the results of MacCarthy and Atthirawong (2003) the results showed that emphasises should be placed on “qualitative” aspects of labour characteristics in the decision making process. There was a consensus on that labour costs do only affects the localisation decision to a minor extent, while the ability to find skilled employees both at the management and shop floor level or the attitude towards work were of high importance. Emphasising qualitative rather than quantitative aspects can be explained by the fact that skilled works are required to be able to apply highly automated production systems within manufacturing.

5.3 Sourcing process and parameters

During production localisation the case companies used both local and global procurement in selecting suppliers for their new facilities. They also aimed at combining both existing and new suppliers during localisation. The decision of selecting a new supplier or using an already existing supplier depended on the market and the product. To select suitable supplier, the sourcing strategies were applied. The potential suppliers needed to have the knowledge, experience and the possibility to meet the demands placed by the company, i.e. to deliver the right product with the right quality at the right time. In line with the results of Hägg *et al.* (2004) cost, core competence, capacity, quality and supply base were essential parameters considered when selecting suppliers. In addition, the selection of the supplier was also influenced by the demand for supply base rationalization, i.e. the companies can only handle a limited number of suppliers in order to maintain the right number and quality of the suppliers. Thus, when selecting suppliers, collaboration between supply managers at the local production plants is also required.

5.4 How the supply base and sourcing parameters affected production localisation decision

In three of the four companies, Company B, C and D, the supply base and sourcing parameters played an important role when making location decisions and were considered as a "must" factor according to Schmenners (1982) definition. Company A, on the other hand, placed the supply base and sourcing parameters as a "wants" factor, i.e. a factor that should be preferably taken into the consideration. As a result, in Company A, the localisation decision may be already taken before the supply base and sourcing parameters are studied. However, it would be advantageous to also consider the supply base and sourcing parameters when making the location decision, since the company aimed at increasing its profit margin through cost minimization. Without considering logistic aspects the company's total production costs may increase due to long transportation, poor quality or increased lead times. A possible explanation of why Company A did not consider the supply base and sourcing parameters in the decision making process might be that they so far did not experienced any major problems in finding suitable suppliers.

Only Company D did not place production to a location where they cannot find any suitable regional suppliers highlighting the importance of the supply base and sourcing parameters on the location decision. Company B and C also emphasised the importance of considering these aspects in the decision making process to avoid problems after start of production. Some benefits that were achieved by placing high attention on the supply base and sourcing parameters in the production location decision process were reliable production, high quality and sustainable investments.

6. Discussion and Conclusions

The first part of the objective of this paper was to review the main factors affecting the overall decision of localising production to a new site. Our empirical findings showed that although cost is a factor of high priority it is insufficient to only consider cost when developing the manufacturing footprint of the company; rather the empirical findings identified six crucial factors that should be considered in the production location decision process. All factors influence the production location decisions process in one way or another although the production localisation factors have diverse degree of influence in each firm.

The second part of the objective was to identify whether the sourcing and supply base development is considered during the decision process or not and in which way; an area which has received only limited attention so far.

Although the results from the case study are somewhat indifferent, the results indicate that it is beneficial to consider the supply base and sourcing parameters when making a localisation decision. The consequences of not reflecting on the supply base can be seriously leading to higher logistic costs and thus also influence the company's ability for cost-efficient production. Getting access to an adequate and reliable supply base helps to avoid problems regarding poor quality and long delivery times as well as it contributes to good relationships. The sourcing parameters identified as relevant to consider in the localisation decision process were cost calculation, core competence, risk analysis, capacity, quality, qualitative and quantitative analysis, supply base and production strategy.

Returning to the questions of how sourcing and supply base parameters can be considered in the production location decisions, it seems that the companies have major difficulties. The location decision process does not give any advice of particularly for sourcing issues. Instead, the companies relied heavily on their sourcing strategy and the related established sourcing process and guidelines. Without being interested in disputing the possibility that a large part of the already established sourcing tools may be re-used in the localisation decision process, we notice that there are also some differences between making a sourcing decision and considering sourcing decisions in the production localisation decision process. For example, the work extent is different comparing selecting a supplier for one component or selecting suppliers for all the components and material required for one product. In addition, more knowledge is needed concerning what sourcing information is needed in the different phases of the location decision process. It is reasonable to assume that in the beginning of the decision process the certainty of the information will differ compared to the final phase of the localisation decision process. Thus, it is of interest to study the sourcing activities that need to be accomplished in each phase of the localisation decision process. This being said, it can be concluded that more research is needed about the strategy for how to source material and components for a new production location.

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Polish FDI’s – Network Perspective

Michał Zdziarski, Ph.D
Warsaw University, Management Faculty
ul. Szturmowa 1/3, 02-678 Warsaw, Poland
Mzdziarski@mail.wz.uw.edu.pl
+4822 629-48-91

Biographical note: Michał Zdziarski, Ph.D is Assistant Professor of Strategic Management and International Business at Management Faculty, Warsaw University and Research Director at International Management Center, Warsaw University. As a Principal Researcher of the Conference Board he was responsible for re-design and content leadership of the global research program - The CEO Challenge™. His research interests include leadership, top management teams, strategy formulation, decision making, stakeholder analysis, interlocking directorates, social network analysis and foreign direct investments. Contacts:
+48505176174

Abstract

We observe increasing levels of investment flows in a direction opposite to well-explored internationalization of established firms from developed to emerging economies. I present geographic clustering patterns of foreign direct investments (FDI) from the largest developing country in Eastern Europe. I show how, over the three years, the structure of FDI network has changed. I model outward FDI from Poland as a network in which companies are linked if they invest in the same location. I inquire into which factor explains observed geographic clustering better – EU membership, historical legacy of transition, geographic proximity, or relative level of GNI per capita?

Keywords: Internationalization, Outward foreign direct investments, Emerging markets, Clustering, Network

I. Introduction

Internationalization of companies from emerging markets is becoming an area of primary interest for International Business (IB) and entrepreneurship scholars (Buckley et al., 2007, Luo, Tung, 2007, Yiu, Lau and Brutton., 2007). There are good reasons explaining the growing interest in studying companies from developing economies. We observe increasing levels of investment flows in a direction opposite to well-explored internationalization of established firms from developed to emerging economies. Yet there is relatively little published research presenting strategies, models and patterns of internationalization of firms based in emerging economies (Mathews, 2006). This paper contributes to calls for exploring Foreign Direct Investments (FDIs) that are “the other way round” from developing to developed countries (Yamakawa, Peng and Deeds, 2008), and to increase research into entrepreneurship and internationalization strategies of companies from developing countries (Brutton, Ahstrom, and Obloj, 2008). It fills partially the existing knowledge gap by presenting a longitudinal study of FDI localization patterns from the largest developing country in Central Eastern Europe – Poland. The transformation of Central Eastern Europe offers a unique research setting to test the applicability of existing theories in a new context (Meyer & Peng, 2005).

The outward FDI is associated with establishing a new entity in a foreign country and is considered to be the most advanced stage in the process theory of internationalization (Johansson and Vahlne, 1977) in which firms make greater commitments than simply increasing their foreign sales (McDougall and Oviatt, 2000). Common investment in the same location makes a relationship between companies likely, even if they invest in unrelated industries. This is because executives from companies investing abroad in the same location have many opportunities for networking, information search and discussing joint initiatives. These opportunities include participation in country specific Chambers of Commerce, participating in trade and industry missions, meeting at major cultural and sporting events, flying business class on the same routes, attending parties in Embassies, working on government relations in both their home and host country, and the use of specialized service companies providing knowledge and expertise about the host country in addition to other places where links are built such as interlocking directorates and alliances. The list of opportunities is by no means exclusive and finding out how executives use these and other possible links in information searches and joint initiatives is indeed worth a further qualitative study that is planned in the next phase of presented research. I suppose the likelihood of contact and knowledge flow among companies that invested in the same location is especially large for developing countries with a relatively small amount of companies that have outward FDI in same location. The probability of relationships among companies increases with each additional country where both firms have FDI.

Even without direct contact with executives of firms that invested in similar locations, a firm may vicariously learn from others getting information about their conduct indirectly through observation (Baum, Li, and Usher, 2000, Gimeno, et al, 2005). The gradual process of learning from networks in the process of internationalization is theorized in the network approach to internationalization (Johansson and Mattsson, 1987). Several studies on developing countries FDI have confirmed the importance of networks, and the participation of business groups in the sequence and results of internationalization (Elango and Pattnaik, 2007, Yiu, Lau and Brutton, 2007, Peng and Zhou, 2005). This approach differs from the dominant resource based view of the firm (Barney, 1991) in its focus on the relational aspect of the FDI decision process that is socially embedded (Granovetter, 1985). Due to embeddedness, firms often act in similar ways in close temporal proximity which leads to patterns that are called clustering (Gimeno et al., 1995, p.297). Firms from the same country tend to internationalize their operations in similar locations, as well as to exit from investments in similar locations – both processes leading to geographic agglomeration of investments (Porter, 1990, Kim, Delios and Xu 2010). Learning in clusters reduces transaction costs and is an important factor in a firm's ability to build a competitive advantage in a complex, global environment (Dunning, 2009).

In the explanatory network analysis of FDI based relationships I present patterns of geographic clustering of Polish FDI's. I am using data on all FDI of companies listed on the Warsaw Stock Exchange in the years 2007-2009, to model them as an affiliation network in which companies are linked if they invest in the same location. There are two theoretical explanations of FDI clustering (Dunning & Lundan, 08, Rugman & Verbeke, 2004):

1) tendency of firms to invest in neighboring countries where psychic distance is low, and transportation network makes movement of goods, personnel and technology relatively easier.

2) tendency of large, multinational companies to invest in developed countries in market seeking.

One of the legacies of communism for transition economies is that there are few large, multinational companies that emerged from Central and Eastern Europe. The largest Polish company by assets, turnover and market capitalization – PKN Orlen SA was 347 largest company according to 2010 list of Fortune Global 500. It is the only Polish company on this list. It is therefore justified to expect that only the first clustering pattern will emerge, and there will be many investments in neighboring countries while close to zero investment in more distant, developed economies.

There are three contributions of this paper to current literature:

1) application of network approach in analysis of FDI affiliation network in search of patterns of similar investment location strategies and geographic clustering.
2) combination of statistical methods of block-modeling and multidimensional scaling in detection of clustering patterns with use of country attributes to verify theoretical explanations of observed data.
3) building the body of knowledge about location choice of FDI from emerging to developed countries, as well as to other emerging markets, by examination of structural characteristics and dynamics of outward FDI from Poland in years 2007-2009 in disaggregated level of transactions.

The paper is organized as follows:

In the first section I present briefly institutional and historical background influencing the process of internationalization of Polish companies. In section two I describe research data, applied methods and techniques. In section three I present clustering patterns in locations selected by sets of Polish companies with similar investment patterns. In the last section I discuss a summary of findings and propose further research agenda.

II. Institutional and historical background

Narula and Guimon (2010, p.9) suggest that any attempt to analyze investment development paths (further referred to as IDP) for Central and Eastern European countries needs to consider carefully the very specific historical and political context. Indeed, the internationalization of firms from Central and Eastern Europe in general, and Poland in particular, is very specific given its historical context. These countries, politically dependent on the Soviet Union after World War II, were governed for over 50 years under institutional settings known as communist regimes and centrally planned economies. Economically they were organized as centrally planned, economies with a very limited role of both market transactions and firm level hierarchies, as mechanisms of resource allocation. Allocation of resources was almost entirely organized by a country's Communist Party and its agencies, including central and local government institutions. Communist Parties were granted country political monopolies by the Soviet Union, which directly controlled and influenced their conduct in all spheres of social and political life including economical relations. Several market institutions such as stock exchanges, property laws, and the monetary system were either non-existant or weak functioning at most. State owned companies had little autonomy to make strategic decisions such as FDI. Export was centralized and monopolized in specialized state owned agencies, and it was not at all under the discretion of managers of state owned firms to decide the levels and directions of foreign sales. With some variance among countries of the Communist block, private firms did not exist, except for some small enterprises providing basic services. Inward investment of any foreign company was hardly possible.

Under these conditions, the initial FDI structure was deviating from the IDP paradigm (Boudier-Bensebaa, 2008). The IDP paradigm predicted initially four, and later five, phases in which the balance between inward and outward FDI changes depended on the level of economic development (Dunning, 1981, Dunning and Narula, 1996, Narula and Dunning, 2000). In Central and Eastern Europe the wave of outward FDI was earlier than any inward FDI while Dunning and Narula (1996, p.35) proposed that in initial internationalization phases the stream of inward FDI will flow before outward FDI will emerge. This fact can be interpreted as the effect of the Soviet Party policy aiming to access technologies and resources from competing blocs of democratic countries. An alternative or perhaps parallel explanation is that FDI served as a defensive instrument of “system escape” (Jaklič, Svetličič, 2002) to mitigate inefficiencies of central planning.

The transition from centrally planned, Soviet dependent economies into market oriented, sovereign democracies started with negotiated revolution and the Solidarity movement in Poland. The Warsaw Roundtable agreement between Solidarity and Communist Party leaders was followed by a complete transition in institutional settings in Poland. In chain reaction, the transformation of all countries in Central and Eastern Europe quickly followed. While Central European countries shared much historically, especially their dependence on the Soviet Union, their cultural background is rooted in a much longer history resulting in important differences that include, but are not limited to, FDI country profiles (Boudier-Bensebaa, 2008, Narula and Guimon, 2010, Gorynia, Nowak and Wolniak, 2010).

Countries had also varied their approach to transformation and institutional change from centrally planned to market oriented economies. Many state-owned companies were sold through privatization to foreign investors in the initial years of transformation which resulted in high levels of FDI inflows through brownfield investments. Brownfield investments are considered to bring higher risks of crowding out effects than greenfield investments (Narula and Guimon, 2010). The share of foreign-owned companies in the list of 500 largest companies in Poland exceeds the share of both private Polish companies and state-owned companies, counted in absolute number and in cumulative revenues, which indicates that some crowding out effect is indeed observable. It is also worth mentioning that over 80% of the banking sector measured in assets is owned and controlled by foreign banks. Banks play an important role in internationalization as providers of financial resources needed for foreign expansion. Over 50% of all FDI from Poland were done by listed companies. This justifies the selection of listed companies for my research, but may also suggest both the crucial role of the Stock Exchange as capital provider for internationalization, and the limited interest of banks to finance such strategic initiatives.

The investment development path studies presenting aggregate data for Poland prove that inward FDI are much higher than outward FDI, a pattern that can be observed with different magnitude for all countries in the region (Gorynia, Nowak, and Wolniak, 2007, Boudier-Bensebaa, 2008, Gorynia, Nowak and Wolniak, 2010). This pattern is characteristic for the countries in the second level of the IDP paradigm. The level of outward investment in Central and Eastern Europe is substantially lower than what one would expect looking at indicators such as GNI per capita, or technological and educational capabilities of these countries (Narula and Guimon, 2010). Gorynia, Nowak and Wolniak (2010) decomposed inward and outward FDI dynamics at the country level to show that Poland is simultaneously in level 2 and 4 of the IDP framework if other Central Eastern European countries are separated from developed economies.

III. Data and methods

This research is based on data on FDI of all Polish non-financial companies listed on the Warsaw Stock Exchange in the years 2007-2009. Selection of the time period for this study is justified by the fact that the number of FDI transactions has almost doubled in the observed time frame. I have used a multi-source database for this study. Data on FDI's was extracted from the annual reports and firm's public statements published in this period. GNI per capital in US dollars , which I applied as a relative indicator of the level of country development, is taken from the World Bank database. Distances between countries are calculated based on circle measure distances between capitals calculated with use of: http://www.chemical-ecology.net/java/capitals.htm I also use two dummy attributes to verify the influence of EU membership, and historical legacy of transformation from a centrally planned into a market oriented economy in the Central and Eastern European bloc, for clustering tendencies of Polish FDI.

The level of data analysis differs from most earlier studies of FDI from emerging economies which tend to focus either on aggregate data on country level (Gorynia, Nowak, and Wolniak, 2007, Boudier-Bensebaa, 2008) or were based on survey data (Yiu, Lau and Brutton., 2007). The design of this study allows for in-depth structural analysis of FDI based on disaggregation of FDI into individual transactions based on archival, complete data set for 2007-2009. Modeling FDI as an affiliation network enables bridging between two most common approaches to study internationalization - country and firm level analysis. It is methodologically grounded in structural paradigm (Wellman and Berkovitz, 1988). While structural paradigm is well established in organizational science (Borgatti and Fosler, 2003) its use to analyze FDI is rather novel contribution of this study.

I am using social network analysis methods (Wasserman and Faust, 1994) in detecting groups of companies with like patterns of investments that are clustering in similarities in locations. I apply block-modeling techniques (White, Boorman & Breiger, 1975, Scott, 1991, Wasserman and Faust, 1994) and multidimensional scaling for graphic presentation of clustering patterns in low dimensional space (Young, 1987). I apply metric multidimensional scaling optimization for similarities with algorithms used in Ucinet software for network analysis (Borgatti, Everet, and Freeman, 2002). Based on multidimensional graphs in which countries are located in distance based on proximity of their investment patterns I further explore relationships among attributes of countries based on block models and data on geographic distance, GNI, EU membership and historical legacy of Central Eastern European transformation. The goal of this explanatory analysis is to validate the procedure of block modeling in detecting clusters with theoretical explanations of observed structural relationships. I apply block-modeling algorithms with Pajek software for network analysis (Batagelj and Mrvar, 1996) using 100 repetitions to optimize allocation of countries into separate clusters. I have selected 2 clusters for each year of my study, and increased it to 3 to observe the cohesion and size of extracted blocks.

IV. Results.

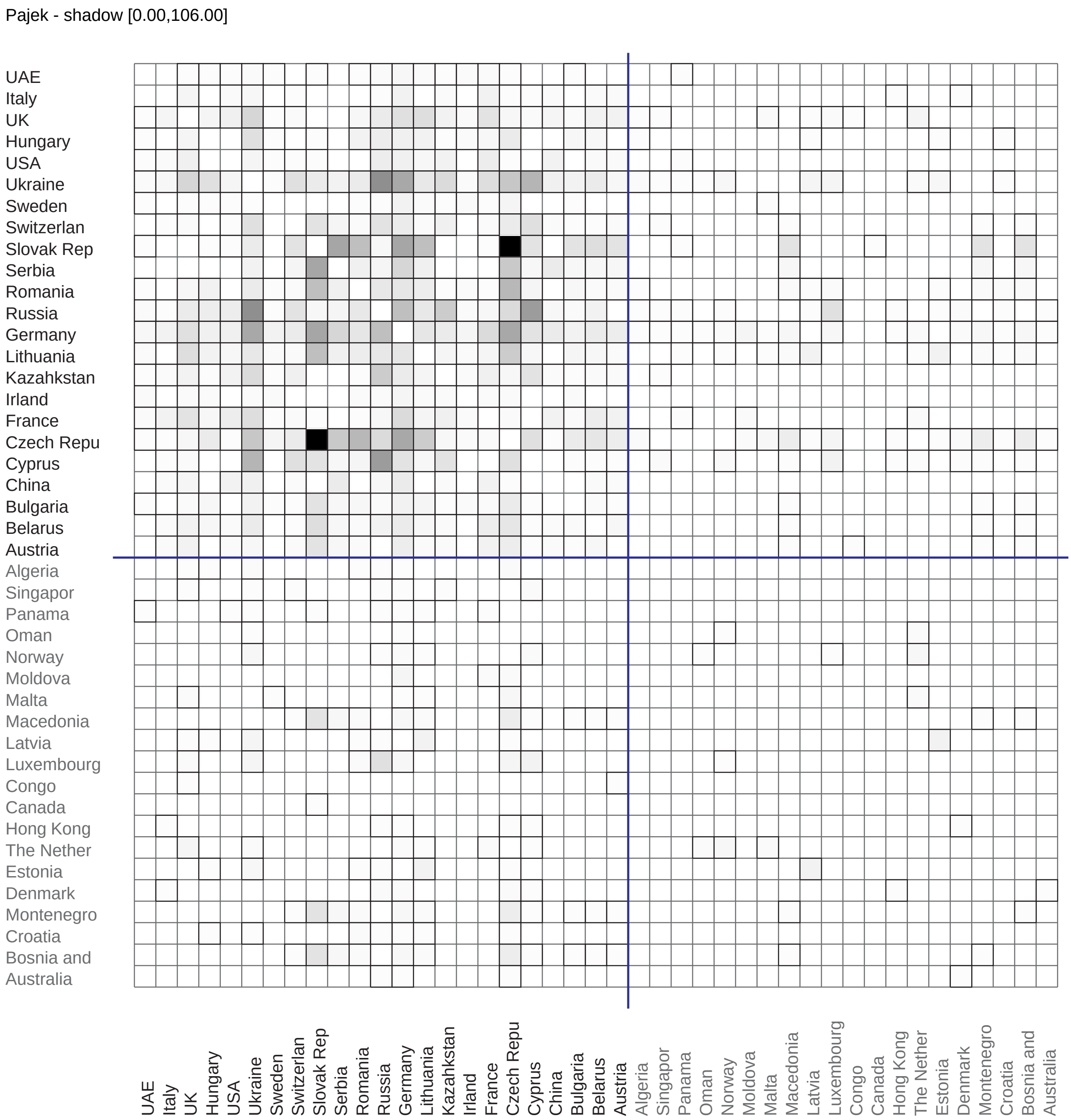
In the following table I am presenting basic data about the number of countries, firms, and FDI in consecutive years 2007-2009 as well as the density of the network in which countries are connected if the same company invested in them.

	2007	2008	2009
Number of countries	43	53	59
Number of firms	106	121	128
Number of FDI	331	496	628
Density	0.37	0,36	0,37
Average degree	15,3	18,7	21,2

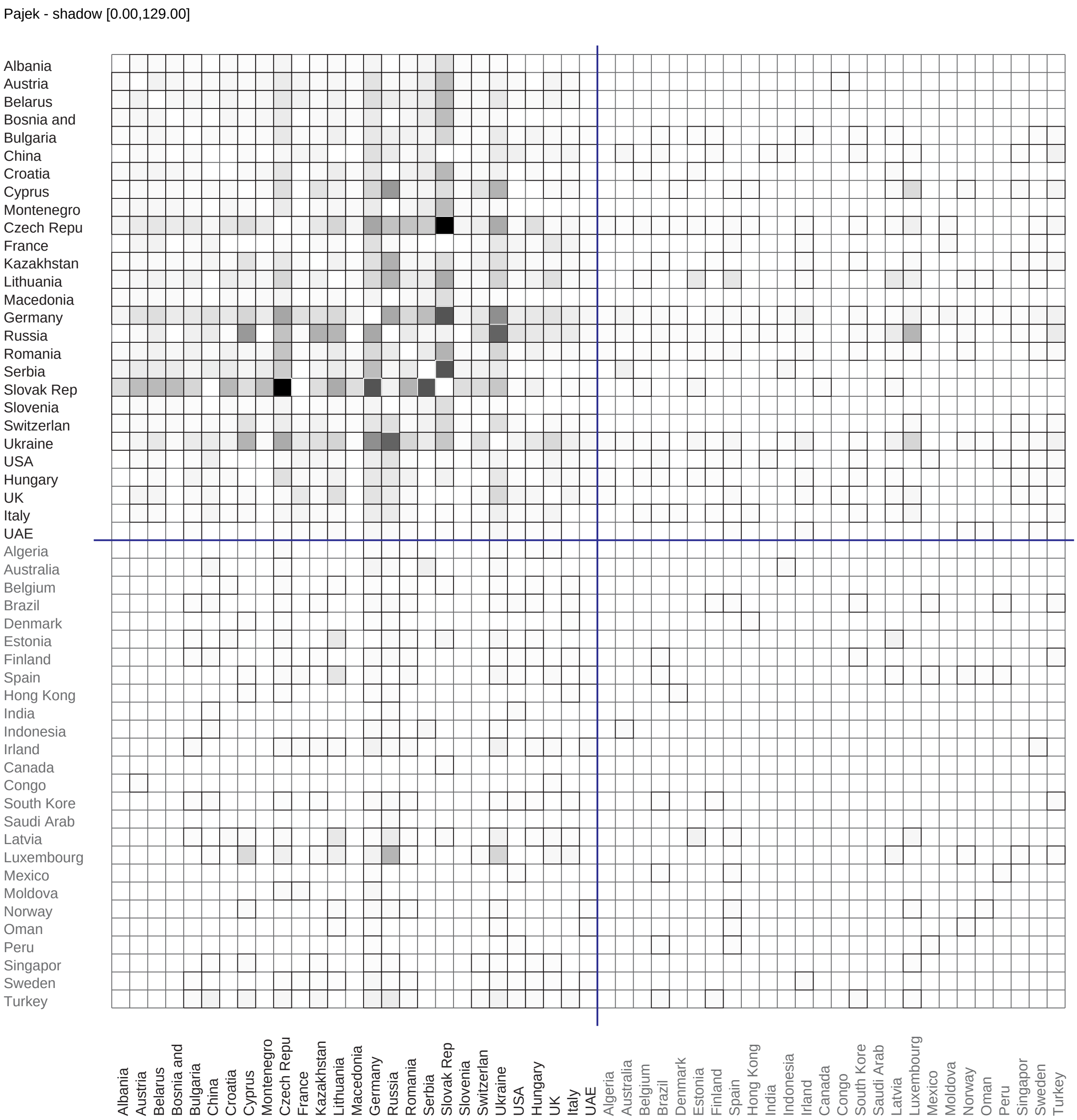
Table 1. Data review.

There are several observations from this initial data table that can guide further research. The number of countries Polish companies invested in had increased by 16 or 37% in the relatively short period of observation in 2007-2009. It looks like Polish companies substantially increased their global footprint and executives had chosen FDI locations from a much wider set of options in 2009 compared to 2007. This is not simply an effect of the larger population of companies which increased approx 20% in that period. New companies were listed on the Stock Exchange, and companies that were listed before 2007 have made their initial FDI in the observed period. There is an 89% increase in number of FDI transactions in three years – the single fastest growing category of observed data. This is reflected in almost constant density measures in the observed time. Initial data review suggests that we can expect not only absolute increases in the number of countries, firms and FDI, but also increasing patterns of co-location in core groups of countries by larger groups of companies.

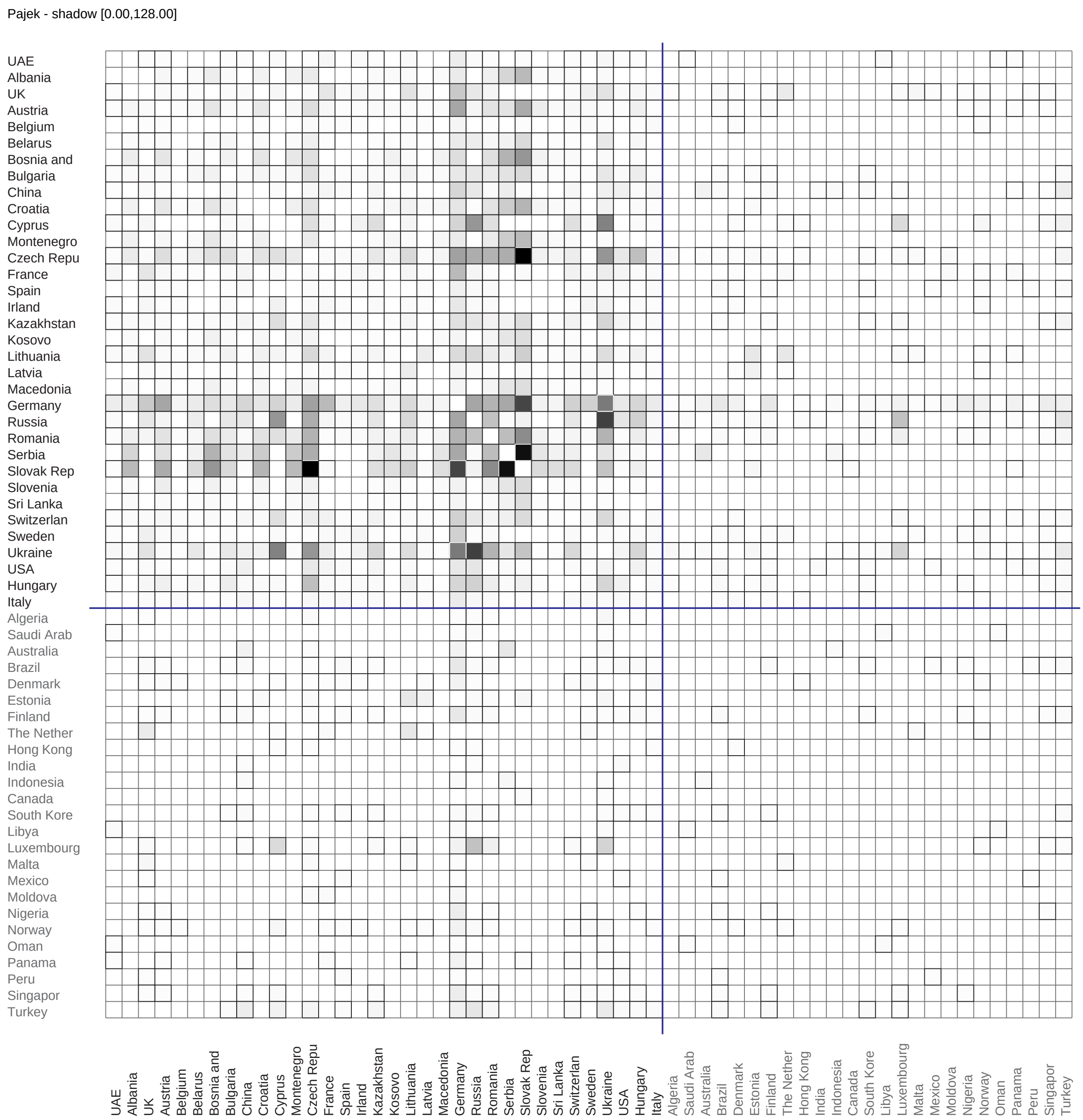
In the following pictures I am presenting the result of block-modeling of FDI co-location in the years 2007, 2008, 2009. I am using structural equivalence to find blocks of countries with similar patterns of Polish companies FDI co-location in other countries. The structural equivalence concept enables us to find categories or groups of nodes that have similar positions in a network (Scott, 1991, p.126). The block-modeling procedure in Pajek is described in Batagelj et al (2004). I have pre-defined the number of clusters to two for the years 2007, 2008, and increased the number of clusters to 3 for the year 2009. In the explanatory phase I have checked between 2 and 4 clusters for each of the years in search for what could be interpreted as a meaningful division of nodes into categories. In each procedure I have used a random start and 100 repetitions of the block-modeling procedure in order to minimize errors of clustering nodes into structurally equivalent blocks. The number of errors for block-modeling into two clusters of countries in 2007 is 364, in 2008 is 550, and from block-modeling into three clusters in 2009 is 606.



Picture 1. Block-model based on structural equivalence in FDI patterns among countries in 2007.

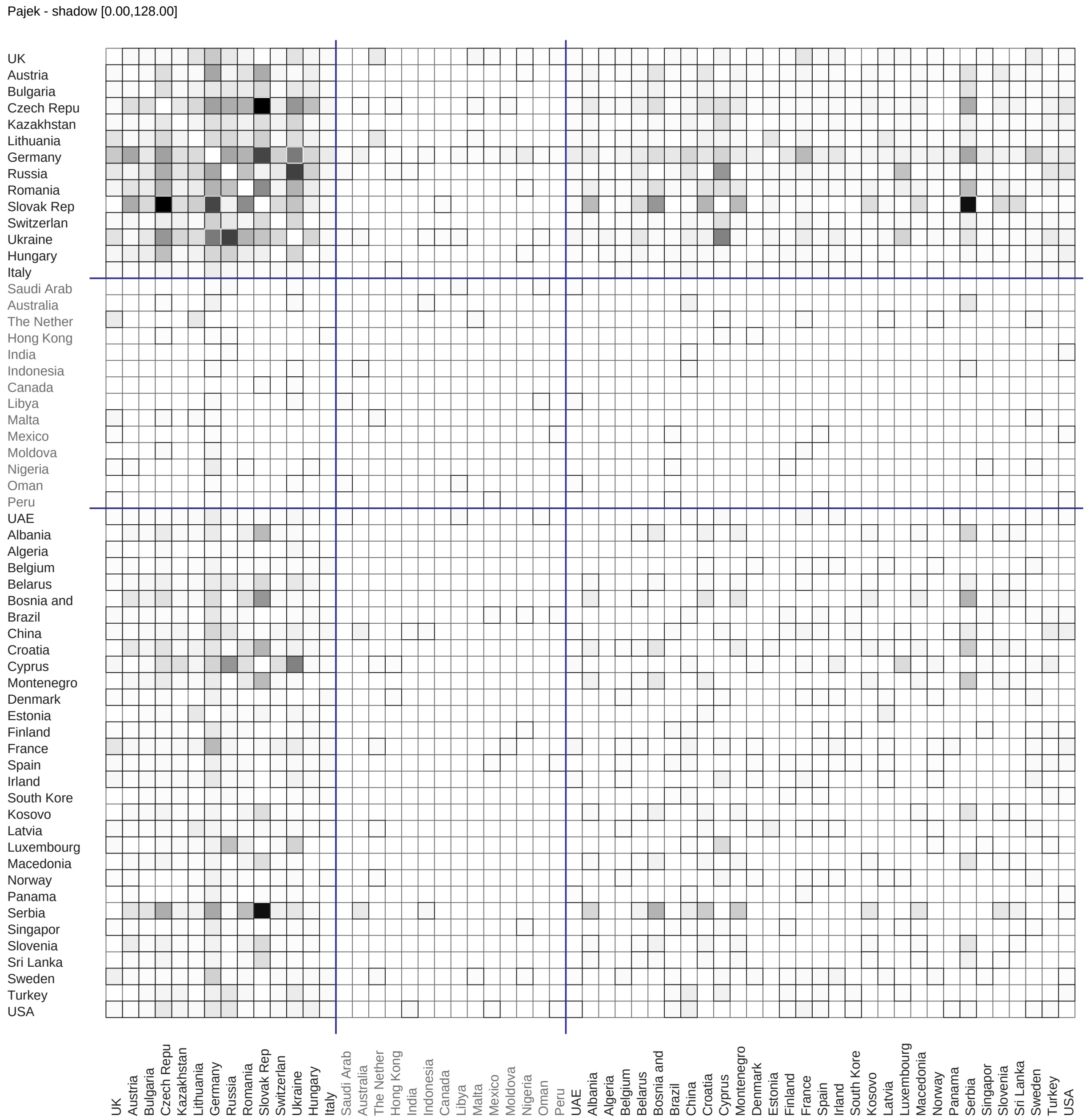


Picture 2. Block-model based on structural equivalence in FDI patterns among countries in 2008.



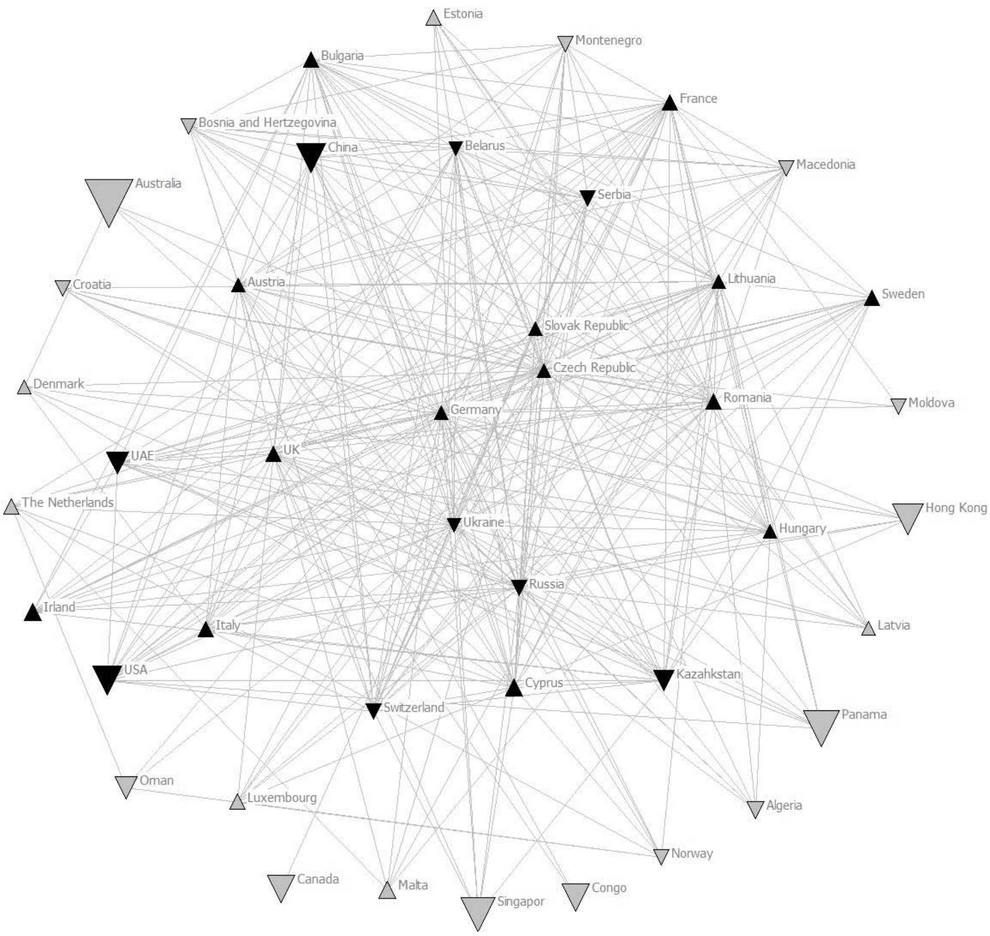
Picture 3. Block-model based on structural equivalence in FDI patterns among countries in 2009.

The matrices in the above pictures present patterns of Polish FDI and structural equivalence of countries in which firms tend to co-locate investments in relation to other countries in the network. In the first two matrices there are two block-models which show a core-periphery structure of colocation. Countries in block 1 are the core as many other investments in this group are co-located for each of these countries, while relatively few investments are co-located with countries from group 2. Countries in block two are in the peripheries of observed relationships. Investments in these countries tend not to be co-located with FDI in any other country. We can see that between the years 2007 and 2008 the density of co-location increases in the first bloc, while the second bloc of countries remains equally weakly correlated through its investment location patterns. The number of countries has risen by 4 in the core, and by 6 in the periphery, in the first year of observation. In the second year of observation the number of countries in the periphery decreases by 1. 7 new countries have risen to the core of the observed network in the second year. Based on the observation of unequal dynamics in core and periphery I decided to test alternative block-modeling into three clusters with hypothesized emergence of semi-periphery structure. This semi-periphery structure is presented in blocks number 3 in the picture below. We observe that both block one and two decreased in size and became more sharply distinguishable through their patterns of internal relations as well as relations to other blocks.



Picture 5. Block-model based on structural equivalence in FDI patterns among countries in 2009.

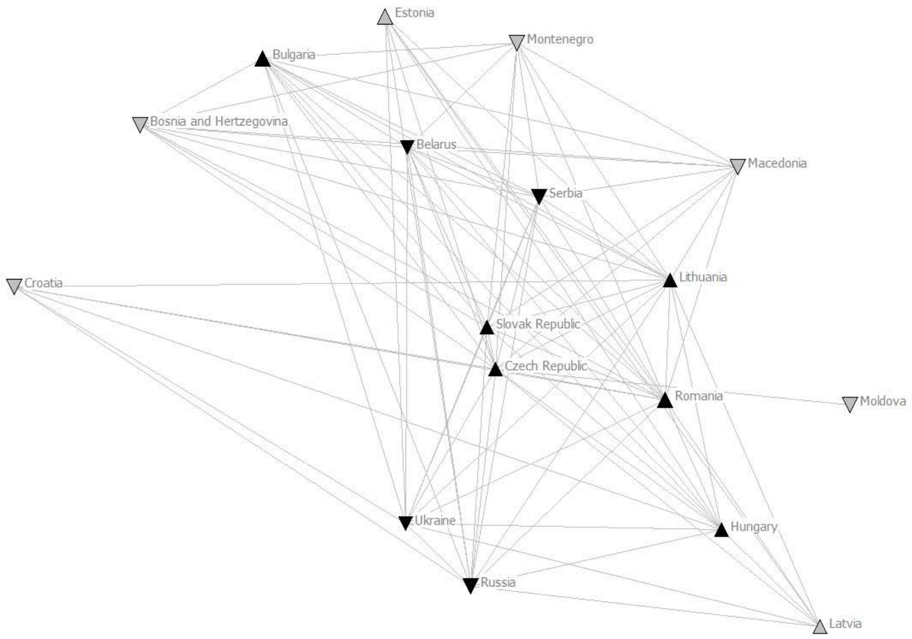
In the next step of the analysis I explore how block-models of observable locations correspond to country attributes commonly used to explain location clustering patterns of companies. I use attributes of physical distance, GNI per capita as a proxy of relative development, and check for effects of EU membership and transformation from a centrally planned to market economy in Central and Eastern Europe on observed investment patterns. Network visualizations presented below are produced with NetDraw software for social network analysis (Borgatti, 2002).



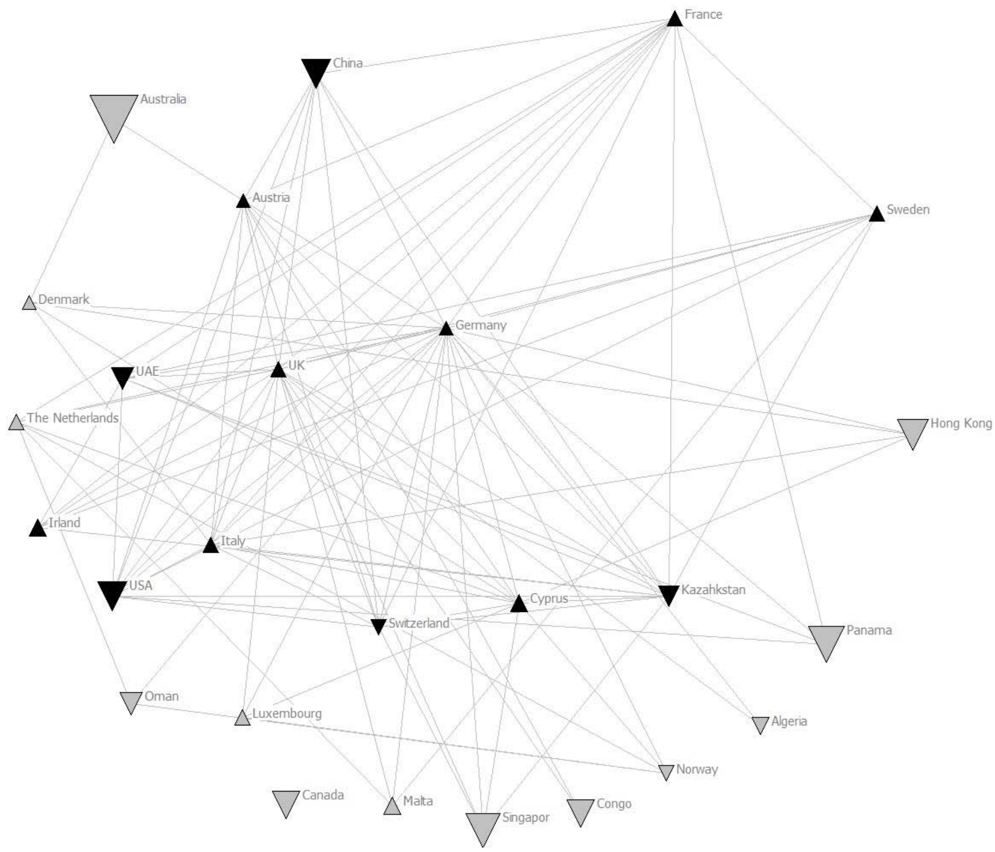
Picture 6a. Polish FDI Clustering in 2007. Prepared in NetDraw(Borgatti, 2002)
Legend
Shapes:
Upper triangle – EU member country
Lower triangle – non EU member country
Colors:
Black –first block from block-modeling. Core of the FDI clustering network
Grey – second block from block-modeling. Periphery of the FDI clustering network.
Sizes:
Geographic distance from Poland.

I present the network designed with graph theoretic formula of multidimensional scaling. Countries that are closer geographically have more similarities in investment co-location patterns of Polish FDI. A stress test for multidimensional scaling returns a value of approx. 0.39 after 10 iterations for each of the presented networks. Graphical models give adequate representation to 0.61 variability in the observed data on relationships through FDI in the same location. Polish companies tend to invest together in countries that are closer to each other on the graph. This rule is much stronger for countries in the core of the picture which was detected with the use of block modeling. Countries in block one described as core had similar patterns of investments among themselves and had little similarity with countries located in block 2. The latter countries form block one described as periphery. They have few relations among themselves as well as with core countries. Their proximity is then less precise and can be influenced by single co-location with other country. Looking at country attributes we see a rather weak influence of EU membership. EU member countries are found in both the core and periphery with only slightly higher representation in the core block that seems to be related to geographic distance. It is worth mentioning that several EU countries including Spain, Belgium, Denmark, and Finland are not even present in the periphery group, which means that there was no single FDI of any Polish listed company in 2007 to these countries.

Geographic distance seems to explain an important part of the variance between core and periphery. We observe all of the most distant countries with largest nodes in the periphery of the network graph. The only two exceptions of distant countries that are in block one are China and USA. These two world’s largest economies and recipients of FDI confirm the rather obvious expectation that size of economy matters. For clarity of the graph I am not presenting GNI data used as proxy for development. I have applied this measure with Polish GNI level for consecutive years as a threshold, but observed no interesting patterns in clustering, that can be related to this measure. The lack of any relationship between development level and outward investment patterns supports the earlier observation that FDI from Central and Eastern Europe do not fit expected values in relation to country level of development (Narula and Guimon, 2010). The last attribute of historical legacy of transformation occur important in determining clustering and proximities on the graph. In the pictures below I present network partitions based on this attribute. In picture 4b I present clustering patterns of FDI to Central and Eastern Europe, and in picture 4c to other countries that do not have a historical legacy of a centrally planned economy and political dependence on the Soviet Union.

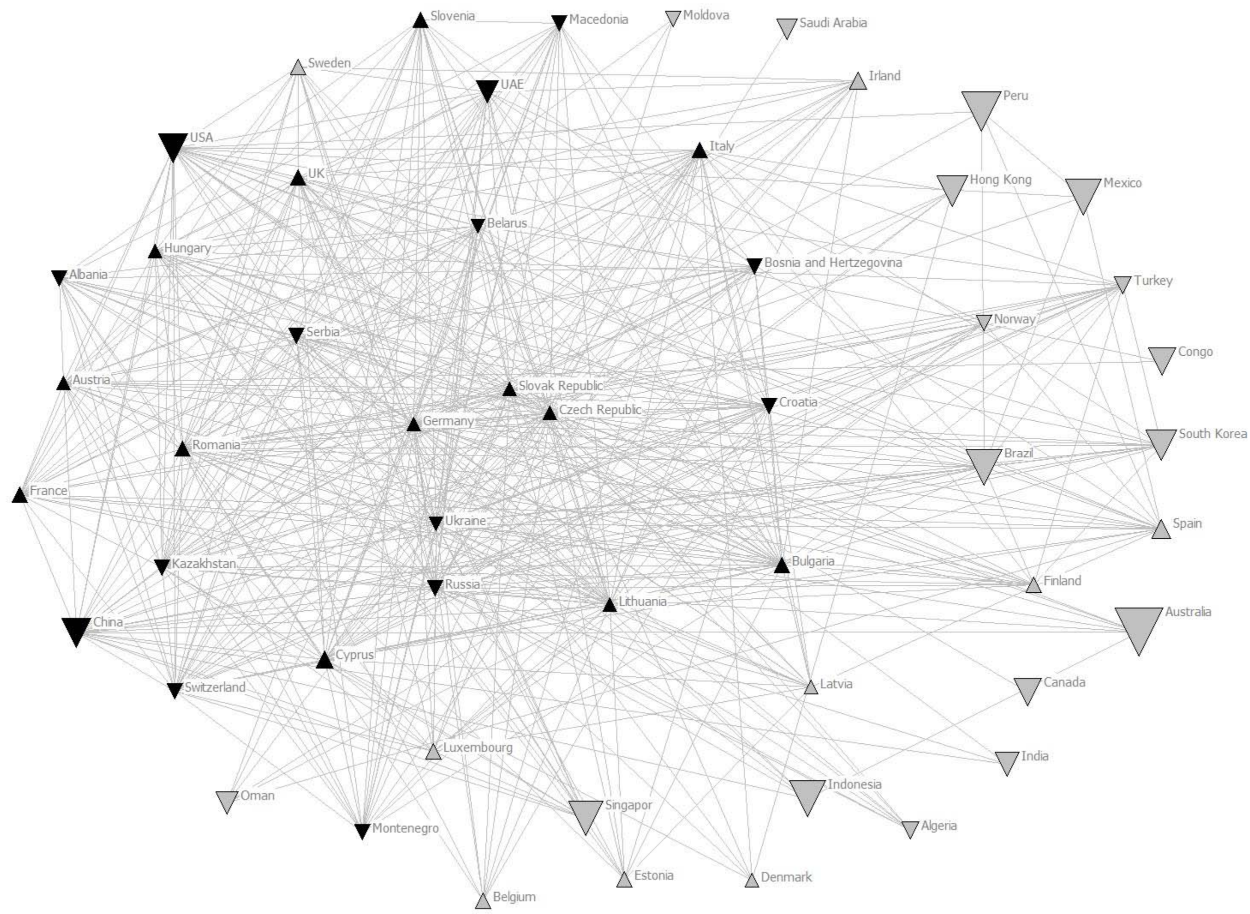


Picture 4b.Polish FDI Clustering in 2007 to transition economies in Central and Eastern Europe. Prepared in NetDraw (Borgatti, 2002)
Legend
Shapes:
Upper triangle – EU member country
Lower triangle – non EU member country
Colors:
Black – first block from block-modeling. Core of the FDI clustering network
Grey – second block from block-modeling. Periphery of the FDI clustering network
Sizes:
Geographic distance from Poland.



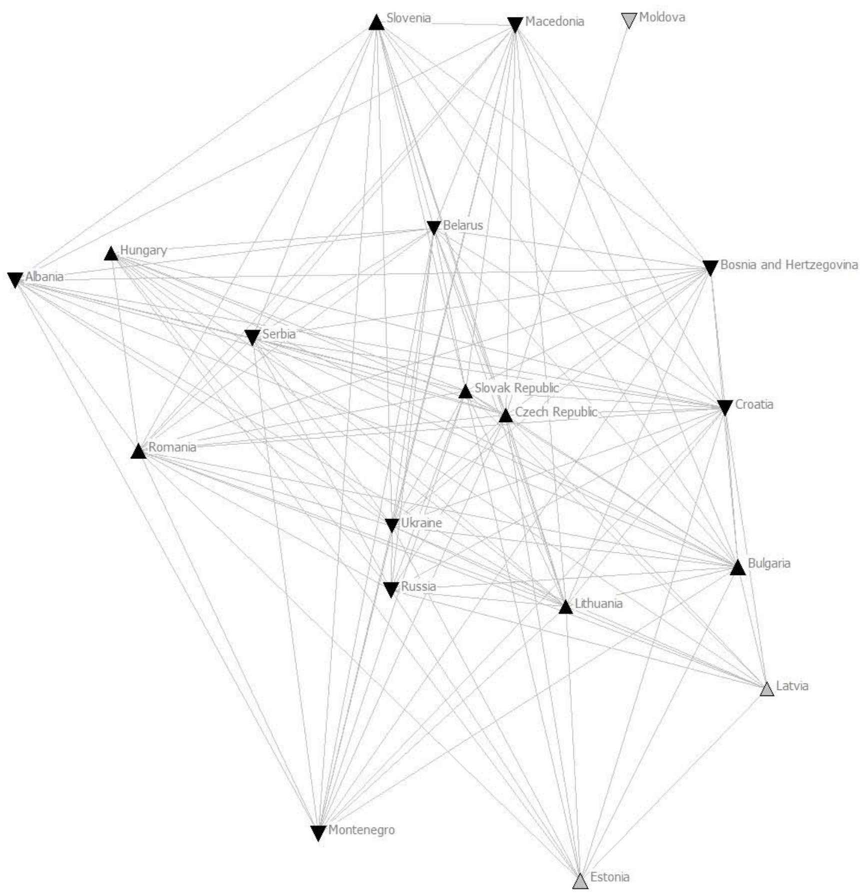
Picture 4c.Polish FDI Clustering in 2007to countries other than transition economies in Central and Eastern Europe. Prepared in NetDraw(Borgatti, 2002)
Legend
Shapes:
Upper triangle – EU member country
Lower triangle – non EU member country
Colors:
Black – first block from block-modeling. Core of the FDI clustering network
Grey – second block from block-modeling. Periphery of the FDI clustering network
Sizes:
Geographic distance from Poland.

While participation in blocks is not clearly conditioned by a common historical legacy, we can observe that multidimensional scaling has placed countries in picture 4b and 4c in distinct positions of the graph. This indicates that investment patterns in countries which experienced a centrally planned economy and later transition are similar and we can observe clustering dynamics in these countries. There are a few exceptions: FDI in France, Sweden and Hong Kong seemed to be often made by companies that invest in Central and Eastern Europe as they are placed nearby countries in the Eastern European block. On the other side of the picture we find Croatia. Investment of Polish companies into Croatia must be more often co-located with FDI into countries outside Central and Eastern Europe. Overall historical legacy seems to play an important role in observed clustering patterns. EU membership does not seem to influence proximity in investment patterns.



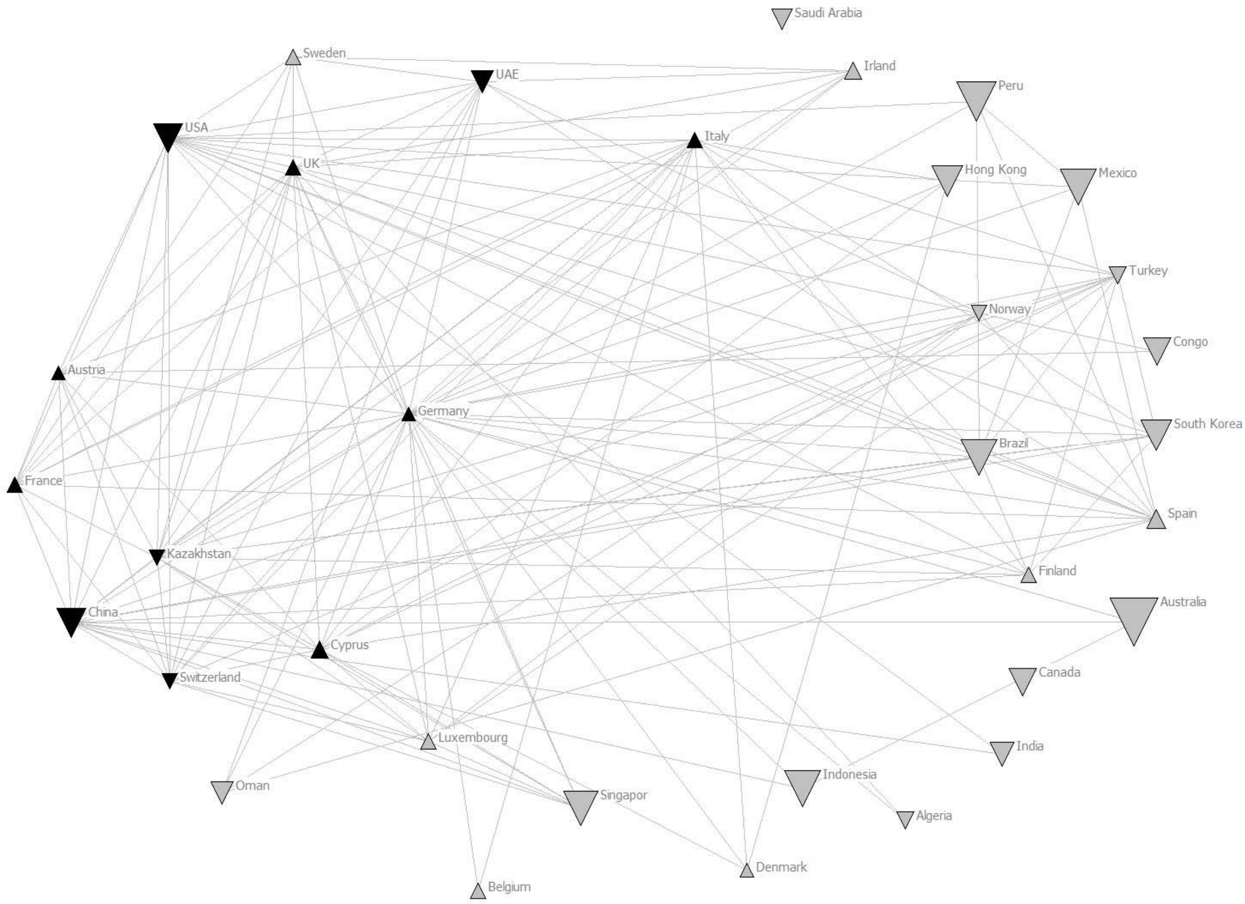
Picture 5a. Polish FDI Clustering in 2008. Prepared in NetDraw(Borgatti, 2002)
Legend
Shapes:
Upper triangle – EU member country
Lower triangle – non EU member country
Colors:
Black–first block from block-modeling. Core of the FDI clustering network
Grey– second block from block-modeling. Periphery of the FDI clustering network.
Sizes:
Geographic distance from Poland.

Compared to the network presented in picture 4a, both number of nodes – countries, and relationships – co-located FDI increases in the picture 5a. Countries in the core and periphery are located in more separate dimensions of the graph through application of multidimensional scaling. We observe two consecutive processes: a notable rise in the absolute number of countries and the rising co-location patterns of countries in the core of the network. While the number of EU versus other countries in the core seems equal, we can observe that the majority of countries in the periphery are not members of the EU. Several EU member countries in the periphery of the network signal the very initial FDIs Polish companies made into Spain, Ireland, Finland, and Belgium. Distance remains important – with the exception of China, US and UEA, all countries in the core are in close geographic proximity to Poland. All other distant countries are located in the second block of periphery which suggests FDI into them are quite unique ventures of entrepreneurial companies. Historic legacy remains important, as shown below.



Picture 5b. Polish FDI Clustering in 2008 to transition economies in Central and Eastern Europe. Prepared in NetDraw (Borgatti, 2002)
Legend
Shapes:
Upper triangle – EU member country
Lower triangle – non EU member country
Colors:
Black – first block from block-modeling. Core of the FDI clustering network
Grey – second block from block-modeling. Periphery of the FDI clustering network
Sizes:
Geographic distance from Poland.

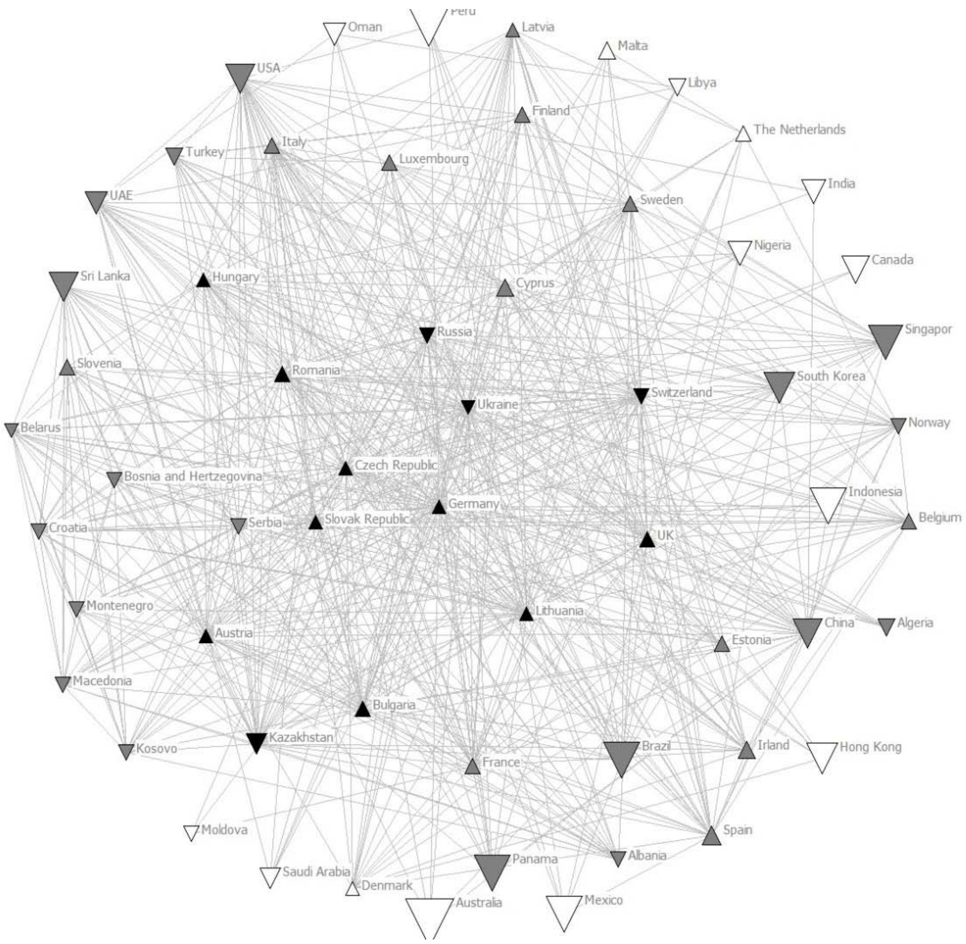
The most striking observation of the partitioned network of Central and Eastern European countries is that all of them moved toward the core except Estonia, Latvia and Moldova. This suggests that some companies strategically oriented their investment into post-communist countries. Within a group, placement looks related to geographic proximity of countries. Czech Republic and Slovakia are closest, but other notable groups are Russia, Ukraine, Lithuania and Romania, Hungary, Serbia and Albania. EU membership does not seem to be an important factor in locational decisions within this region.



Picture 5c.Polish FDI Clustering in 2008 to countries other than transition economies in Central and Eastern Europe. Prepared in NetDraw (Borgatti, 2002)
Legend
Shapes:
Upper triangle – EU member country
Lower triangle – non EU member country
Colors:
Black –first block from block-modeling. Core of the FDI clustering network
Grey– second block from block-modeling. Periphery of the FDI clustering network
Sizes:
Geographic distance from Poland.

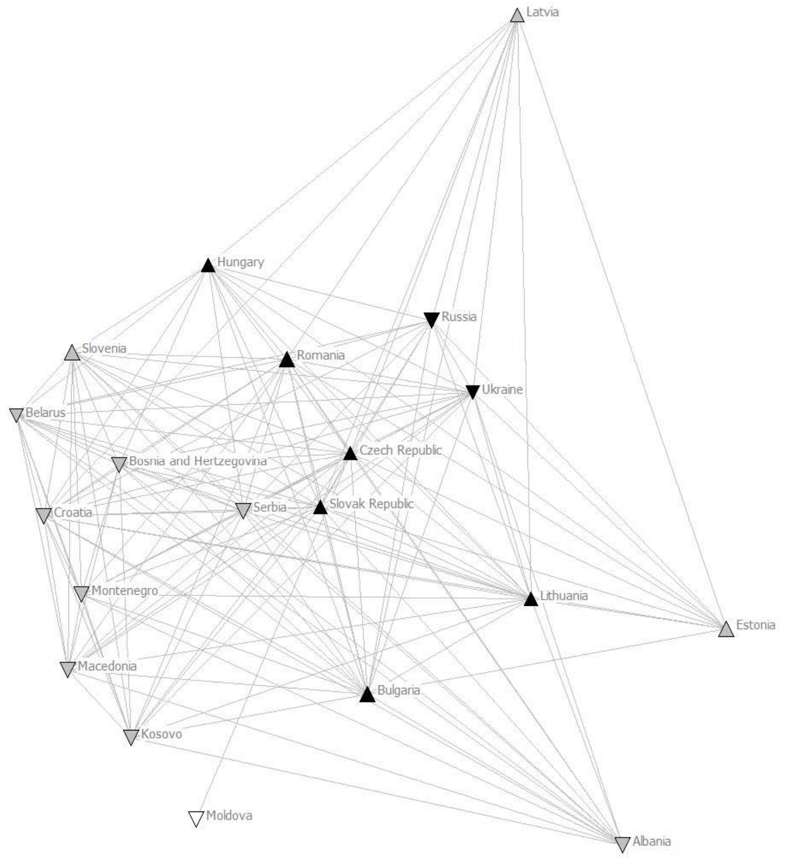
Remaining countries which have not suffered from a centrally planned economy are less concentrated in the core block of the network. The majority of these countries are on the periphery, and many of them are located far from Poland. There is no observable clustering pattern within this group that can be explained by EU membership, geographic proximity or development level.

In the third year of observations, the network further increases in size, remaining equally dense. This means that both co-location and clustering increase nearly four-fold in relation to the increase of the countries. Based on this observation I explored if increasing the number of blocks in block-modeling procedure to three will result in a more interesting structure of relationships.



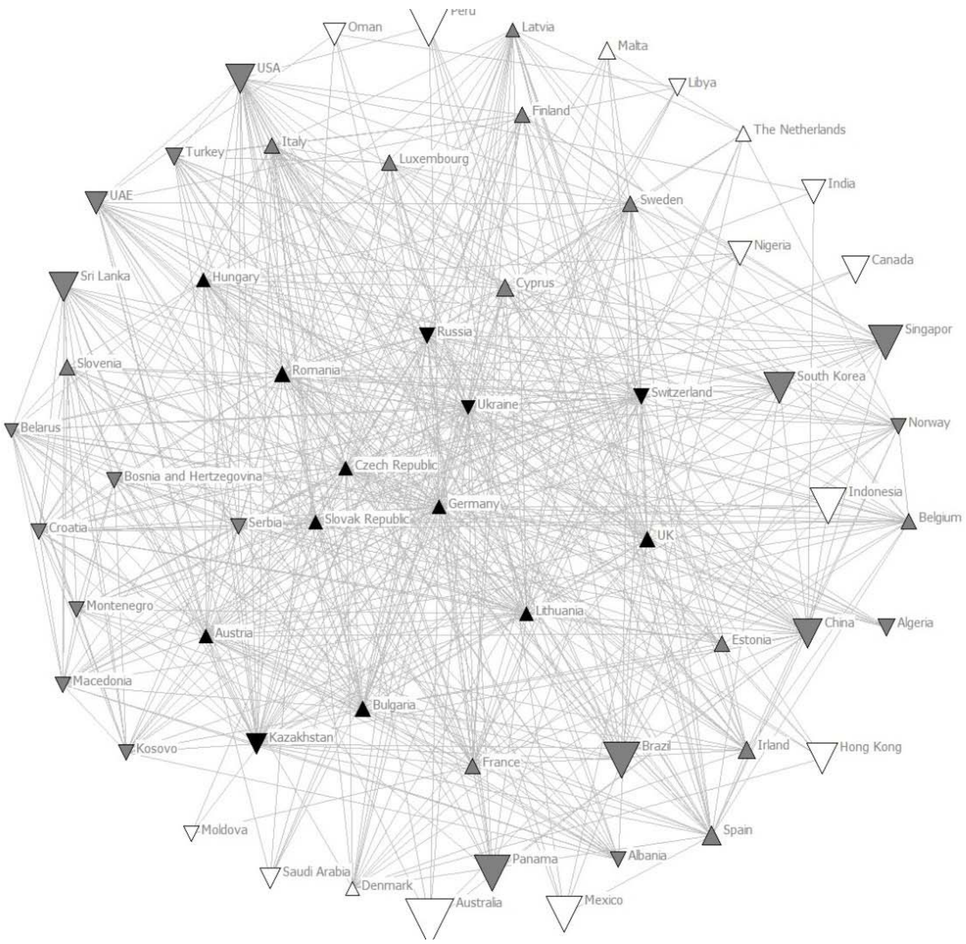
Picture 6a.Polish FDI Clustering in 2009to countries other than transition economies in Central and Eastern Europe. Prepared in NetDraw (Borgatti, 2002)
Legend
Shapes:
Upper triangle – EU member country
Lower triangle – non EU member country
Colors:
Black – first block from block-modeling. Core of the FDI clustering network
Grey– second block from block-modeling. Semi-periphery of the FDI clustering network.
White – third block from block-modeling. Periphery of the FDI clustering network.
Sizes:
Geographic distance from Poland.

The core group is composed of countries in close geographic proximity with the exception of Kazakhstan, which appears in this group due to several resource related investments in the energy sector. We can consider it an outlier in our set of observations.
The second most distant country is the UK. The addition of the semi-periphery level enables us to see an emerging pattern of colocation into other EU member countries which are all but one located either in the core or semi-periphery of the network except The Netherlands and Malta. Semi-periphery includes several distant countries like Brazil, China, South Korea, USA, Panama, Sri Lanka, and Turkey. In what is now a more cohesive core, all countries are located in close geographical proximity to Poland. The introduction of the semi-periphery level of observation indicates that there is notable variance in FDI patterns in Central and Eastern European countries.



Picture 6a. Polish FDI Clustering in 2009to transition economies in Central and Eastern Europe. Prepared in NetDraw (Borgatti, 2002)
Legend
Shapes:
Upper triangle – EU member country
Lower triangle – non EU member country
Colors:
Black – first block from block-modeling. Core of the FDI clustering network
Grey– second block from block-modeling. Semi-periphery of the FDI clustering network.
White – third block from block-modeling. Periphery of the FDI clustering network.
Sizes:
Geographic distance from Poland.

Central and Eastern European countries remain in close location on the graph which suggests increase in co-location patterns. Whole cluster of countries moves from core to periphery of the FDI network between 2007 and 2008. This suggests emergence of distant patterns of Polish FDI co-location into southern block of countries in Central and Eastern Europe. Sub network of countries with legacy of transformation shows geographic direction dimensionality. FDI into countries in Eastern, Northern and Southern directions seem to cluster into relatively distinct groups.



Picture 6a.Polish FDI Clustering in 2009to countries other than transition economies in Central and Eastern Europe. Prepared in NetDraw (Borgatti, 2002)
Legend
Shapes:
Upper triangle – EU member country
Lower triangle – non EU member country
Colors:
Black – first block from block-modeling. Core of the FDI clustering network
Grey– second block from block-modeling. Semi-periphery of the FDI clustering network.
White – third block from block-modeling. Periphery of the FDI clustering network.
Sizes:
Geographic distance from Poland.

While this sub-graph does not give such a clear picture of directionality of investments as the earlier graph, two groups of countries seem co-located in a meaningful manner. Asian countries including China, South Korea, Indonesia, Singapore and Hong Kong occupy a close place in the graph. Another group of countries in which joint FDI patterns emerge is Spain, Brazil, Mexico, and Panama. There is also a flow of EU member countries towards the semi-periphery and core with a group of 9 EU member countries occupying positions close to the center of the sub-graph. The center of the graph is where many of Central Eastern European countries are located, which suggests increasing convergence of investment patterns among these groups.

V. The Conclusion

Distance and institutional history matter the most in relation to observed clustering of Polish FDI. My research presents a short but important period in outward development dynamics. I have used block-modeling and multidimensional scaling techniques to detect patterns of clustering that I related to attributes including distance, EU membership, GNI per capita, and historical legacy of transition from a centrally planned to market economy in Central and Eastern Europe. Geographic distance seems to explain a lot of variance in all three years of analysis. With an increased number of countries and FDI between 2007-2009, directional patterns also emerge with groups of companies tending to invest in cohort in the Balkans, South America, Spain, and Asia. As these investments are still relatively rare and appearing in the semi-periphery structure of the observed network, I would expect that knowledge searching and transfer, and social relational aspects of these investment decisions, would be especially interesting subjects for extended research. Are companies investing together in semi-peripheries connected by interlocking directorates or joint membership in business organizations? Are they engaged in knowledge transfer and joint initiatives in markets into which they decided to expand? The fact that several countries of distant location moved to the semi-periphery in which there are observable clustering patterns suggests that companies make similar decisions in close time proximity about locations to what may be seen as less likely directions.

There is of course a quite substantial group of countries in the peripheral block of the network which is expanding substantially by 16 new countries in the observed time. These novel FDI locations indicate a distinct way of internationalization into places where no other companies explored before. While this move enables other to follow and eventually form a cluster in the future, research into the decision process about such entrepreneurial FDI, and financial results of companies undertaking them, would be another interesting extension of this study. Lack of relationships to FDI in other countries while undertaking investment into locations from the periphery of the network suggests that some companies do not follow the Upsalla model in their process of FDI expansion.

The historical legacy of transformation from a centrally planned to a market economy is another factor that is clearly related to clustering patterns. Many Polish companies specialize in investment into several countries of Central and Eastern Europe. This observation confirms earlier findings of Gorynia, Nowak and Wolniak (2010). Distinct outward investment patterns into Central and Eastern Europe support their suggestion to separate Central and Eastern Europe in studies of Polish investment IDP.

Theoretical expectation of FDI clustering into neighboring countries is supported by the findings of this research. Clustering patterns in most developed economies is only starting to emerge weakly, as the critical mass of FDI transactions increases in observed years. The fact that Polish companies invested in 16 new countries in that period including 9 of G20 countries where they did not have any FDIs is worth mentioning. Based on observed network dynamics, I to propose that a pre-condition of the emergence of new multinationals from emerging economies is that they have opportunities to learn from a network of peer country companies which share the risks of entering into new markets. The future will show if these investments into new territories will be followed by imitative movements of other companies, and eventually lead to the emergence of Polish multinationals. Without presence of other home country companies in all developed countries the emergence of multinationals seems highly unlikely.

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A Value Chain Perspective on the Internationalisation Process of Modular Product Manufacturer – An Emerging Country Perspective

Rasha Rezk and Jagjit Singh Srai,
Institute for Manufacturing, Manufacturing and Management Division,
Department of Engineering, University of Cambridge CB3 0FS
Tel: 44 (0) 1223 338175 http://www.ifm.eng.cam.ac.uk/cim/

ABSTRACT

This paper takes a manufacturing value chain-based analysis to investigate the evolution path of a Chinese modular manufacturer, from inception to its emergence as a competitive player in the global field. This paper presents a methodology for mapping the stages of internationalisation across a firm's value chain, exploring the dispersion and governance arrangements within a mostly modularised product supply chain, and within a highly decoupled functional value chain. In so doing, a configuration-profiling tool has been developed building on related concepts from international business (IB) and operations management (OM) domains, to explore the different network configuration states that are linked to specific internationalisation phases of development, providing insights on motives and capabilities within various configuration models.

The approach enables the value chain configuration profiling of the products international evolution, including the capture of the functional disaggregation patterns of the firm, at various stages of evolution, within both emerging and developed markets. The analysis codifies how the firm followed a multi-domestic international footprint within this product division, illustrating the process of functional and organisational reconfiguration. This paper represents a new way of modelling a firms' internationalisation process using a value chain configuration perspective.

INTRODUCTION

A lively debate has ensued as to whether existing IB theories, which are mainly based on developed countries are sufficient to explain the emergence of emerging countries multinational corporations - EC-MNC (Rugman, 2009), or whether new theories are needed (e.g. LLL Mathews, 2002, 2006). Former internationalisation models are revisited to take a network approach to understand the activities of MNCs (e.g. Johanson and Vahlne, 2009). New models have described EC-MNCs international footprint considering firm and country specific advantages, whilst taking other contextual factors such as industry and value chain scope (e.g. Ramamurti and Singh, 2009). Extending this approach and a related functional and process-based value chain perspective, recent IB and OM studies have attempted to capture the internationalisation strategies of EC-MNCs in comparison to their counterparts from developed countries (e.g. Mudambi, 2008; Srai and Fleet, 2011). While OM literature considers the firm's manufacturing and supply network, introducing new strategic and operational parameters, the interface between the two mainstreams of literature remains rather thin.

A network perspective that involves a value chain analysis as structured methodologies often focuses on the functional activities. What activities firms undertake in-house/offshore/outsource, and how they reconfigure, disperse and disaggregate those activities (e.g. Contractor et al, 2010), which control strategy they adopt disaggregating their value chain across geographies maintaining control over their most valuable processes in an attempt to develop their capabilities and competitive advantages (e.g. Mudambi, 2008; Mudambi and Venzin, 2010). However, a broader network perspective could enrich existing theories, one that incorporates other dimensions such as governance, product architectures and development, coordination and partnering arrangements. The existing IB and OM theories suggest that these dimensions could have a significant impact on the firm's internationalisation strategies.

This paper seeks to explore the internationalisation path and motives of an EC-MNC using a supply network configuration perspective. The study aims to offer a methodology for mapping the stages of internationalisation against the manufacturing value chain activities identifying the different evolutionary patterns of the firm's network configuration. The approach entails exploring firms' network configurations options, using related concepts and dimensions from both IB and OM domain to build a framework that analyses the influence of product structure and value chain modularity on defining the firm's value chain scope, geographic dispersion and governance arrangements. In addition, the developed conceptual framework also supports the selection options for network configuration that enables particular motives and capabilities to be realised within the various configuration models of the different internationalisation phases of the firm.

FIRMS' INTERNATIONAL OPERATIONS

Early internationalisation models that explored firms' internationalisation path, such as Uppsala model (Johanson and Vahlne, 1977) and innovation models (Bilkey and Tesar, 1977; Reid 1981), showed that firms incrementally internationalise their functional activities, commencing with downstream activities then replicating a vertically integrated supply chain structure in different foreign locations. These models offered a market-driven internationalisation perspective; where foreign direct investment is intended to supply particular products to (particular) foreign markets. The choice of the foreign locations were found to be influenced by location variables, the level of the physic distance (Johanson and Vahlne, 1977) and the investment level was determined by the firm's knowledge of market. Another market-driven model introduced by Vernon (1966), but based on the product life cycle, also suggested that firms would replicate their supply chain activities based on the market they are serving, which is influenced by the product life cycle.

The industry and product structure might no longer support these vertically integrated, replicated models. The prevailing findings in the literature suggest that industries begin in an integrated mode and become disintegrated over time (Fixson and Park, 2008), with products becoming modular; this results in a change in the industry structure towards higher degrees of specialisation (Galvin and Morkel, 2001) and a decentralised structure as a result of the reduced level of coordination (Langlois and Robertson, 1992). Globalisation occurs when firms have an 'institutionally modular' product or service; that is, a product or service which 'fits' within the vertical structure of the sector of the host country (Jacobides, 2005; Jacobides Tae, 2006) while product diversification could moderate the relationship between international diversification and performance (Hitt et al, 1997).

The modularisation between value chain activities allows the decoupling of tangible and intangible activities where firms may specialise in part of the value chain "value propositions" instead of owning a vertically integrated structure with a geographic dispersion strategy that is either concentrated or dispersed (Mudambi, 2008). The value chain may also be decoupled to reduce the product lead time, where parts of the supply chain may be decoupled upstream "towards supplier" focusing on supply integration (lean supply chain) or downstream (towards the customer) focusing on demand integration (agile supply chain) (Naylor et al, 1999; Treville et al, 2004). Accordingly, the value chain maybe decoupled/fragmented at different stages depending on the product configuration and industry requirements.

THE DISPERSION AND EVOLUTION OF THE FIRM'S VALUE CHAIN

It is argued that the optimal disaggregation and slicing of the firm's value chain between home, foreign affiliates and contractors should be evaluated against the degree of modularisation of value chain activities, division of labour and modern technology (Contractor et al, 2010), taking into consideration that the co-ordination cost between different activities won't undermine the offshoring and outsourcing choices (Contractor et al, 2010). Srai (2012) analyses industry tier structure and value chain functional integration requirements that firms need to consider as they develop into global players. The degree of disaggregation of industrial value chains and their supply structure (multi- tier/long or assembly/short chain) along with the degree of coupling between different value chain stages are shown to influence the functional and tier structure boundaries in which firms' international footprints emerge.

In addition, the role of the firm and its subsidiaries is likely to evolve undertaking a process of reconfiguration and organisational change, where the disaggregation/aggregation of the firm's value chain could alternate during the firm's internationalisation path. Rugman et al (2010) suggested that firms' subsidiary roles could be aggregated at value-chain level, whilst the effects of regional integration on the national subsidiary along with CSA/FSA could alternate the subsidiary functional role permitting a particular subsidiary to play a lead functional role in the firm’s global network, and later this role could be downgraded/upgraded or even eliminated.

Identifying the functional and process reconfiguration together with the changes in subsidiaries’ role may inform not only of their evolution patterns, but may also provide potential motives of the firm’s foreign investment. Building on the Uppsala stage model, and Porter’s (1980, 1985) ‘functional-based’ value chain concept, Dunning and Lundan (2008) have used a network approach to explain the possible evolution of MNCs and how the different phases of internationalisation depend on the initial motive for FDI. Using a related ‘process-based’ value chain perspective, Srai and Fleet (2011) investigated and identified different investment patterns found in both traditional western MNCs and those of emerging countries showing that the main drivers behind the firm’s foreign investment maybe deduced from the ‘stage’ of the value chain the firm choose to allocate in its foreign/international locations.

Despite the different perspectives that IB and OM studies offer, both have suggested that firms undergo a process of functional and organisational reconfiguration during their internationalisation path. This paper seeks to explore the drivers behind fragmenting/integrating firms’ value chain, in particular, how the network tier structure (Lambert & Cooper, 2000; Carbonara et al, 2002; Choi and Hong, 2002; Srai, 2012) and activity modularity (Naylor et al, 1999; Mason and Towill, 1999; Treville et al, 2004; Mudambi, 2008; Contractor et al, 2010; Srai, 2012) influence the firm’s subsequent international footprint.

APPROACH

The evidence from the literature suggests that in order to capture the internationalisation process of a firm, a network approach may provide new insights to the different stages of the firms’ evolution (Johanson and Valne, 2009; Mathews, 2002; Johanson and Mattson, 1988). Value chain configuration and analysis tools are developed building from related concepts in the literature, where selected dimensions from IB and OM domain have been identified (see Table 1) providing a framework to map and capture the different configuration options of the parent firm and its subsidiaries. The selected configuration elements support alternative value chain evolutionarily models in terms of the firms’ dispersion (geographic, physic) and governance arrangements along its internationalisation path. In addition, the dimensions also incorporate how the firm managed to organise its operations strategy in terms of material and information flow.

Having identified the key dimensions and approach. The research takes the firm’s supply network as the unit of analysis, but taking a focal firm perspective, an approach used in the operations management area (Lamming et al, 2000; Srai and Gregory, 2008). The research seeks to investigate the evolution path of the firm, from inception to its emergence as competitive players on the global filed. The global trend of FDI outflow per industry was used to capture industries which have become highly internationalised over the last 25 years identifying electronics industry as one of the main contributors of OFDI having both emerging and western firms competing globally possessing a high degree of internationalisation.

As the supply network structure and product modularity are key variables, an exploratory case study from the white goods sector have been selected, the selected sector is also identified as an established mature industry. Although, multiple-cases approach enable the researcher to generate theories it also enables the researcher to identify common patterns among the cases and avoid chances of association (Eisendhardt, 1991). Given the complexity of applying a theoretical approach from two different schools of thought, with the aim to test the initial framework, the research will focus on one case study to reduce complexity, using multiple data collection tools to assist with the triangulation of data thereby strengthening the validation of the qualitative outcome of the research. The applied data collection tools include in-depth interviews, documentation and secondary data sources.

The selected case study is from an emerging country, has entered the international market as a contract manufacturer and established itself amongst the most successful multinationals in the industry. In 2011 the company brand had the world's largest market share in white goods, with 7.8 per cent retail volume share. Moreover, the firm developed a global manufacturing value chain operating in various emerging (E) and developed (D) markets, which makes it a suitable case for the purpose of this research. In order to capture the evolution path of the selected case, the appropriate time frame starts from the initial international experience as a Contract Manufacturer to international customers, traditionally the Original Equipment Manufacturers (OEMs) through to the current situation where the firm has established its own global chain. The adoption of the above criteria allows the alternative firms’ configuration patterns to be captured for the different internationalisation pattern.

CASE STUDY PROTOCOL

Due to the longitudinal nature of the research, the data was collected in a chronological order to capture the firm’s internationalisation phases’ sequence. Exploring causal relationships, looking directly and longitudinally at processes, states and events, which lead to specific outcomes (Miles and Huberman, 1994). Next, at the different internationalisation phases of the firm, the aforementioned configuration mapping tools were used to capture the different configuration profiles (See Table 2) of both the parent firm and its subsidiaries identifying alternative firm’s value chain models and displaying the evolution its subsidiaries in the network. Given the longitudinal nature of the study, company documents and archival material was used as secondary data to capture the information that interviewees do not recall, and to compare different sources of data. The use of multiple sources of data will increase construct validity through triangulation of data (Yin, 2002).

STUDY FINDINGS - EMERGING VALUE CHAIN MODELS

The empirical findings showed that the firm adopted more than one strategy sequentially along their internationalisation path, which constituted of 5 phases (See Figure 1). Each phase represented a different manufacturing value chain structure. These alternative value chain models were driven by the product configuration and location variables and supported by the modularisation between the value chain activities.

Phase 1 “Contract Manufacturer” – The firm acted as concentrated tier 1 supplier based in Qingdao, China supplying markets in Western Europe and US. These markets were selected based on the business relationships established by the firm with OBM. Later, the company expanded its foreign market to act as a multi-regional supplier for Western Europe, US, then

Southeast Asia and Middle East. The company was acting as a low cost supplier, exploiting its cost differentiation advantages. The replenishment model was supply-demand focus and the company was manufacturing the customer own products.

Phase 2 "Own Brand Manufacturer" Own brand development with export linked to existing export market, exploiting the firm's cost differentiation advantages and establishing brand awareness in various markets. The company still acted as highly concentrated tier 1 supplier based in Qingdao, China, controlling a vertically integrated model and supplying its products to both developed and emerging countries (see Figure 2). The product value was of a low/medium value, however, the company started expanding its product lines in white goods sector.

Phase 3 "Overseas Subsidiaries" – Downstream dispersion establishing various distribution channels in Europe and US and horizontal dispersion in emerging markets with the associated downstream activities.

The firm took a more cautious approach in D (Europe, US) markets, following the physic approach where it set-up its sales subsidiaries to increase its knowledge of the market. In emerging markets the company set-up production facilities in various markets in Southeast Asia. The firm was aware that the Southeast Asian market was dominated by Japanese and Korean high-price products, which offered an opportunity for the firm's lower-cost products. Manufacturing plants were set-up as joint ventures with its local Chinese partners. However, these plants were only subassembly serving domestic emerging markets, where the fabricated intermediate products were sourced from China.

At this stage the governance mechanism differed in E than in D markets. In D markets the governance was minimal with transactional-based relationships. In E markets, it was more integral as the firm provided production lines, technology, and the partner was responsible for the land, labour and distribution network.
The product as this stage was ranked as number 1 in China but had a weak global brand. The firm continued to expand its product lines in white goods and also expanding to brown goods.

Phase 4 " Overseas Production Network" - At this stage the firm had 3 different value chain models (See Figure 2). In E markets the firm was horizontally diversified in various emerging countries, with a multi-domestic manufacturing configuration network. In D markets there were two approaches, a vertically integrated model in Italy where the firm acquired built-in appliances manufacturer to expand its product category in Europe. While, in US the firm set-up subassembly plants serving domestic markets with the fabricated intermediate products supplied from China.

The different value chain models also had different supply and integration mechanisms. In Italy, the subsidiary had a full autonomy to design, and develop range of products, as well as local sourcing. In E markets the firm was localising more of its production process and integrated those to its existing downstream activities. While in the US the sourcing was mainly dependent on China.
Phase 5 "Overseas Integrated Value Chain" – At this stage the firm was integrating its highly geographically dispersed global network, developing synergy between different offshored activities and assets in different locations along the whole value chain. The firm established the following:

- An integrated supplier network (global sourcing e.g. raw materials such as plastic sheets are sourced from China based on group contract) following a JIT- zero inventory strategy with on demand manufacturing and delivery.
- Key partnership with various retailers in Europe, America and Japan
- Industrial complexes "production hubs" to serve regional markets (e.g. in Jordan and Pakistan). Locations were chosen based on proximity to the market they will be serving to act as sourcing hub serving several markets.
- Mutual collaboration across the value chain span (R&D, supply, demand) where the transformation of knowledge where mutual across the network (i.e. parent –subsidiary "top-bottom" and subsidiary –home "bottom-up")
- Extended its foreign investment in E and D markets, where it established an integrated value chain manufacturing network in US and expanded its research and design facilities in emerging markets (e.g. India).

Although the firm established an integrated supplier and retail network and improved a synergy between the various offshored activities. The firm's value chain was found to be disaggregated geographically and organisationally by product division (see Figure 3).

DISCUSSION

The study findings show how the firm moved into both upstream and downstream elements of the manufacturing value chain, and across the value chain (horizontal) in various emerging and developed markets. These strategic investments have enabled the firm that started as a subcontractor to foreign firms, acting as a low cost partner; to become a global brand manufacturer, playing a global lead role in the white good sector. Considering those different elements of configuration, and the firm's investment patterns, it is evident that the firm followed a market-driven internationalisation path. Although the firm seems to have followed an incremental path, its manufacturing value chain has undergone a process of integration and fragmentation and finally re-integration of the geographically dispersed activities, sliced/managed by product division.

In the earlier stages of the firm's internationalisation path, the firm retained a vertically integrated value chain structure based in china, where it was exporting its product to D & E markets. This export model was triggered by the fierce domestic competition, as the firm's profit market shrunk heavily due the market overcapacity, it started explore foreign markets. Following the traditional market-driven approach, the firm began its downstream investments in routes-to-market that support sales and product servicing channel developments (Srai, 2012), dispersing its downstream activities in D & E markets. These investments were supported by the modularisation between the value chain activities (Mudambi, 2008; Contractor et al, 2010), particularly for the investment in E market, as the firm was able to allocate partial part of its production "subassembly" with the associated downstream activities. The overseas production units were driven by economies of scale and value-density considerations targeting near-to/local markets (Srai, 2012).

The firm soon expanded its value chain activities in both E & D markets, and the role of E and D subsidiaries evolved very rapidly, but neither incrementally nor identically. In Europe, the firm had to acquire a subsidiary that manufactures built-in appliances in Italy, as it didn't have the capabilities to develop such products. The subsidiary retained a vertically integrated chain and was isolated from the rest of the firm network. The subsidiary had a full autonomy to design, and develop range of products, as well as local sourcing. The main goal was supplying particular products to the European markets. Meanwhile, in E markets and US the firm developed its activities incrementally, however supplying different products and different technology. The subsidiaries in E markets also evolved rapidly where it didn't only perform low-end value chain activities (i.e. subassembly) but increasingly high value added activities such as R&D and design where relocated in E foreign locations (Pyndt and Pedersen, 2006).

Finally as the company broaden its product categories and presence in both E & D markets. The geographic dispersion, and changing roles in the manufacturing value chain drove the need for new governance arrangements during the internationalisation process. The migration from transactional partner relationships to more collaborative approaches to support market development, efficient supply and product innovation. Global sourcing strategy was replacing the localisation strategy, as well as the over dependency on Chinese plant. Largely decoupled, fragmented value chain activities, where re-integrated multi-domestically and managed by product division.

CONCLUDING REMARKS

The finding showed that each activity was disaggregated on a product level and how the firm was managing the material/information flow between the firm and its subsidiaries, however, each activity need to be analysed on a more disaggregated level as it contains both advanced and standardised tasks even R&D activities that encompass both extremely complex tasks and more simplified activities (Pyndt and Pedersen, 2006; Contractor et al, 2010). Accordingly each task within each activity need be explored i.e. where it is located, who is performing this task, and how do firms plan and implement different organisation forms between these tasks, as well as, the managing the interdependency level between the stages of the value chain.

It is also essential to explore not only the intra-firm but also inter-firm governance arrangements, which was found to be rapidly evolving during the firm evolution path. Exploring how the firm manage its evolving relationships with suppliers and its strategic and future positions, including 'the importance of the geographic distance between production and the R&D department (Pyndt and Pedersen, 2006). even those in modular activities where it is easier to link and delink suppliers (Gereffi et al, 2005), as the process of cutting a relationship and starting all over again could be expensive and consume time to mitigate exorbitant information and coordination (Pyndt and Pedersen, 2006).

The configuration profiles captured alternative value chain models for the different phases of the firm's internationalisation displaying the evolution of the subsidiary roles in the network. In addition, configuration elements identified the motive behind the firm's foreign investment. Nevertheless, these findings are based on one case study, future research will involve larger sample of cases to explore the different archetypes of firm evolution where the configuration mapping dimensions can better differentiate the network models adopted by internationalising firms.

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Table1: Selected Configuration Dimensions from IB and OM domain

Author/year	Configuration Profiling (Firm/subsidiary level)		
		Dimension	Measurement
Johanson and Valne 1977	Geographic Dispersion	location choice " "psychic level"	Emerging - developed market – global (E & D) - language, culture, political systems, business practice, industrial development
Porter 1980, Shi and Gregory 1998, Mudambi 2008,		Geographic dispersion level "GSI"	Centralised – low dispersion – high dispersion
Contractor et al 2010,Sria and Gregory 2008, Dunning and lundan 2008, Rugman et al 2010, Srai 2012		Value chain activity mapping/ product (component)	geographic dispersion of the firm's functional activities showing the disaggregation of the value chain and along its product category between home and foreign subsidiaries (E/D) – where the product developed, produced, sold
Mudambi 2008, Contractor et al 2010, Rugman et al 2010, Srai 2012	Governance Mechanisms	Intra-firm governance "ownership activity level"	Retaining control over value chain activities vs. outsourcing – control strategy (vertically integrated, semi-integrated, specialised, functional slicing)
Srai and Gergory 2008, Sturgeon and Kawakami 2010)		Network Role	Firm/subsidiary position in the network (supply cluster manufacturer, partner/ platform lead, global lead)
Lambert & Cooper '00, Carbonara et al. 2002, Choi and Hong 2002, Srai and Gregory 2008	Tier Structure	Tier positioning "ownership of component/ product level" - Depth - Width	vertical positioning of the firm in the supply chain (number of tiers across the supply chain that is owned by the firm "vertically integrated") - product structure in terms of the number of BOM levels(depth) Horizontal positioning Number of customer/supplier within each tier/BOM component for given level (width)
Naylor et al 1999, Treville et al 2004, Srai 2012, Contractor et al 2010 Mudambi 2008	Level of coupling/ interaction "Activity Modularity"	Decoupling point "integration mechanism"	Degree of coupling between value chain stages - fully decoupled, upstream (supplier integration), downstream (demand integration) , closely coupled VC Vs. tangible and intangible decoupling – value proposition
Mason and Towill 1999 Srai and Gregory 2008, Srai 2005 Verbeeke et al 2006		Flow of material	Decoupling point associated with material and information flow Flow between operations key units - Components – intermediate products – finished products (local-local, global-local, local-global) & replenishment model
Ferdows 1989, Srai and Gregory 2008, Yang et al 2008		Flow of information	Local-local, top-bottom, bottom-up, network optimisation (for each activity)
Baldwin and Clark, 2000 Galvin and Morkel 2001 Ulrich 1995	"Supported" Product Configuration elements	Component/product modularity	Integral vs. modular (modules dependencies, degree of standardinsation, functional element mapping to physical components)
		variety	Platform commonality – delayed differentiation
Srai and Gregory 2008		Value density	weight to value ratio (low, medium, high)
Vernon 1966, Fisher 1997		Product life cycle	Introduction "innovative" vs. Mature "commodity"
Srai and Gregory 2008		Product mix	No of product lines, SKUs (narrow, diversified "same chain", high" different chain") along the varies tier structure

Table 2: Configuration Profiling tool using the selected configuration dimensions

Value Chain/Network configuration options

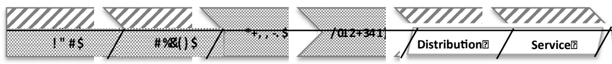
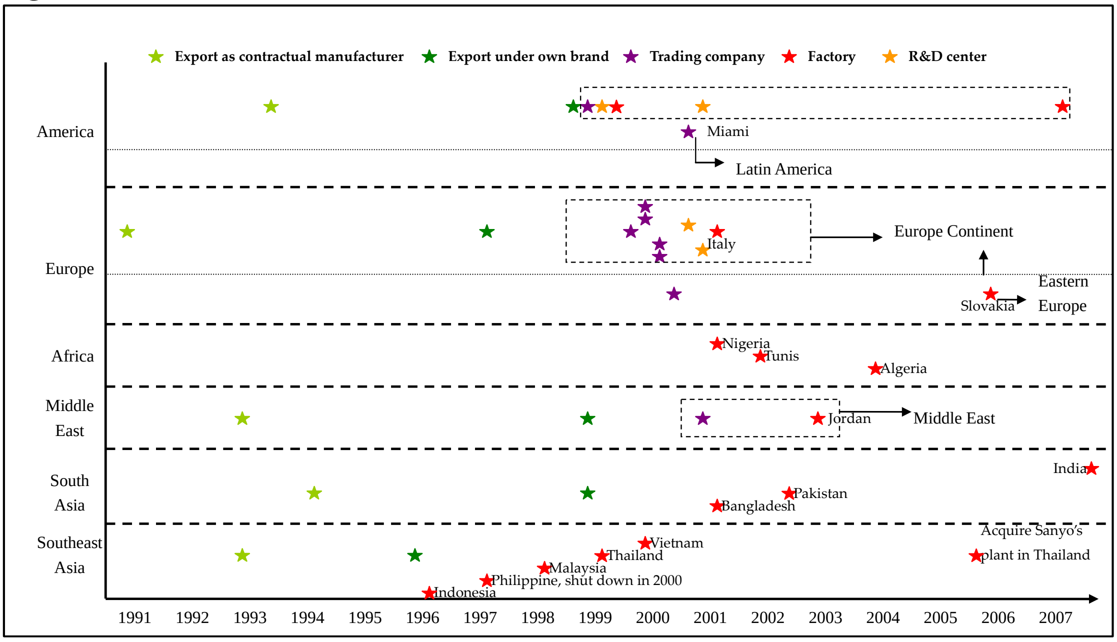
Geographic Dispersion VC mapping Home – Subsidiary E – Subsidiary D			Product A & C Product B
Psychic level	close psychic distance	Distant market (E/D)	Both (E&D)
Geographic dispersion level	Centralised	Low dispersion	Highly dispersed
Governance Intra-firm governance (ownership activity level)	Vertically integrated	Specialised (e.g. branding)	Functional slicing
Network role/positioning	Supply cluster	Partner/platform lead	Global lead
Network governance/ Industry	Minimal/market based	Modular | Hierarchical	Network
Tier Positioning	Concentrated tier 1 supplier	Tier (2,3)	OEM
Level of Coupling Decoupling point	Closely Coupled	Partially Upstream | Downstream	Fully Decoupled
Material flow (Input) components	Local -Local	Regional Local - R | R - Local	Local – Global | Global – Local
Material flow (Input) semi-finished	Local -Local	Regional Local - R | R - Local	Local – Global | Global - Local
Material flow (output - FP)	Local -Local	Local - R | R - Local	Local – Global | Global - Local
Information flow	Inflow (parent-subsidiaries) "knowledge transfer"	outflow (subsidiaries-parent) "Reverse innovation"	Mutual – network (transformation of knowledge)
Replenishment Model	Transactional	Supply-demand focus	Customer value creation
Product Configuration Product Mix	Narrow/limited products	Diversified (same chain)	Highly diversified (various chain e.g. W/BG)
Value density	Low	Medium	High value density
Product modularity	Highly integral single unit	interchange ability of modules allowing for "plug-in/plug-out	Highly modular complex structure
Product maturity stage	Introduction	Growth and maturity	decline

Figure 1: Chine White Goods Manufacturer Internationalisation Phases



Adapted from Kaimei Wang 2010 and Li 2007

Figure 2: Evolution of the firm's value phase 1- 4

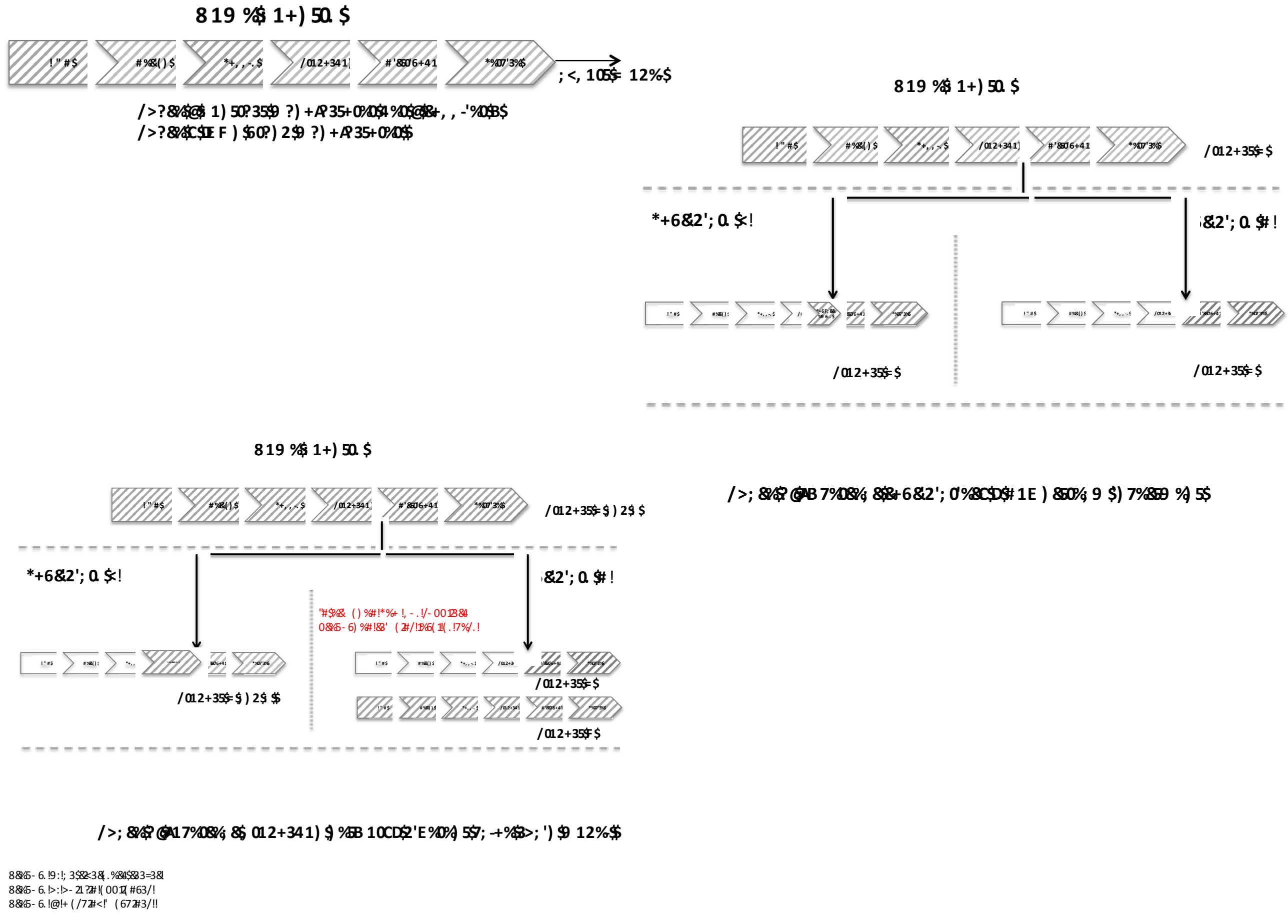
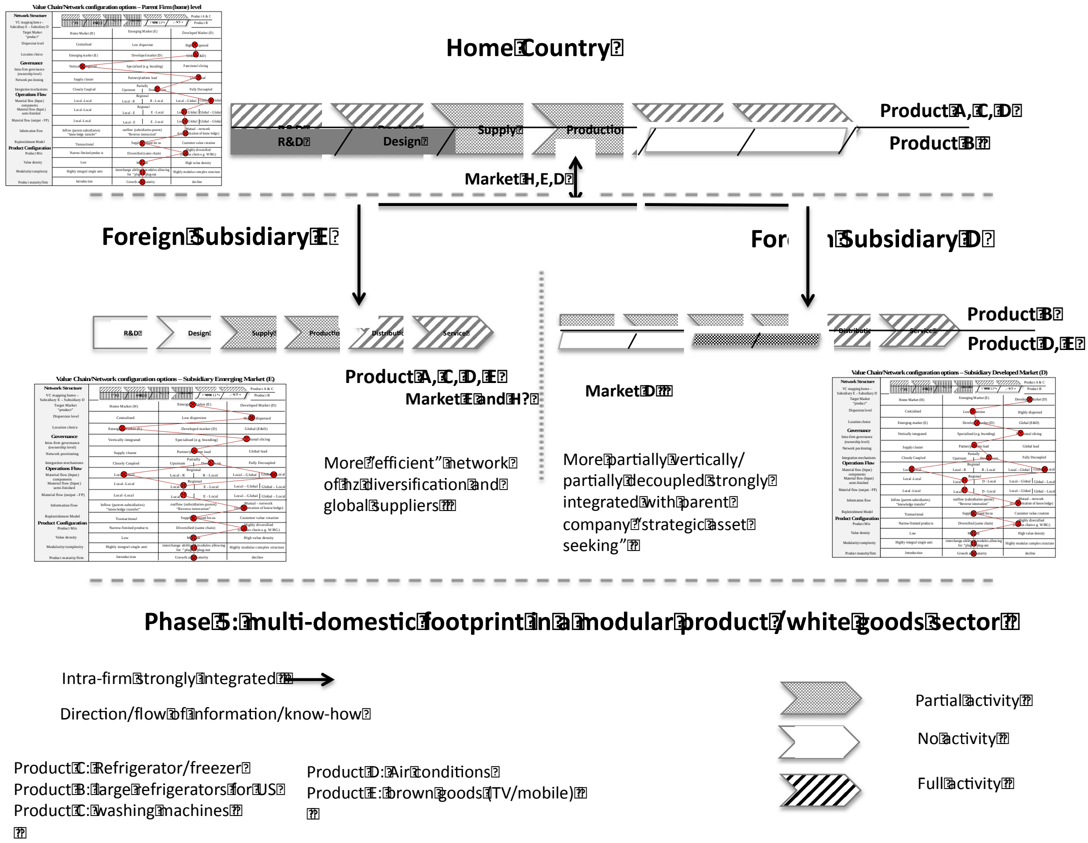


Figure 3: Multi-domestic footprint – phase 5 of the firm's internationalisation



Institutional Distance and Establishment Mode Choice of Brazilian Multinationals

Gabriel Vouga Chueke
ESPM (Escola Superior de Propaganda e Marketing), Observatory of Brazilian Multinationals,
Rua Álvaro Alvim 123, 04018-010 São Paulo, Brazil
gabriel.vouga@espm.br

Felipe Mendes Borini
ESPM (Escola Superior de Propaganda e Marketing), Department of International Business,
Rua Álvaro Alvim 123, 04018-010 São Paulo, Brazil
fborini@espm.br

Afonso Fleury
University of Sao Paulo, Department of Production Engineering,
Av. Prof. Luciano Gualberto, travessa 3, 05508-010 São Paulo, Brazil
acfleury@usp.br

Abstract

In this study, we examine the influence of institutional distance, firm and industry characteristics on the Establishment Mode Strategy of Brazilian multinationals - the choice between an acquisition and a Greenfield investment. To reach this goal, we build upon the recently developed construct of Transaction Costs Theory and Institutional Theory an analytical framework, decomposing the institutional distance between formal institutions (economic, financial, political, administrative, demographic, geographic and knowledge distance) and informal institution (cultural distance). Using a binomial logistic regression model and controlling for other effects, the hypotheses are tested by analyzing data on 129 entries into 30 countries by acquisition and Greenfield investment. The results suggest a possible association between entry by acquisition and factors related to the firm-level and formal institution (financial, political, and demographic distance). Findings also suggest a strong relationship between Greenfield investments and informal institution (cultural distance) and industry-level factors.

Keywords: Establishment mode choice, Acquisition, Greenfield investment, Brazilian multinationals

1.Introduction

Internationalizing firms can enter foreign countries through different entry modes, ranging from contractual modes such direct exports and licensing, to equity modes such as greenfield joint ventures and full acquisitions (Slagen and Hennart, 2007). Cho and Padmanabhan (1995) state that the entry mode literature is divided into two main research streams: the first (Establishment Mode Choice), which this research is based upon, seeks to raise the factors that influence the choice between an acquisition and a greenfield investment (Wilson, 1980; Hennart and Park, 1993, Andersson and Svensson, 1994; Brouther and Brouthers, 2000; Harzing, 2002; Larimo, 2003; Dikova and Witteloostuijn, 2007, Lee and Liberman 2010). The second stream (Entry Mode Choice), analyzes the decision of sharing or not the control of overseas operations by establishing own subsidiaries or through International Joint Venture.

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When a multinational firm decides to invest equity in a foreign market, it faces at least two strategically decisions. First, the company should decide to build a plant abroad from scratch (Greenfield investment) or to engage in an acquisition - buy a company already established in the target market. Second, it will have to decide to do it alone or through local partnership (Dikova and Witteloostuijn, 2007). The choice between acquisition or greenfield investment would thus be based on the level of control, ownership and commitment sought by the multinational firm (Meyer and Estrin, 2001).
Despite the theoretical developments that have occurred over the past 30 years, Slangen and Hennart (2007) point to the need to build theories that seek to explain the determinants of Establishment Mode Choice. Seeking to collaborate with this effort, researchers are inspired by different theoretical approaches, especially the Transaction Cost Theory (TCT). They seek to propose integrative frameworks that consider different levels of analysis and different theoretical approaches in order to raise the factors that influence this important strategic decision (Lee and Lieberman, 2010). Moreover, Dikova and Witterloostuijn (2007) and Berry *et al.* (2010) argue that many studies in this field have been exclusively aimed at identifying the influence of factors associated with the firm or industry level. Thus, there would be a research gap to be filled by conducting studies that seek to analyze the influence of the host country's institutional environment in the establishment mode choice.
The present study aims to verify whether there is any association between the establishment mode choice (choice between a greenfield investment and an acquisition) and the institutional distance between the country of origin of the multinational enterprise (Brazil) and the host country.
We believe, after carrying out an extensive literature review on major national and international journals, that this is the first quantitative study to investigate the entry of Brazilian multinational enterprises into various countries, focusing on the choice between acquisition and greenfield investment (Andrade, 2008; Slagen and Hennart, 2007). This fact contributes to efforts made by researchers from other countries, from the adaptation and testing of research variables in the context of emerging markets, like Brazil.
To reach the proposed objective, an analytical framework was proposed, which considers the institutional distance between the home and host country, and factors associated with the firm and industry level as control variables.

2. Theoretical Foundations

The international business literature has developed the concept of institutional distance from the efforts of researchers like Hofstede (1980), Kogut and Singh (1988), who sought to understand how the level of economic, education, language and cultural development has influenced the internationalization process of firms from developed countries. Nevertheless, the emphasis on the institutional perspective started with Kostova´s study (1996), about the differences from the institutional environment of home and host country and the legitimacy of management practices between the parent company and our foreign subsidiaries, considering the multiple pressures exerted by internal and external environment. After the publication of the Kostova´s study, many investigations inspired on this perspective were carried out motivated by the role of institutions in the context of emerging economies (Dikova and Wittloostujn, 2007, Peng et al., 2009).
We begin the discussion about institutional distance from the concept of cultural distance, since it is the most widely used in the field (Hall, 1976, Kogut and Singh, 1988; Barkena *et al.*, 1996; Hennart and Larimo, 1998; Ghemawat, 2001; Dikova and Wittloostujn, 2007). Cultural distance could be understood as the difference between the home and host markets rather encouraged FDI as a ways of overcoming transactional and market failures (Shenkar, 2012).

In order to measure the cultural distance between countries, Kogut and Singh (1988) developed a measure, that would become the most common in the area. This measure sought to integrate four dimensions proposed by Hofstede (1980): (i) uncertainty aversion, (ii) power distance, (iii) masculinity / femininity and (iv) individualism / collectivism. These dimensions were defined from an investigation carried out with IBM managers located in 40 countries in the 1970s. In later editions, Hofstede expanded his sample to 68 countries and added a new dimension entitled "long term orientation", originated from Michael Harris Bond study.

Some criticisms can be made about Hofstede dimensions (Drogendijk and Slangen, 2006): (i) the data refer only to 1/3 of countries in the world (Berry *et al*., 2010), the proxy used to analyze differences between countries is based on IBM organizational culture - ecological fallacy. Moreover, differences between countries are reduced to a single dimension, whose character is static. Perhaps, due to these limitations, the empirical results found in the field of entry strategies related to cultural distance are ambiguous and contradictory (Slagen and Hennart, 2007).

Alternatively to Hofstede´s approach (1980), new and complementary methodologies have been created to measure cultural distance. According to Berry *et al*. (2010), the most consistent effort would be that of Schwartz, who, based on extensive literature review and empirical studies with students and professor in various parts of the world, created an analytical framework for the understanding of cultural values. In turn, the GLOBE project (House et al., 2004) emerged as a collective effort of 160 researchers in 62 countries in the attempt to understand the relationships between the dimensions of culture, from the viewpoint of society, the organizational culture of different institutions, the processes of leadership and the organizational behavior. It is understood that this effort would be an extension of the work of Hofstede (2006), which would add new dimensions like: performance orientation, assertiveness and humane orientation.

GLOBE project proposes two analytical categories: (i) cultural practices: perceptions of individuals about their own culture and (ii) cultural values: how individuals believe that their culture should be.

The "advantage" in using the dimensions shown in the GLOBE project lies in the fact that this database shows more analytical dimensions which could be disaggregated. It is noteworthy that, even if there are several methodologies for surveying differences between countries, all have the same problem, the one-dimensionality, since they emphasize only cultural aspects.

In an attempt to extend the explanatory scope of the concept of cultural distance, Hennart and Larimo (1998) proposed the *institutional distance* construct, which sought to observe the impact of issues related to cultural differences in the internationalization process, from the perspective of Transaction Cost Theory, unlike Hofstede (1980). Kostova (1996), Kostava and Zaheer (1999) define the institutional distance as similarities and differences between regulatory, cognitive and regulatory frameworks between countries.

Ghemawat (2001) also contributed to such issue, proposing various distances that influence the performance of firms abroad, such as: (i) cultural distance: differences of languages, religions, races, social rules and values (ii) geographical distance: physical distance, size of the host country (iii) institutional distance: colonial ties, political systems, institutions, and (iv) economic distance: availability of natural, human and financial resources,
infrastructure, access to inputs and knowledge.

On the past studies, the institutional distance was only an alternative to explain the behavior of multinational enterprises, being related with two aspects: (i) legitimacy to the host country and (ii) efficiency in the transfer of organizational practices (Xu and Shenkar, 2002). Xu and Shenkar (2002) proposed to expand the scope of this concept, seeking a better understanding of multinationals entry mode strategy in foreign markets.

As a result, new insights have emerged in the field (Xu and Shenkar, 2002; Dikova and Witteloostuijn, 2007; Peng *et al.*, 2008; Dow and Larimo, 2009; Berry *et al*., 2010). Cultural distance would be only one of the elements that constitute to the institutional distance, which would be more comprehensive. Following this trend, scholars have sought to bring the concept of cultural distance close to Institutional Theory in order to integrate the variety of differences between countries. In studies on entry mode, there is a premise that different types of distance can affect, in many ways, the firm's strategic decisions.

Based on the ongoing debate, Berry et al. (2010) disaggregate the *institutional distance* construct into a set of multidimensional measures based on the Institutional Theory. Thus, they sought to fill a gap in this area from the structuring of an integrative analytical framework of institutional distances, decomposing them into nine kinds of distance.

The distances proposed by Berry *et al*. (2010) have several implications in the entry mode choice. For example, *Economic distance* would be related to the purchasing power of consumers and their preferences, with the host country's macroeconomic stability and the level of openness to foreign capital inflow. *Financial distance* would reflect the different financial systems of countries, which would influence the way a firm and its competitors would finance their operations - from financial markets or by other means. *Political distance*, related to differences between political systems, would analyze the impact of different government regimes such as democratic and autocratic, the existence of international trade agreements and the influence of the government in the economy.

Administrative distance could be defined as differences in colonial ties, language, religion, legal system. *Demographic distance* would be associated with the attractiveness of the target market and its growth potential. The capacity to generate knowledge and innovation, which could influence the location of an investment and the entry mode, is defined as the *knowledge distance*, measured by the number of patents of a country and *per capita* scientific papers. Finally, *Geographical distance* would have an effect on trade between countries, on direct investments and other economic activities between countries, such as cost of transportation and communication.

The *Connectedness distance*, which corresponds to differences in tourism and internet use, was not used in this study, since the database available for this dimension is limited to information from 1995.

3. Assumptions

Based on *Institutional distance*, this section seeks to establish the relationship between the entry mode strategy and *institutional distance*. Figure 1 shows the analytical framework that supports the research hypotheses. As central assumption, it is believed that the *institutional distance* is associated with the entry mode choice of Brazilian multinational enterprises.

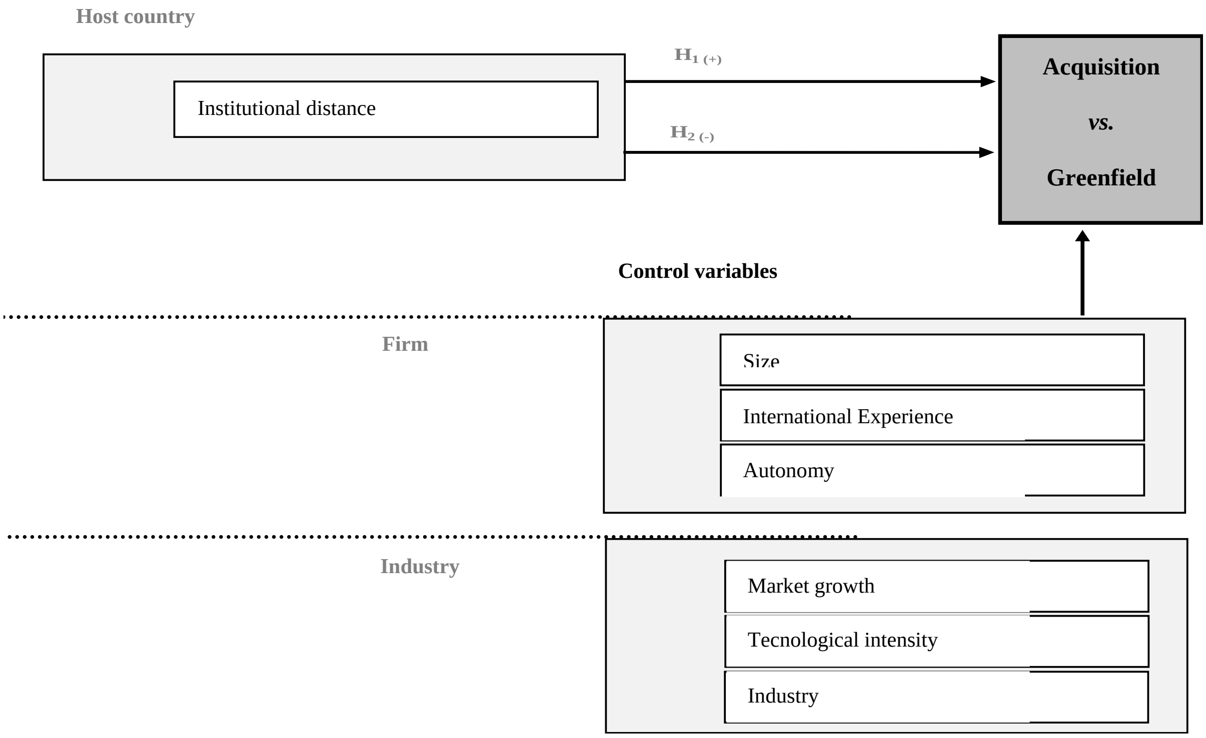

Figure1. Analytical framework

The assumption adopted in most studies is that the differences between countries could influence the firm's performance, entry costs, management practices, profit potential and risk of operating in distant countries (Kogut and Singh, 1988; Brouthers and Brouthers, 2000). This could be explained by differences in institutional environments between investing and host countries. It is expected that the greater the distance between the parent country and the host country, the higher the operation costs and the greater the uncertainty level.

The level of institutional development would be associated with factors related to formal and informal institutions of each country (Peng, 2009). This implies that the entry mode can be determined by formal institutions (economic, financial, political, administrative, geographic and demographic factors) and informal institutions (cultural factors), and the distance related to each of these groups of institutions would imply a different strategic choice with respect to the entry mode.

Informal institutions are associated with higher cost of management, since managers have to face cultural differences leading with employees. A high level of distance between parent and foreign cultures demands a greater level of control by headquarters, which reduce the information asymmetry and the risk of opportunism (Anderson and Gatignon, 1986). Therefore, in acquisitions, due to the fact that companies already established are integrated, there would be major difficulties to assimilate productive and managerial practices and the organizational culture originated from the parent firm, especially in culturally distant countries (Erramilli and Rao, 1993; Larimo, 2003). The greater the distance from informal institutions, the less the chance of entering through acquisitions, due to the potential increased costs for integration of cultures (Hennart and Park, 1993; Cho and Padmabhan, 1995; Larimo, 2003; Lee and Lieberman, 2010).

In turn, greenfield investments would enable the parent to transfer its management practices and organizational culture more efficiently, since it could shape the subsidiary in accordance with the organizational culture, enabling the maximization of specific advantages and greater internal legitimacy (Larimo, 2003). Therefore:

H_1: Distances related to informal institutions between the host country and the investing country would be associated with the entry through greenfield investment.

Under the institutional perspective viewpoint (Peng et al., 2009), the strategic choice of entry by acquisitions would not focus only the transfer of specific assets. It could also contribute to reducing the impact of environmental uncertainty, since acquired companies would be more familiar with the formal institutional environment of the host country. This entry mode could serve as vehicle for acquire knowledge about the host country, knowledge about managing relationships with local government, suppliers channel and other intangible resources related to formal institutions of the host country. Also, it could provide access to tangible resources under the laws and rules of the target country, such as physical location, access to raw materials and local funding (Dikova and Wittloostujn, 2007, Meyer et al, 2009). The acquisition of tangible and intangible resources would therefore contribute to reduce the uncertainty level related to formal institutions and thus of transaction costs. Thus:

H_2: The distances related to formal institutions between the host country and investing country would be associated with entry through acquisition.

4. Methodology

The process of data collection relied on multiple sources of evidence. Initially, we used the database of Fleury *et al.* (2007 and 2010) to have information about Brazilian multinationals in an advanced internationalization stage, with sample composed of 129 subsidiaries of Brazilian multinationals abroad. These companies are characterized by having investments abroad, which were acquired or constituted from the beginning (greenfield investment), since they belong to the primary sector, manufacturing and technology-based service firms.

The information provided by Fleury *et al.* (2007 and 2010) was supplemented from secondary data sources belonging to international research institutes. This methodology was selected since the purpose of this study was to evaluate the influence of firm, industry and country factors related to the entry strategies of Brazilian enterprises in foreign markets, and data from Fleury *et al.* (2007 and 2010) study only refer to the firm level. Secondary sources were used to support the development of control variables belonging to industry and host country level (institutional distance).

The logistic regression method was adopted, since this technique has proven to be more robust when dealing with non-metric variables and non-normal distributions (Hair *et al*., 2005). As a prerequisite for the analysis using the logistic regression technique, the sample size should show at least five observations per independent variable and number of cases of the smallest group above the number of independent variables.

5. Description of the Research Variables

5.1 Dependent variable

5.1.1 Entry Mode (establishment mode choice)

A dummy variable was created and coded as follows: (0) for acquisition – purchase of property abroad and (1) for greenfield investment - implementation of operation abroad from the beginning (Hennart and Park, 1993, Barkema and Vermeulen, 1998; Larimo, 2003; Dikova and Witteloostuijn, 2007; Tan, 2009).

5.2 Independent Variables

5.2.1 Institutional Distance

The effect of the institutional distance on the entry mode choice was subdivided into eight different distances, according to recommendations of Berry *et al*. (2010). Economic, financial and demographic distances, for example, were calculated based on macroeconomic data and obtained from the database of the World Development Indicator. The political distance was obtained through sources such as the Political Constraint Index, Freedom House, World Development Indicator, and World Trade Organization. The geographical distance calculation was based on data provided by the CIA Factbook. Sources as the United States Patent and Trademark Office and Information Sciences Institute were also used to measure the knowledge distance.
The cultural distance, considered in this research as one of the dimensions that make up the institutional distance (Peng et al., 2009), unlike Berry *et al*. (2010), was measured using methodology of the GLOBE project (House *et al*., 2004), since these measures are still little explored in field (see discussion in the special issue of JIBS, 2010). The cultural distance was calculated using the methodology proposed by Kogut and Singh (1988), which consists in developing a composite index based on cultural dimensions, which seeks to calculate the difference between the investing country and the host country.

	Dimension	*Source*	*Years available*	*No. of countries (in 2004)*
1.	*Economic distance*			
	Income	WDI	1960–2005	179
	Inflation	WDI	1960–2005	157
	Exports	WDI	1960–2005	165
	Imports	WDI	1960–2005	165
2.	*Financial distance*			
	Private credit	WDI	1960–2005	122
	Stock market cap	WDI	1988–2005	122
	Listed companies	WDI	1988–2005	122
3.	*Political distance*			
	Policy-making uncertainty	POLCONV	1960–2005	155
	Democracy score	Freedom House	1960–2003	151
	Size of the state	WDI	1960–2005	155
	World trade agreements	WTO	1960–2005	133
	Regional trade agreements	WTO	1960–2005	133
4.	*Administrative distance*			
	Colonizer–colonized link	CIA Factbook	Constant	198
	Common language	CIA Factbook	Constant	198
	Common religion	CIA Factbook	Constant	198
	Legal system	La Porta et al., 1998	Constant	198
5.	*Cultural distance*			
	Power distance	WVS	1980–2004	68
	Uncertainty avoidance	WVS	1980–2004	66
	Individualism	WVS	1980–2004	69
	Masculinity	WVS	1980–2004	69
6.	*Demographic distance*			
	Life expectancy	WDI	1960–2004	202
	Birth rate	WDI	1960–2004	202
	Population under 14	WDI	1960–2005	203
	Population under 65	WDI	1960–2005	203
7.	*Knowledge distance*			
	Patents	USPTO	1977–2005	166
	Scientific articles	WDI and ISI	1960–2003	110
8.	*Global connectedness distance*			
	International tourism expenditure	WDI	1995–2004	119
	International tourism receipts	WDI	1995–2004	115
	Internet users	WDI	1995–2004	209
9.	*Geographic distance*			
	Great circle distance	CIA Factbook	Constant	196

Figure 3. Distance dimensions, sources, year availability, and country coverage
Source: Berry *et al*. (2010)

5.3 Control variables

5.3.1 Firm's size

The firm's size construct, which represents the size of the investment abroad, was measured from the number of employees of the foreign subsidiary (Larimo, 2003).

5.3.2 Parent's age

The parent's age was calculated based on the difference between the company's foundation year and the year 2011. Information about the foundation year was raised by research on the website of parents companies (Harzing, 2002).

5.3.3 International experience

The parent's international experience was measured based on the number of years in which the subsidiary is present abroad (Cho and Padmanabhan, 1995; Erramilli, 1991). *5.3.4 Autonomy*

The autonomy was measured through methodology recommended by Birkinshaw and Nobel (1998) using the 1-5-point Likert scale, and the construct was composed by the average of four variables, which showed *alpha de crobach* of 0.692. The Fleury *et al.* (2007 and 2010) questionnaire questions that supported the construct were: What is the authority that your subsidiary has to perform: (a) Changes in the design of products / services offered, (b) Entry into new markets within the country, (c) Launch of new products / services, (d) Changes in the production process?

5.3.5 Technological Intensity

The *technological intensity* construct was obtained from the classification of ISIC codes - International Standard Industrial Classification - provided by OECD - Manufacturing Industry Classification, which classifies manufacturing industries into high-technology, medium-high technology, medium technology and low technology segments (Hennart and Park, 1993; Brouthers and Brouthers, 2000; Larimo, 2003). Service firms were classified as high technology.

5.3.6 Market Growth

The market growth rate was calculated from the difference between the GDP percentage change of the target country and the world's GDP percentage change between years 1990 and 2006 (Slagen and Hennart, 2007). Thus, it is believed that this methodology, usually adopted in economic studies, would be more consistent than those used in field.

5.3.7 Sector

For the sector classification, a dummy variable was created using the following coding: (0) for the manufacturing sector and (1) for IT service sector.

6. Analysis and Discussion of Results

6.1 Analysis of results

Table 1 shows the model composed of independent, dependent and control variables. Model 1 is composed of the independent variables, which represent the host country level, which in turn tests the research hypotheses related to the institutional distance - formal and informal. Model 2 was added of control variables belonging to the firm level, and model was added of those of the sector level. Finally, the final model was presented, which was composed of the variables that were significant in previous models.

From the data shown in Table 1, it appears that the model proposed from the interaction of the different analysis levels, composed of ten independent variables, shows log-likelihood value of 53.804, chi-square distribution of 58.757, significance at 0.05, with data adjustment.

Variables	Model 1	Model 2	Model 3	Model 4
Constant	-0,875	4,827	-2,886	3,077
Geografic distance	0,644	-	-	--x--
Demografic distance	-1,629**	-	-	-1,285*
Financial distance	-1,702!	-	-	-0,187
Political distance	-2,047*	-	-	-1,763*
Knowledge distance	-1,661	-	-	--x--
Economic distance	6,05**	-	-	3,167*
Globe practice	2,17!	-	-	3,244**
Globe value	-2,619	-	-	-2,647**
Size	-	-1,307**	-	-1,515**
Age	-	-0,007	-	--x--
International experience	-	-0,01	-	--x--
Autonomy	-	-0,571*	-	-0,594*
Tecnology intensity	-	-	-0,07	--x--
Manufacturing	-	-	2,86**	1,088
Service	-	-	3,746**	2,717!
Market growth	-	-	0,144	--x--
Chi-square	34,185	41,854	22,492	58,757
Cox & Snell	0,302	0,345	0,163	0,503
Nagelkerke	0,409	0,472	0,219	0,682
Classification percentage	70,50%	75,8	61,9	83,3
N = 129				

Figure 3. Logistic regression results

With regard to the explanation capacity, the model has Nagelkerke R coefficient of 0.682. According to Hair *et al*. (2005), this index can be regarded as representative in social sciences. The model classification percentage has also an index more than satisfactory, 83.3. It was observed that these values show improvements, compared with each of the levels in isolation. Regarding the significance of variables, it was observed that only two of them were no longer significant in the multilevel model, namely: Financial distance and Manufacturing, referring to the sector in which subsidiaries operate. However, variable *Service*, also related to the competitive sector, undergoes change, becoming significant at 0.10.

Based on the analysis of the Beta signal, the variables that were associated with the entry strategy through greenfield are: *Economic distance* and *Cultural distance* (Globe practices). In turn, the variables associated with the entry strategy through acquisition are: *Demographic distance, Political distance* and *Cultural distance* (Globe values). In other words, both hypotheses 1 and 2 are partially supported, but not entirely, since the economic distance seems to be associated with the entry through greenfield and the cultural distance (globe values) associated with the entry through acquisition. Thus, both supported and divergent relationships are worthy of discussion, as follows in the next section.

6.2 Discussion of Results

The cultural distance was analyzed from the distinction between practices and values, according to methodology developed by House *et al*. (2004). It was observed that both constructs were significant, but showed negative correlation between them. This fact is consistent with the empirical results achieved by the GLOBE Project (Javidan *et al*., 2006), in which seven of the nine variables proposed showed this type of behavior. The explanation for this correlation is based on the idea that practices would be the representation of what really occurs in the organization and that, in many cases, values could go against these practices, leading to changes.

When analyzing the cultural distance of practices, which is the category most related to the firm level, the result is that Brazilian companies would enter in culturally distant countries through greenfield investments (*supporting H1*). These results are consistent with those of Singht and Kogut (1988), Hennart *et al*. (1995), Harzing (2002) and others, who argue that a greater distance between countries could cause greater uncertainty in the process of post-acquisition management and transfer of management practices, resulting in increased costs and reduced efficiency of operations.

Moreover, it is worth arguing that the cultural distance of practices was positively correlated with the *economic distance* construct, as in the study of Javidan *et al*. (2006).

Considering the negative correlation, it is understood that the cultural distance of values is not relevant for explaining the entry choice. However, this information supports the validity of the search result, since the same correlation was obtained in the original study (House *et al*. 2004).

The results related to the financial distance and political distance suggest that Brazilian companies would have a trend for making acquisitions in countries with higher levels of political uncertainty and greater differences in relation to obtaining private credit and access to capital markets. It is interesting to note that the financial distance increases speculation about access to resources for international expansion. It is assumed that Brazilian companies could choose entering abroad through acquisitions in order to obtain financial resources at lower cost than in Brazil.

We research presents the results of entry cases in different years, which may influence the interpretation of information relating to access to credit, since, in recent years, there were several economic crises.

The *political distance* has the opposite behavior of the *economic distance*. How to explain this negative correlation? It has been hypothesized that the economic distance would be related to informal institutions, and the GDP, a variable used to measure this construct, would be a good proxy for human development, which would be associated with cultural issues, which, in turn, would press firms to achieve greater internal legitimacy. This argument finds support in Javidan *et al*. (2006).

On the other hand, political issues would have a greater association with formal institutions, which were represented mainly by political uncertainties and by the democratic regime of the target country. Thus, when observing the political distance and its relation with the entry mode, the argument advocated by the Transaction Costs Theory would lose strength. Therefore, the relationship between uncertainty and efficiency could be justified by the Institutional Theory, which argues that in countries with high political uncertainty, firms could achieve greater efficiency through the acquisition of knowledge on how to operate in high-risk countries. This strategy could also be used to access resources regulated by governments such as raw materials, location for operation etc. Such view is supported by recent studies, such as those by Brouthers and Dikova (2010), Meyer et al. (2009) and Dikova and Wittloostujn (2007).

The results related to demographic distance, key dimension to understanding differences between countries, as measured by life expectancy, age and other factors related to population, and which indicate the attractiveness of a market and its growth potential, indicate that Brazilian companies entering new markets through acquisitions might be interested in learning about how to act in these markets, especially in emerging countries, which account for 62% of cases observed. This hypothesis is based on the idea that Brazilian companies, due to their little international experience and for being the late mover in these markets, would seek access to such knowledge through acquisitions. Unlike variable *market growth*, which sought to analyze the market growth from proxies related to the GDP percentage change, considering past data and future projections, the demographic distance is based on aspects that indicate potential future consumption. Perhaps the different methodologies used to measure these constructs collaborate to elucidate the reason for obtaining statistical significance in only one case - demographic distance.

The control variables, such as those related to the entry mode and firm's size, meet the results of previous investigations (Hennart and Park, 1993; Brouthes and Brouthers, 2000; Larimo, 2003); the variable *size* showed positive association with the entry through acquisitions. It was expected that larger firms, due to their greater availability of financial and managerial resources, were more likely to enter in foreign markets through acquisitions.

Although the results corroborate theories developed in the context of countries considered developed, the case of Brazil draws attention, since 60% of firms analyzed in the study do not have shares in the stock market - most used form by foreign companies to raise funds to internationalize. Thus, the question is: how Brazilian companies leverage capital for this purpose?

It is speculated that the entry into foreign markets through acquisitions could then be supported by factors such as: (i) exchange rate valuation, (ii) financial subsidies from the Brazilian government, (iii) overcapitalization due to the potential of the internal market, and / or (iv) search for cheaper capital abroad.

When analyzing the size of the subsidiary abroad in terms of human resources, it is observed that the operations of Brazilian companies are small, and 69% of subsidiaries sampled have fewer than 500 employees. Thus, there is concern regarding the acquisition strategy choice, since, according to field investigations, the entry choice through acquisition would aid in obtaining staff.

A recent investigative effort carried out by TAN (2009), could help in understanding this fact, since, according to the author, acquisitions could serve as a means to obtain intangible resources related to the capabilities of foreign subsidiaries, such as transfer of technological knowledge, local network and other forms of tacit knowledge that could assist in developing competitive advantages of firms deemed latest entrants, such as those of Brazil.

The *autonomy* construct was also significant. Initially, there was an assumption that the greater level of autonomy granted to the foreign subsidiary would be associated with the entry by acquisition. The logistic regression results confirmed this assumption, which is consistent with the study by Kim and Hwang (1992) and Harzing (2002). Probably, Brazilian companies delegate more autonomy to their foreign subsidiaries, seeking to increase efficiency of their operations abroad. For this, they would delegate activities related to the adaptation of products to meet the specific demands of the host country. Moreover, such strategic guidance could contribute to the absorption of knowledge on the local market and the development of distinctive competencies, which reinforce previous analysis related to the acquisition of intangible resources such as local network.

This fact could indicate a difference in the internationalization process of firms located in emerging economies. It is believed that firms originating from developed economies would opt for international acquisitions, aiming to create global knowledge for innovation in products and processes. However, Brazilian companies do not seek to differentiate themselves through competitive innovations, but rather the acquisition of strategy to obtain access to resources already scarce in target developed countries. As an example, the case of Coteminas Company, belonging to the textile sector, has acquired one of the largest U.S. companies in this sector, aiming to have access to its privileged distribution channel.

On the other hand, when analyzing the entry of Brazilian companies into economies also considered emerging such as Argentina, it is assumed that the acquisition strategy is chosen due to the fact that asset prices are lower in these countries. Descriptive data indicate that 61% of entries in Argentina were through acquisitions. In this context, autonomy would serve as a tool to increase local responsiveness and learning on how to manage overseas operations. It is

noteworthy that, based on this analysis, it is interesting to distinguish the process of entry into developed countries from the process of entry into emerging countries (Shenkar, 2012).
The level of *industry* analysis showed only one statistically significant result. The competitive sector proved to be relevant in the entry mode choice of Brazilian companies, which result is consistent with studies by Brouthers (2002) and Brouthers and Dikova (2010). As research hypothesis, it was considered that the entry of firms in the primary sector / extraction of foreign market would be associated with the entry by acquisition. The results found support this hypothesis, suggesting that the extraction / primary sector would be associated with the entry abroad through acquisitions. This fact could be seen as a characteristic of this segment, since the main business of firms belonging to this segment would be the exploitation of natural resources, which could suffer strong influence from government regulations and / or be in possession of local firms.
In turn, IT service firms, as demonstrated by the hypothesis test, have predilection for entering abroad through greenfield investments. This could be explained by the idea that, in this sector, the high technology intensity would lead the firm to protect its competitive differential, thus avoiding the risk of opportunism. To this end, entry through greenfield investment would be more appropriate.
This argument is consistent with the investigations of Hennart and Park (1993), who indicate that Japanese companies with strong competitive advantages entered the U.S. market through greenfield investments, seeking to protect their idiosyncratic assets. Moreover, Brazilian companies could opt for this strategy due to the lack of labor available abroad in the information technology segment, which restrict the entry by acquisition.

7. Conclusions

The results of this research contribute in different ways to the ongoing discussion in the academic field of studies on the entry mode choice. Firstly, due to the novelty of the proposal, since no studies analyzing the establishment mode choice based on the Brazilian reality or using the dimensions proposed by the GLOBE project were found. Also, literature lacks of studies addressing the three levels of analysis simultaneously.
Another contribution is due to the finding associating the entry mode with the institutional distance between countries. The results showed that there is a relationship between the entry strategy and formal and informal institutions of the host country. It was observed that the acquisition strategy is more associated with formal institutions, represented by demographic, financial and political distances, and with variables that make up the *firm's* level of analysis, such as size and autonomy of the subsidiary. Greenfield investments are associated with informal institutions, such as cultural distance and economic distance, which, according to Javidan *et al*. (2006), would be associated with cultural distance.
The evidence raised reinforces the argument by Berry *et al*. (2010) about the need to disaggregate the *institutional distance* construct into several variables to better understand the influence of formal and informal institutions in the process of internationalization of firms. Concerning the Transaction Costs Theory, it was observed that it is in agreement with the findings of this research, particularly with regard to the understanding of greenfield investments, which would serve as strategy to safeguard firms from uncertainty that would make them less efficient in the transfer of specific assets, highly dependent on informal institutions.
However, when analyzing the entry mode through acquisitions, the Transaction Costs Theory lose explanatory power, as it would be weak in explaining how formal institutions push firms to be more responsive to the institutional environment of the host country. As an alternative to the Institutional Theory, it could contribute to explanations related to the internationalization

process of companies that are late entrants, which could lack of competitive advantages based on specific assets, when compared to companies from developed economies.
The association found between the size of the subsidiary and the entry mode draws attention. It was observed that although with small operations abroad at the time they internationalize, Brazilian companies sampled in this research choose entry by acquisitions. This fact is not in agreement with traditional theoretical assumptions, which postulate that acquisitions would be more suitable for large-scale overseas operations. This finding may indicate the need for the development of theories focused on the reality of firms located in emerging economies such as Brazil.
Moreover, it would be interesting to analyze the role of autonomy granted to Brazilian subsidiaries abroad, because, before this study was carried out, it was believed that Brazilian companies, for being within a paternalistic cultural context, when entering abroad, would seek greater control of operations in foreign markets - ethnocentric management orientation. The opposite result obtained here may indicate the need to carry out further studies on autonomy from different angles, such as product and administration autonomy, among others.
As management contribution, it is believed that managers of Brazilian companies could use the variables adopted as a criterion to identify factors that influence the entry mode choice. Another potential contribution concerns the government scope, since the results of this study show the weight of formal institutions in the process of entry of firms in foreign countries.
The main limitations of this study are the lack of data related to Brazilian firms and industries in which they compete and the sample size, since, due to the complexity of the subject and the diversity of variables and measures, a greater number of observations for the preparation of possible generalizations would be required.
It is suggested that the hypotheses and measurements proposed in this research should be tested again in future researches, especially in studies focused on the reality of developing countries. Another effort could be undertaken in order to strengthen the role of pressures exerted by formal and informal institutions in each of the analysis levels proposed. Also, due to inconsistent field findings and variety of methodologies used, qualitative-base researches are suggested.

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International Mergers and Acquisition Activities of Chinese and Indian Multinationals: Changing Patterns, Value Creation and Market Reaction

Aysun Ficici and C Bulent Aybar
Southern New Hampshire University, Manchester, NH USA

Abstract
This study investigates the Internationalization strategies of Emerging Market Multinationals with a focus on Chinese and Indian Multinationals. Hence, it scrutinizes the value implications of Chinese Multinationals (CMs) and Indian Multinationals (IMs). This study examines 763 mergers and acquisitions (M&A) announcement of 93 IMs during the sample period of 2000-2010. First, the paper explores the effects of cross-border expansion patterns on firm value creation. Second, it examines market reaction to the announcements of cross-border expansion patterns by integrating event study methodology. Finally, it evaluates the effects of merger momentum on firm value of cross-border expansion activities. This study finds that most IMs earn positive abnormal returns during the event windows defined in this study. Hence, it is generally evident that there is value creation in international expansion activities of IMs.

Keywords: International Investments, Foreign Direct Investment; Cross-border Mergers and Acquisitions; Emerging Market Multinationals; Internationalization; Event Study

Introduction
This study examines the valuation effects of cross-border expansion patterns of a distinct group of firms - Emerging Market Multinationals (EMMs) that originate from the emerging markets (EMs) of China and India. The study commits its analytical foci on Mergers and Acquisitions (M&As), given that both the Chinese (CMs) and Indian Multinationals (IMs) achieved to build multinational service and production networks akin to their developed country counterparts by internationalizing their operations through regional or global configurations with the utilization of these three specific types of expansion patterns. These multinational firms' diffusion in to the global economic system signals formation of relatively complex organizational structures with potentially distinct characteristics. As a result of their dynamic international activities, these new players with regional and global focus have become a significant mechanism for the transfer of capital, technology, management and various other assets within and between developing and developed countries, and created new engines of growth in emerging markets.

The cross-border expansion patterns of EMMs, which initially began or came to be recognized in the late 1970s, were launched with exporting activities.[1] These activities are constantly evolving and stimulating modification in the way CMs and IMs conduct their business operations. Although both CMs and IMs have been going through varying levels of transformation for

[1] Louis T. Wells. *Third World Multinationals.* Cambridge, Mass.: MIT Press, 1983.

R. Aggarwal (1985). "Emerging Third World Multinationals: A case study of the foreign operations of. Singapore firms." *Contemporary Southeast Asia,* 7: 193-208.

several decades, their renowned transformation gained pace since the early 1990s in the face of intensified integration of their home markets to the world economy, which was inaugurated with the beginning of the new era of globalization. Owing mostly to their home market integration to the global market, domestic companies located in these markets adopted increasingly outward oriented postures and included M&As, JVs, and SAs into their global operations as opposed to focusing solely on export activities. It was inevitable for them to diversify their expansion strategies since they either had to take advantage of regional or global business opportunities or needed to respond to increasing competition from foreign companies.[2] However, despite their growing regional and global importance, our knowledge of various attributes of these firms is limited and most work conducted in this area gives conflicting results on value creation effects of cross-border expansion activities of CMs and IMs. Therefore, the primary objective of this study is to examine the valuation effects of CMs and IMs' cross-border expansion patterns. Therefore, the research problem can be presented in the form of a question: Do cross-border expansion activities that involve M&As, create value for IMs?

This study includes a sample size of 93 Indian Multinational firm, mostly drawn from the *Top 50 non-financial Emerging Market Transnational Corporations*. UNCTAD's World Investment Report. The internationalization events take place between 2000 and 2010. These transaction announcements entail 763 mergers and acquisitions. In this study event-study methodology is utilized to capture the market reaction to expansion announcements as well as to examine the impact of each announcement on the firm value around the announcement date.

The paper is structured as follows: Part II focuses on the methodological literature review based on value creation, and M&A activities in cross-border expansion patterns. The reminder of the study is organized as follows: Part III discusses the data and methodology. CM and IM sample data are obtained from the United Nations' UNCTAD world investment report on transnational corporations and export competitiveness. Merger and acquisition as well as joint ventures transactions data for 2000-2010 are extracted from the Securities and Data Corporation's (SDC) Worldwide Mergers and Acquisitions database.

Here, the standard event study methodology is utilized to evaluate the impact of each expansion announcement on the firm value. The event-study methodology is inspired by the efficient market hypothesis that capital markets are efficient instruments to evaluate and process the impact of new information available on firms.[3] The market model assumes a linear relationship between the return of any security and the return of the market portfolio. Part IV presents the empirical results; and Part V concludes the study with final remarks and discussion.

Part II -Methodological Literature Review

Patterns of Emerging Market Multinationals: The concept of the international operations of firms from developing nations (most are now identified as emerging market nations) is not a novel phenomenon. The first recognizable emerging market firm operations dates all the way back to the pre-World War I period. However, this was only actualized within the Latin American region. Although, some Latin American firms experienced international expansion in the 1920s, it was too little to account for. In fact, expansion activities of firms from the developing

[2] See Chen (1981), White (1981), and Lau (1992).

[3] Fama, Fisher, and Jensen (1969).

economies began in the 1960s and increased vigorously during the 1970s. The time lag was mainly due to the restrictive government policies of the 1930s - 1960s. Government restrictions, mainly exchange controls and inward-looking foreign trade policies of Indian Government hampered IMs for geographically wide-scale expansion.[4] For this reason, the expansion activities of the IMs stayed only within the region.

When the expansions began to increase and spread to outside of the region in the 1960s and the 1970s, they were mainly executed by private investors that historically invested in liquid form or in real estate, purchasing available stocks and securities. Furthermore, some investments can also be characterized as *capital flight* rather than as FDI. In the late 1970s, however, the decisions to expand were induced by cultural, political pressures and instability.[5] Such factors as risk diversification in unstable political systems, avoidance of domestic tax obligations, labor laws, and foreign exchange restrictions also provoked IMs to internationalize. In later years (1980s and 1990s), changes in government policies, the economic growth within various developing countries, the improvement of their balance of payments, and implementation of interregional programs as well as the consequence of IMs.[6]

In the early years of IM expansion, geographic preference mostly depended on host countries' geographic proximity, and ethnic/cultural closeness to their home countries.[7] However, in recent years, the strategic significance of geographical location, geographic reach, as well as transnationality rather than cultural/ethnic ties came to be more important in making expansion decisions.[8] While in the early stages of international expansion, IM activities were mainly based more on labor intensive, low cost and technologically small-scale manufacturing operations, in recent years, their operations and technological adaptations have begun to display a more innovative outlook, which are more in line with rapid technological and industrial changes.[9]

These changes also triggered changes in the modes of international expansions of IMs. In the early years of expansions, exports were favored for international operations. They carried out trade-related export strategies and/or export led growth strategies and thereby established export businesses as incremental commitments throughout the 1980s.[10] In the early 1990s, however, joint ventures and strategic alliances began to dominate the expansion seen. Besides these activities, the operations of IMs have come to include, cooperative arrangements, strategic alliances, firm networks, and M&A activities.[11] Although M&A activities have minimally been experienced since the mid-80s, in recent years, they have become more apparent. Today, M&A activities are becoming popular strategic tools for IMs looking to expand their market reach or to develop new sources of material. In addition, the accumulation of ownership advantages is motivating and increasing M&A activities of IMs. Due to these changes, IMs are also modifying

[4] See Diaz-Alejandro (1977).

[5] Diaz- Alejandro (1977).
[6] White (1981).

[7] See Wells (1981), and Ting and Shive (1981).
[8] See Lau (1992) and Lim and Moon (2001).
[9] See R.B. Lall (1986) and Lau (1992).
[10] Wells (1977) Chen (1981), and Diaz-Alejandro (1977).
[11] See Kogut (1988), Hennart (1991), Buckley and Casson (1996), and Calantone and Zhao (2001).

their internal operations at intra- and inter-firm levels in a wider geographic access and focusing on efficient use of capital and resource as well as to their geographical reach.
Yet, IMs face a set of transaction costs, risks and opportunities more than they previously experienced. They also confront such issues as geographic dispersal of assets and liabilities across the globe and access to capital markets of different locations with variable exchange rates and differing regulations in further intensity. Hence, an understanding of the cross-border expansion patterns is one key to understanding the impact of IMs on international business and a channel in understanding IM value creation.

Transaction Cost Economics and internalization perspectives in international business literature suggest that firms extract above normal returns from cross border investments by internalizing market imperfections when their firm specific assets cannot be sold for their internal value due to market imperfections.[12] Therefore, rents derived from internalization are expected to be capitalized into a higher value of the firm. Consequently, when IMs first initialized their international expansion activities as manufacturing firms, they gained their initial advantage through internalizing market imperfections.

Similarly, Market Structure Approach - The Industrial Organization Approach states that multinational firms are organizations of international production rather than international capital movement. Here, ownership advantages are seen as a *net cost advantage* of foreign owned firms in local markets. In order for a firm to invest abroad, it should have specific advantages to compensate for the advantages of local firms. Hence, firm specific advantages may be due to such reasons as market imperfection caused by product differentiation and marketing skills, imperfections in factor markets, economies of scale, and government intervention in the marketplace. To obtain these advantages, however, the production needs to be home-based; in this way value creation may be attained. [13]

Hymer's theory can also explain some of the reasons for cross-border expansion and for their existence in the international frontier. In the early years, Indian firms gained special assets through horizontal investments. This was mainly as a result of knowledge accumulation. In this way, firms adapted foreign technology to a specific small-scale operation and applied it to new markets at low marginal costs. This emerged as a necessary condition for the firms' cross-border expansion activities and value creation.

In most cases, however, the decision for international expansion is determined by ownership, internalization, and locational advantages, which are available to the IMs. This has especially been the case in recent years. Dunning's (1981) macro level study on Indian firms indicates that the net outward investment from these countries increased over time. Dunning ascribes this increase to the rising ownership advantages. Hence, IMs gained ownership advantages in two perspectives: the technologies they utilized for FDI were more labor intensive and appropriate for host countries; and they developed production processes as their factor endowments. Therefore, for IMs ownership advantages and value creation arise from making technologies adaptable to smaller market sizes and factor endowments of other developing countries. Overall,

[12]See, e.g., Caves (1971), Williamson (1975), Hymer (1976), Buckley and Casson (1976), and Morck and Yeung, (1992).
[13] Market Structure Approach/ The Industrial Organization Approach: First proposition of this approach comes from Hymer (1960, 1970).

the existence of ownership advantages suggests that value creation had to exist for firms to expand abroad in the past.
When location advantages are considered, it becomes explicable that they arise from the foreign market – meaning low factor prices or customer access, together with the trade barriers or transportation costs make direct investment more profitable than exporting. Therefore, locational advantages may lead to value creation. The advantages also arise in part from the fact that for many products there is production cycle.[14] Product life-cycle theory can partially explain the cross-border expansion activities of EMMs.[15] For example, during the late 1970s, when China adopted an open-door policy and introduced *compensation trade*, it attracted investors from Hong Kong in the apparel industry, which were expanding internationally through licensing. At that particular time, the apparel manufacturing had reached a mature stage in developed countries due to the growth of developing country exports to developed countries. Hence, the operations in China attracted Hong Kong manufacturing ventures. When these firms accumulated knowledge in managing offshore operations, they built additional offshore firms – later these firms expanded into China through joint factories in other countries.[16] Therefore, value creation that the EMMs achieved during that time was also based on knowledge accumulation.

This is especially valid for Indian EMMs with mature technologies. As a result of having mature technologies, gradual expansion into the developed countries was actualized. In the early years, the investments seemed to originate from wealthier emerging market EMMs to smaller or poorer countries. Gradually, small horizontal investment flows from EMMs to the developed countries came to surface in the 1980s. This again can be identified as a stage in the product-life-cycle.[17] Taiwanese EMMs also illustrated the same pattern in that they received their original technologies from the developed nations, but later adapted these technologies to other developing nations' standards. Doing so, gave them the competitive advantage in foreign markets that they expanded into and helped create firm value.[18]

Although some M&A activities have been experienced since the mid-80s, they are coming up to the surface more forcefully today. For example in China, between 1985 and 1996, Hong Kong firms actualized 57.4 percent of M&A activities - amounting more than that of the U.S. firms, which was accounted for 48.2 percent. Hong Kong firms mostly chose acquisition of majority interests to expand into China in recent years.[19] The accumulation of ownership advantages also motivated and increased early M&A activities of EMMs. The early M&A activities of the 1990s were related to ownership advantages, which were based on EMMs ability to coordinate activities across sectors. These types of ownership advantages are usually identified as

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[14]See, Locational advantages: The International Product Life-Cycle Approach (Vernon, 1966).
[15] Lecraw (1981).
[16] Wells (1977) suggests that most international production activities of the company in the developmental stages were located in developing countries. Wells also conveys reducing risk by diversifying as a significant driving factor for EMMS to expand, since some firms respond to market pressure well and are able to survive in foreign markets. Moreover, EMMs seem to have some kind of competitive advantage over the MNCs from the developed countries.

[17] Wells, (1981).

[18] Ting and Schive (1981).

[19] See Milman (1999), and Dent and Randerson (1997).

transaction type O advantages that were apparent in EMMs early stages of expansion. Later, *asset type Ownership advantages* were exploited.[20]

Furthermore, today strategic networks and interactions are significant incentives for EMMs since they have a great impact upon value creation. The impact of strategic interaction in explaining international expansion goes back to the influential work of Knickerbocker (1973).[21] More recent work in this area speculates that strategic linkage theory displays a reason for expansion and value creation. This theory views FDI as an attempt to link some strategic resources that the firm is deficient of, and which are available in a foreign country. For example, Chen and Chen (1998) find that strategic linkages stimulate Taiwanese EMMs for cross-border expansions. Taiwanese firms are especially motivated by strategic linkages in investing in the United States. On the other hand, they are also motivated by relational linkages for investing in Southeast Asia and China.[22]

Recent research on firm networks and organizational ties show that such features as cooperative arrangements and firm-specific characteristics in M&A, JV and SA activities add value to cross-border expansions.[23] A network is not only an entity made up of integrated structures, it is a process as well. Therefore, networks are structures arising from social relations. As Yeung (1997) expresses a network perspective emphasizes the three dimensions of multinationals – *extrafrim, interfirm,* and *intrafirm* networks. Multinationals shift to *extrafirm* networks through their *interfirm* level (personal relationships, and governance structures). Hence, *intrafirm* relations are based on trust and experience, which are vital for coordination. Today, EMMs are more competent to enter into foreign locations through these networks. Yeung (1997) illustrates this claim through an examination of Hong Kong firms whose transnational operations are entrenched in networks of relationships today.[24] Hong Kong firms that were once seeking economies of scale in the use of equipment and capital goods and internalizing the use of technology and capital goods[25] are now attempting to minimize risk through diversification and network ties. Today, Hong Kong multinationals hold competitive advantage over multinationals from developed nations, not only because Hong Kong multinationals' products are high quality and their management personnel is well trained and relatively low cost, but also because of their integration of relational linkages into their business activities through M&As, JVs and SAs.

EMM Regions. Previous research indicates that country of origin has a lot do to with the pattern of cross-border expansion. To reiterate, this is evident in the way EMMs from different locations expand according to their needs. For example Indian EMMs choose JVs in expanding abroad in order to secure supply of capital goods, machinery, basic materials, technical know-how, and management services. These types of activities also contribute to the growth and diversification of the Indian exports.[26] Motivations for Indian EMMs' expansion also include access to raw materials, exploring new markets, better utilization of capital and manpower

[20] See Dunning, Hoesel and Narula (1997).
[21] Knickerbocker (1973).
[22] Chen and Chen (1998).
[23] Yeung (1994).
[24] Yeung (1997).
[25] Chen (1981).
[26] Wells (1981), and Agrawal (1981).

through economies of scale, and preservation of the existing markets.[27] However, other research suggests that market protection has not been an influential factor for the international expansion Indian firms. Anticipation of higher profits in the host country than in the home country, is also and important factor.[28] Over the years, in pursuit of accessing raw materials and selling manufacturing technologies and to market their products and services, the number of Indian EMMs investing abroad has increased, as they established subsidiaries and joint ventures.[29] Gradually, the expansion patterns began to include M&As as well.

Other studies show that major drivers for Taiwanese firms' internationalizations are very similar to that of Korean multinationals - obtaining raw materials, pursuit of profits by supplying host country markets and by transferring technology and expansion of exports.[30] Similarly, the primary reason for the Hong Kong firms' international expansion through joint ventures, strategic alliances and acquisitions is to maintain and increase their exports to industrialized nations.[31]

Number of bidders. The term bidders considered here is derived from EMMs' relational linkages with other firms. In this study, bidders are considered as other firms that jointly invest and take part in business activities after the announcement has been made. This variable is on applicable to JVs and SAs in this study). The pattern of international expansion in terms of location of production and the ownership of firms can be seen as the outcome of a supply of investment opportunities. Most emerging market EMMs expand through joint ventures with partners in the host country. The preference for joint ventures and mostly minority ownership arises mainly because home country of the EMM does not allow the firm to export capital. This was certainly the case for Indian EMMs during their first initialization of cross-border expansion.[32] Since the Indian government allowed no capital but machinery to be exported, the local partner generally provided the plant, specific equipment and the working capital. Therefore, the local partner became the majority owner of the project. In most cases, lower level of equity participation was widely practiced. As a result, the local subsidiary enjoyed a high degree of autonomy and reaped nearly all advantages.[33]

The Multinational Network Hypothesis is one of the contemporaneous theories that can explain IM activities since IMs began to exploit M&A, JV and SA patterns for their cross-border expansion activities in more recent years. The hypothesis postulates that foreign investment decisions improve the expanding firm's ability to benefit from the systemic advantages inherent in a multinational network. The valuation effects of strategic actions leading to creation of a multinational network stem from the firm's ability to arbitrage institutional, and the informational externalities captured by the firm. The cost savings gained by economies of scale in production, marketing and finance also have a role – to the extent that these options can be

[27] White (1981).
[28] Agarwal and Prasad (1985).
[29] Kumar (1981).
[30] Ting and Schive (1981).
[31] Chen (1981), and Jo (1981).

[32] Agrawal (1985).
[33] Wells (1977).

exercised by the acquiring firm and cannot be traded and acquired by other investors because the value of the firm should increase to reflect the incremental value of these options.[34]

However, it should also be realized that cross-border investments of Indian firms did not necessarily emerge as a deliberate effort to promote joint ventures or other types of FDI. Not all Emerging Market cross-border activities fall in clear categories. In recent years, the trend both for IMs and CMs has been merger and acquisition activities. As it can be observed from previous studies, mergers and acquisitions re strategic tools for firms operating in international markets. They are also a growing phenomenon in cross-border expansion activities of IMs with which firms respond to globalization of various industries and a rapidly changing international business environment.

Since firms may be exposed to higher risks through mergers and acquisitions the value of their international activities has not always been accepted positively by the market. Market reaction to these activities has been negative at times impacting the value of investments. However, this trend has been changing in recent years. One of the goals of this paper is to understand whether the market reaction has been changing over the years and making room for gaining greater value. This part of the paper is the empirical part. The paper utilizes event Study methodology.

Part III - Data and Methodology

IM sample data are obtained from the United Nations' UNCTAD world investment report on transnational corporations and export competitiveness. Merger and acquisition as well as joint ventures transactions data for 2000-2010 are extracted from the Securities and Data Corporation's (SDC) Worldwide Mergers and Acquisitions database.

Here, the standard event study methodology is utilized to evaluate the impact of each expansion announcement on the firm value. The event-study methodology is inspired by the efficient market hypothesis that capital markets are efficient instruments to evaluate and process the impact of new information available on firms.[35] The market model assumes a linear relationship between the return of any security and the return of the market portfolio. For each security i market model assumes that returns are given by:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_t ,$$

where,

$$E[ei] = 0 \text{ and } VAR[eit] = \sigma^2 ei \qquad (1)$$

nd where *Rit* is the return on security *i* at time *t.* The subscript *t* indicates the time, the subscript *i* indicates a specific security, and the subscript *m* indicates the market. *Rmt* is the return on the market portfolio during period *t*. The model's linear condition arises from the assumed normality of returns. The ε_t is a random error term for security *i* at the time of *t*, and the *β*s are firm specific coefficients to be estimated.

Equation (1) is estimates a 255 - day estimation period from t = -11 to t = -265 where t = 0 is the event day. In this study, the window is defined as the period between 10 days prior to the event

[34] Errunza and Senbet (1981, 1984), and Doukas and Travlos (1998).

[35] Fama, Fisher, and Jensen (1969).

to 10 days after the event. The abnormal return (AR) due to the announcement on any given day of the event window is therefore equal to the actual return minus the predicted normal return, given by the prediction error:

$$AR_{it} = R_{it} - \alpha_i + \beta_i R_{mt} \qquad (2)$$

According to previous researchers suggest that that abnormal performance measures such as standardized cumulative abnormal returns (SCARs) are less likely to generate false rejections of market efficiency. In addition, distributional properties and test statistics for cumulative abnormal returns are better understood.[36]

Part IV- Analysis and Results

The results indicate that all international expansion events, on average, show positive abnormal returns during pre- and post- event day and on the actual event day. *SCARs – IMs' (M&As).* A total of 763 events considered. Since significant for market reaction values are at (-10, +10), (-10, +5), (-5, +5) and (-5, +1), market does seem to react to M&A announcements in longer intervals and around the announcement day. At all intervals the market reacts positively to well over 50 percent of expansion announcements of acquirers from India where the z values for median and positives/negatives are both at 5 percent level. There seems to be value creation for Indian firms that expand internationally through M&As. (See Table 1, Appendix I)

Similarly, the results indicate that all international expansion events, on average, show positive abnormal returns during pre- and post- event day and on the actual event day. *SCARs – CMs' (M&As).* A total of 579 events considered. Most intervals display value creation, except abnormal returns of intervals (0,+5), (0,+10), and (+1,+2), which are 48.88 percent, 48.53 percent and 46.66 percent abnormal returns respectively. However, the above mentioned intervals have no significance. Market reacts to M&A announcements in longer intervals and around the announcement day. At all intervals the market reacts positively to well over 50 percent of expansion announcements of acquirers from India where the z values for median and positives/negatives are both at 5 percent level. There seems to be value creation for Indian firms that expand internationally through M&As. (See Table 2, Appendix I)

Part V-Conclusion

This study investigates the cross-border expansion implications on value creation of IMs and CMs for the period between 2000 and 2010. First, the paper explores the effects of cross-border expansion patterns on firm value creation. Second, it examines market reaction to the announcements of cross-border expansion patterns. Third, it evaluates firm performance in relation to the cross-border expansion activities.

This study finds that most IMs and CMs earn significantly positive abnormal returns during the event windows defined in this study. Hence, it is generally evident that there is value creation in cross-border expansion activities. According to the event-study results, value creation is mostly associated with

[36] Fama (1998), and Mitchell and Stafford (1998).

This positive effect is especially apparent a few days prior to the announcement in *informationally-efficient* markets.[37] Therefore, this study shares the view of previous work, as M&As can be considered as value creation mechanisms. Furthermore, this study is also consistent with previous research on the value creation effects of M&As, as the previous expresses that establishing M&As creates significant value for the shareholders of all the partnering firms.[38] The positive effects on value creation are more noticeable within technological alliances where firms experience greater abnormal returns.[39]

Although value creation may be less apparent in the short- term for most expansions as in the case of M&As, it is certainly ostensible in the long-run. Hence, the study is consistent with previous research as the findings suggest the focus of IMs is now mostly related to efficient use of capital and resource.

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[37] Hanvanich and Cavusgil (2000), and Kogut (1991).

[38] Das, Sen and Sengupta (1998), (Chan, Kensinger, Keown and Martin, 1997). and Cahng and Kuo (2001).

[39] Chan, Kensinger, Keown and Martin (1997), and Das, Sen and Sengupta (1998).

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Appendix I

Event Study Table 1

Table 1: Daily and Standardized Cumulative Abnormal Returns of Cross-Border Expansion MA Announcements (Indian Firms)

The table presents the Daily and Standardized Cumulative Abnormal Returns (SCARs) of 763 cross-border MA expansion announcements by Indian Multinationals (IMs) originate from India over the 2000-2010 period. Daily Standardized Cumulative Abnormal Returns (SCARs) are computed from the market model as prediction errors. Day 0 refers to the announcement day of acquisitions as reported SDC Database. Z-statistics [Wilcoxon Sign-Rank Test] is used to test for the statistical significance of mean [SCARs]. The statistical significance of mean [median] difference between groups is computed by One-Way ANOVA [Mann –Whitney Test for unmatched pairs]. Z statistics (Doukas' test) is used to test for the statistical significance of positives/negatives. ***, **, and * denote statistical significance at the 1%, 5%, 10% levels, respectively.

Indian Non-financial firms (2000-2010)

Day	**Mean**	**Z-Value Mean**	**Median**	**WSRT-Z for Median**	**Positive:Negative**	**Doukas Z for Positive: Negative**	**Total Number of Events**	**Positive Market Reaction %**
(-10,+10)	0.01760 **	2.15191	0.00830	1.01501	394:369	0.90506	763	51.64%
(-10,+5)	0.00932 **	1.93650	0.00520	1.08018	392:371	0.76025	763	51.38%
(-10,+2)	0.01618 ***	3.70978	0.00770 **	1.76584	407:356 **	1.84632	763	53.34%
(-10,+1)	0.01591 ***	3.78933	0.00880 **	2.09599	415:348 ***	2.42556	763	54.39%
(-10,0)	0.01313 ***	3.27085	0.00830 **	2.06755	419:344 ***	2.71518	763	54.91%
(-9,+9)	0.01977 ***	2.51299	0.00770	0.97893	415:348 ***	2.42556	763	54.39%
(-9,+5)	0.00986	2.14992	0.00540	1.17747	395:368	0.97747	763	51.77%

	**							
(-9,+2)	0.01671 ***	4.06029	0.00740 **	1.79784	413:350 **	2.28075	763	54.13%
(-9,+1)	0.01645 ***	4.15768	0.00760 **	1.92143	420:343 ***	2.78759	763	55.05%
(-9,0)	0.01367 ***	3.62695	0.00800 **	2.12286	414:349 ***	2.35316	763	54.26%
(-8,+8)	0.02041 ***	2.66734	0.00400	0.52263	400:363 *	1.33949	763	52.42%
(-8,+5)	0.01060 ***	2.39230	0.00500	1.12844	402:361 *	1.48430	763	52.69%
(-8,+2)	0.01746 ***	4.44802	0.00960 ***	2.44603	409:354 **	1.99113	763	53.60%
(-8,+1)	0.01719 ***	4.54550	0.01000 ***	2.64442	436:327 ***	3.94606	763	57.14%
(-8,0)	0.01441 ***	4.02821	0.00580 *	1.62131	409:354 **	1.99113	763	53.60%
(-5,+5)	0.01357 ***	3.51337	0.00580 *	1.50182	414:349 ***	2.35316	763	54.26%
(-5,+2)	0.02042 ***	6.19191	0.00870 ***	2.63753	431:332 ***	3.58404	763	56.49%
(-5,+1)	0.02016 ***	6.41346	0.01130 ***	3.59519	450:313 ***	4.95973	763	58.98%
(-5,0)	0.01738 ***	5.92791	0.01170 ***	3.99097	447:316 ***	4.74252	763	58.58%
(-4,+4)	0.01606 ***	4.52379	0.00740 **	2.08435	427:336 ***	3.29442	763	55.96%
(-4,+2)	0.01963 ***	6.29230	0.01120 ***	3.58963	434:329 ***	3.80126	763	56.88%
(-4,+1)	0.01937 ***	6.56420	0.01210 ***	4.10095	446:317 ***	4.67011	763	58.45%
(-4,0)	0.01659 ***	6.11505	0.01140 ***	4.20271	448:315 ***	4.81492	763	58.72%
(-3,+3)	0.01836 ***	5.96979	0.01210 ***	3.93419	437:326 ***	4.01847	763	57.27%
(-3,+2)	0.02008 ***	6.96605	0.01440 ***	4.99578	448:315 ***	4.81492	763	58.72%
(-3,+1)	0.01981 ***	7.38514	0.01390 ***	5.18122	472:291 ***	6.55264	763	61.86%
(-3,0)	0.01703 ***	7.15596	0.01180 ***	4.95691	459:304 ***	5.61138	763	60.16%
(-2,+2)	0.02055 ***	7.73050	0.01040 ***	3.91206	444:319 ***	4.52530	763	58.19%
(-2,+1)	0.02028	8.26355	0.01310	5.33725	468:295	6.26302	763	61.34%

	***		***		***			
(-2,0)	0.01753 ***	8.13280	0.01020 ***	4.73270	460:302 ***	5.72374	762	60.37%
(-1,+1)	0.01859 ***	8.26046	0.00960 ***	4.26497	474:289 ***	6.69745	763	62.12%
(-1,0)	0.01584 ***	8.31999	0.00845 ***	4.43955	469:293 ***	6.37581	762	61.55%
(0,0)	0.01186 ***	8.72770	0.00555 ***	4.08457	456:304 ***	5.51362	760	60.00%
(0,+1)	0.01459 ***	7.92751	0.00670 ***	3.64035	454:309 ***	5.24935	763	59.50%
(0,+2)	0.01486 ***	7.03494	0.00700 ***	3.31442	436:327 ***	3.94606	763	57.14%
(0,+5)	0.00800 ***	2.69488	0.00430 *	1.44769	403:360 *	1.55670	763	52.82%
(0,+10)	0.01628 **	2.11290	0.00210	0.27257	392:371	0.76025	763	51.38%
(+1,+2)	0.00305 **	1.89999	-0.00150	-0.93553	365:398	-1.19468	763	47.84%

Event Study Table 2

Table 2: Daily and Standardized Cumulative Abnormal Returns of Cross-Border Expansion MA Announcements (Chinese Firms)

The table presents the Daily and Standardized Cumulative Abnormal Returns (SCARs) of 579 cross-border MA expansion announcements by Chinese Multinationals (CMs) originate from India over the 2000-2010 period. Daily Standardized Cumulative Abnormal Returns (SCARs) are computed from the market model as prediction errors. Day 0 refers to the announcement day of acquisitions as reported SDC Database. Z-statistics [Wilcoxon Sign-Rank Test] is used to test for the statistical significance of mean [SCARs]. The statistical significance of mean [median] difference between groups is computed by One-Way ANOVA [Mann –Whitney Test for unmatched pairs]. Z statistics (Doukas' test) is used to test for the statistical significance of positives/negatives. ***, **, and * denote statistical significance at the 1%, 5%, 10% levels, respectively.

Table for Chinese Non-financial firms (2000-2010)

Day	**Mean**	**Z-Value Mean**	**Median**	**WSRT-Z for Median**	**Positive:Negative**	**Doukas Z for Positive: Negative**	**Total Number of Events**	**Positive Market Reaction %**
(-10,+10	0.01364 *	1.63755	0.00400	0.48019	297:282	0.62338	579	51.30%

)								
(-10,+5)	0.01605 **	2.07614	0.00330	0.42679	300:279	0.87273	579	51.81%
(-10,+2)	0.01750 ***	2.36529	-0.00020	-0.02703	287:292	-0.20779	579	49.57%
(-10,+1)	0.02059 ***	2.76289	0.00480	0.64423	305:274 *	1.28832	579	52.68%
(-10,0)	0.01802 ***	2.58376	0.00380	0.54473	304:275	1.20520	579	52.50%
(-9,+9)	0.01042	1.26178	0.00310	0.37548	294:285	0.37403	579	50.78%
(-9,+5)	0.01333 **	1.72884	0.00420	0.54470	300:279	0.87273	579	51.81%
(-9,+2)	0.01478 **	2.01922	0.00440	0.60124	309:270 *	1.62078	579	53.37%
(-9,+1)	0.01786 ***	2.43474	0.00560	0.76342	311:268 **	1.78702	579	53.71%
(-9,0)	0.01530 **	2.26303	0.00400	0.59164	298:281	0.70650	579	51.47%
(-8,+8)	0.01269 *	1.59777	0.00670	0.84381	303:276	1.12208	579	52.33%
(-8,+5)	0.01473 **	1.98848	0.00770	1.03964	308:271 *	1.53767	579	53.20%
(-8,+2)	0.01617 **	2.29456	0.00490	0.69515	311:268 **	1.78702	579	53.71%
(-8,+1)	0.01926 ***	2.73238	0.00800	1.13520	323:256 ***	2.78442	579	55.79%
(-8,0)	0.01669 ***	2.57307	0.00700	1.07889	314:265 **	2.03637	579	54.23%
(-5,+5)	0.01343 **	2.27590	0.00420	0.71179	297:282	0.62338	579	51.30%
(-5,+2)	0.01487 ***	2.71274	0.00500	0.91211	319:260 ***	2.45196	579	55.09%
(-5,+1)	0.01796 ***	3.29815	0.00830 *	1.52413	329:250 ***	3.28313	579	56.82%
(-5,0)	0.01539 ***	3.10850	0.00700 *	1.41343	330:249 ***	3.36625	579	56.99%
(-4,+4)	0.01239 **	2.18602	0.00250	0.44111	302:277	1.03896	579	52.16%
(-4,+2)	0.01306 ***	2.41795	0.00480	0.88892	307:272 *	1.45455	579	53.02%
(-4,+1)	0.01614 ***	2.98902	0.00790 *	1.46296	327:252 ***	3.11689	579	56.48%
(-4,0)	0.01358 ***	2.73954	0.00610	1.23073	324:255 ***	2.86754	579	55.96%
(-3,+3)	0.01286	2.43504	0.00500	0.94662	311:268 **	1.78702	579	53.71%

	***							
(-3,+2)	0.01477 ***	2.92450	0.00480	0.95066	309:270 *	1.62078	579	53.37%
(-3,+1)	0.01785 ***	3.53197	0.00900 **	1.78061	328:251 ***	3.20001	579	56.65%
(-3,0)	0.01529 ***	3.34318	0.00520	1.13704	318:261 ***	2.36884	579	54.92%
(-2,+2)	0.01301 ***	2.79995	0.00500	1.07589	321:258 ***	2.61819	579	55.44%
(-2,+1)	0.01610 ***	3.47888	0.00510	1.10208	327:252 ***	3.11689	579	56.48%
(-2,0)	0.01354 ***	3.23258	0.00450	1.07474	327:252 ***	3.11689	579	56.48%
(-1,+1)	0.01333 ***	2.92167	0.00630 *	1.38052	326:253 ***	3.03378	579	56.30%
(-1,0)	0.01077 ***	2.67783	0.00430	1.06949	332:247 ***	3.53248	579	57.34%
(0,0)	0.00622 **	2.03484	0.00050	0.16370	305:274 *	1.28832	579	52.68%
(0,+1)	0.00878 ***	2.40073	0.00380	1.03907	321:258 ***	2.61819	579	55.44%
(0,+2)	0.00569 *	1.51069	0.00020	0.05305	291:288	0.12468	579	50.26%
(0,+5)	0.00425	0.94884	-0.00080	-0.17864	283:296	-0.54026	579	48.88%
(0,+10)	0.00183	0.32204	-0.00160	-0.28086	281:298	-0.70650	579	48.53%
(+1,+2)	-0.00052	-0.19414	-0.00230	-0.85296	269:310	-1.70390	579	46.46%

***, **, and * denote statistical significance at the 1%, 5%, 10% levels, respectively

Appendix I

1- List of Chinese firms

A-A United Ltd
Measuring, Medical, Photo Equipment; Clocks
AcrossAsia Ltd
Business Services
Along Mobile Technologies Inc
Prepackaged Software
Andes Petroleum Co
Oil and Gas; Petroleum Refining
Anhui Fengyuan Group Co Ltd
Drugs
Anhui Zhongding Sealing Parts

Machinery

APAC Resources Ltd

Wholesale Trade-Durable Goods

AS Watson & Co Ltd

Retail Trade-Food Stores

AS Watson(France)SAS

Retail Trade-Food Stores

Asia Tele-Net & Tech Corp Ltd

Machinery

Asia Tiger Group Ltd

Computer and Office Equipment

AsiaPharm Group Ltd

Drugs

AV Concept Holdings Ltd

Electronic and Electrical Equipment

Azeus Systems Holdings Ltd

Business Services

BALtrans Holdings Ltd

Transportation and Shipping (except air)

BALtrans International(BVI)Ltd

Air Transportation and Shipping

Baoshan Iron & Steel Co Ltd

Metal and Metal Products

Baotou Aluminium(Group)Co Ltd

Metal and Metal Products

Best Tone Holdings Ltd

Mining

BOE

Electronic and Electrical Equipment

Bonso Electronics Intl Inc

Machinery

Bright Orient(Holding)Ltd

Textile and Apparel Products

BYD Electronic Company Limited

Electronic and Electrical Equipment

Cafe de Coral Holdings Ltd

Retail Trade-Eating and Drinking Places

CASH On-Line(Celestial Asia)

Business Services

CASIL Clearing Ltd

Electronic and Electrical Equipment

Cathay Pacific Airways Ltd

Air Transportation and Shipping

CDC Corp

Business Services

CDC Games Ltd

Prepackaged Software

CHALCO

Metal and Metal Products

Changjiang & Jinggong Steel

Metal and Metal Products

Chemoil Energy Ltd

Wholesale Trade-Nondurable Goods

Chevalier Intl Hldg Ltd

Holding Companies, Except Banks

Chevalier Pipe Technologies

Rubber and Miscellaneous Plastic Products

China Aviation Oil Supply Corp

Miscellaneous Retail Trade

China Digital Commun Grp Corp

Chemicals and Allied Products

China Dongxiang (Group) Co Ltd

Wholesale Trade-Nondurable Goods

China Fishery Group Investment

Agriculture, Forestry, and Fishing

China Fishery Group Ltd

Agriculture, Forestry, and Fishing

China Gas Holdings Ltd

Oil and Gas; Petroleum Refining

China Intl Marine Containers

Metal and Metal Products

China Investments Holdings Ltd

Wood Products, Furniture, and Fixtures

China LotSynergy Holdings Ltd

Business Services

China Merchants Hldgs(Intl)Co

Transportation and Shipping (except air)

China Mining Resources Grp Ltd

Mining

China Mobile Commun Corp

Telecommunications

China Mobile(Hong Kong)Grp Ltd

Telecommunications

China Oilfield Services Ltd

Oil and Gas; Petroleum Refining

China Railway Resources Co Ltd

Construction Firms

China Resources Snow Brew Ltd

Food and Kindred Products

China Shenhua Energy Co Ltd

Mining

China Shipping Terminal Dvlp

Transportation and Shipping (except air)

China Telecom Corp Ltd

Telecommunications

China Timber Resources Grp Ltd

Transportation and Shipping (except air)

China Unicom Ltd

Telecommunications

China World Trade Corp

Construction Firms

Chinadotcom Corp

Business Services

Chinakey(Hong Kong)Ltd

Textile and Apparel Products

Chinese National Petroleum

Oil and Gas; Petroleum Refining

Chongqing Iron & Steel Co(Grp)

Metal and Metal Products

CIL Holdings Ltd

Wholesale Trade-Durable Goods

CITIC Pacific Ltd

Miscellaneous Manufacturing

CITIC Resources Holdings Ltd

Wood Products, Furniture, and Fixtures

CK Life Sciences Intl Inc

Miscellaneous Retail Trade

CK Life Sciences Intl(Hldg)Inc

Miscellaneous Retail Trade

CLP Holdings Ltd

Electric, Gas, and Water Distribution

CLP Power Asia Ltd

Electric, Gas, and Water Distribution

CLP Power Intl

Electric, Gas, and Water Distribution

CNOOC

Oil and Gas; Petroleum Refining

CNOOC Ltd

Oil and Gas; Petroleum Refining

CNPC

Oil and Gas; Petroleum Refining

CNPC Exploration & Development

Oil and Gas; Petroleum Refining

CNPC International Ltd

Oil and Gas; Petroleum Refining

CNPC(Hong Kong)Ltd

Oil and Gas; Petroleum Refining

COFCO Ltd

Food and Kindred Products

Cofco Property Group Co Ltd

Miscellaneous Retail Trade

Computer & Tech Hldg Ltd

Business Services

Comtech Group Inc

Business Services

Corgi International Ltd

Miscellaneous Manufacturing

COSCO

Transportation and Shipping (except air)

COSCO Pacific Ltd

Transportation and Shipping (except air)

Creative Master Bermuda Ltd

Miscellaneous Manufacturing

Ctrip.com International Ltd

Business Services

Culture.com Technology Ltd

Business Services

Dairy Farm Intl Hldg Ltd

Retail Trade-Food Stores

Decca Holdings Ltd

Wood Products, Furniture, and Fixtures

Dickson Concepts(Intl)Ltd

Wholesale Trade-Durable Goods

DMX Technologies Group Ltd

Prepackaged Software

Dream International Ltd

Miscellaneous Manufacturing

Dress Line Hldgs(Tristate)

Textile and Apparel Products

Easyknit Enterprises Hldgs Ltd

Textile and Apparel Products

EganaGoldpfeil(Hldg)Ltd

Measuring, Medical, Photo Equipment; Clocks

e-Kong Group Ltd

Telecommunications

Elec & Eltek International

Electronic and Electrical Equipment

E-Life International Ltd

Transportation and Shipping (except air)

Elixir Group Ltd

Business Services

Emer International Group Ltd

Machinery

e-New Media Co Ltd

Miscellaneous Services

Enric Energy Equip Hldg Ltd

Metal and Metal Products

Enviro Energy Intl Holdngs Ltd

Business Services

Epure International Ltd

Public Administration

Era Info & Entertainment Ltd

Motion Picture Production and Distribution

Esprit Holdings Ltd

Textile and Apparel Products

FDS Networks Group Ltd

Business Services

Finet Group Ltd

Business Services

First E-Pro Ltd

Telecommunications

FlexSystem Hldg Ltd

Prepackaged Software

FM Holdings Ltd

Chemicals and Allied Products

Focus Media Holding Ltd

Advertising Services

Forest Glen Group Ltd

Wood Products, Furniture, and Fixtures

Fulbond Holdings Ltd

Wood Products, Furniture, and Fixtures

Fushi International Inc

Metal and Metal Products

Fuyao Glass Group Inds Co Ltd

Stone, Clay, Glass, and Concrete Products

Gansu Yasheng Indl(Grp)Co Ltd

Chemicals and Allied Products

GD Power Development Co Ltd

Electric, Gas, and Water Distribution

Genting International PLC

Hotels and Casinos

Gold Mountains(HK)Intl Mining

Mining

Golden Harvest Films Distn

Motion Picture Production and Distribution

Golife Concepts Holdings Ltd

Wholesale Trade-Nondurable Goods

Gorient(Holdings)Ltd

Transportation Equipment

Grand Toys International Ltd

Miscellaneous Manufacturing

Grande Holdings Ltd

Measuring, Medical, Photo Equipment; Clocks

Grandtop Intl Hldg Ltd

Textile and Apparel Products

Grandvest International Ltd

Textile and Apparel Products

Great Eagle Holdings Ltd

Hotels and Casinos

Great Pacific Investments Ltd

Leather and Leather Products

Greater China Sci-Tech Hldgs

Leather and Leather Products

Greka China Ltd

Mining

Grow Rapid Ltd

Metal and Metal Products

Guangju Energy(Hong Kong)Co

Wholesale Trade-Nondurable Goods

GuoGuang Electric Co Ltd

Electronic and Electrical Equipment

Haier Electrical Appliances

Wholesale Trade-Durable Goods

Haier Group Corp

Electronic and Electrical Equipment

Hanny Holdings Ltd

Computer and Office Equipment

Hans Laser Technology Co Ltd

Electronic and Electrical Equipment

Harbin Guangyu Storage Battery

Electronic and Electrical Equipment

Hembly International Hldgs Ltd

Transportation and Shipping (except air)

Holyworld Group Ltd(Yue Fung

Electronic and Electrical Equipment

Hong Kong Electric Intl

Construction Firms

HongKong Electric(Holdings)Ltd

Electric, Gas, and Water Distribution

Hongkong.com Corp

Business Services

Huaneng Power Intl Inc

Electric, Gas, and Water Distribution

Hunan Nonferrous Metals Corp

Metal and Metal Products

Hunan Nonferrous Metals Hldg

Metal and Metal Products
Hunan Sunward Intelligent
Wholesale Trade-Durable Goods
Hunan Sunward Intelligent Mach
Machinery
Hurray! Holding Co Ltd
Telecommunications
Hutchison International Ltd
Telecommunications
Hutchison Port Holdings
Transportation and Shipping (except air)
Hutchison Port Holdings Ltd
Transportation and Shipping (except air)
Hutchison Telecommun Intl Ltd
Telecommunications
Hutchison Telecommun Tech
Telecommunications
Hutchison Whampoa Ltd
Telecommunications
IDS Group Ltd
Business Services
IDS Impac Ltd
Business Services
Innomaxx Biotech Grp Ltd
Drugs
INTAC International Inc
Telecommunications
Integrated Dist Svcs Grp Ltd
Business Services
iSteelAsia.com Ltd
Wholesale Trade-Durable Goods
Ji Lin Ji En Nickel Ind Co Ltd
Mining
Jiangsu Aoyang Tech Corp Ltd
Chemicals and Allied Products
Jinan Iron & Steel Group Corp
Metal and Metal Products
Johnson Electric Holdings Ltd
Electronic and Electrical Equipment
Kantone Holdings Ltd
Prepackaged Software
Kemoil Ltd
Prepackaged Software
Kenlory Ltd
Business Services
Keysuccess International Ltd

Miscellaneous Manufacturing
King Pacific Intl Hldgs Ltd
Construction Firms
Lafarge Shui On Cement Ltd
Stone, Clay, Glass, and Concrete Products
Lenovo Group Ltd
Computer and Office Equipment
LF Centennial Ltd
Wholesale Trade-Nondurable Goods
Li & Fung Ltd
Wholesale Trade-Nondurable Goods
Lijun Intl Pharm(Hldg)Co Ltd
Drugs
Linktone Ltd
Business Services
Linmark Group Ltd
Business Services
Luen Thai Holdings Ltd
Textile and Apparel Products
Lung Cheong Intl Hldg Ltd
Miscellaneous Manufacturing
Lung Kee International Ltd
Metal and Metal Products
M Dream Inworld Ltd
Business Services
Macau Success(Hong Kong)Ltd
Amusement and Recreation Services
Mainland Headwear Hldg Ltd
Textile and Apparel Products
Matrix Holdings Ltd
Miscellaneous Manufacturing
Maxibase International Ltd
Miscellaneous Manufacturing
Mayer Holdings Ltd
Metal and Metal Products
Meadville Holdings Ltd
Electronic and Electrical Equipment
Mediamaster Ltd
Motion Picture Production and Distribution
Memory Devices Ltd
Electronic and Electrical Equipment
Mindray Medical Intl Ltd
Measuring, Medical, Photo Equipment; Clocks
Mongolia Energy Corp Ltd
Mining
Morning Star Resources Ltd

Transportation and Shipping (except air)

Mui Hong Kong Ltd

Transportation and Shipping (except air)

Nanjing Panda Electn Co Ltd

Electronic and Electrical Equipment

Netel Technology Holdings Ltd

Telecommunications

New Concept Capital Ltd

Electronic and Electrical Equipment

New Hope Agri-Business Co Ltd

Agriculture, Forestry, and Fishing

New Smart Energy Group Ltd

Oil and Gas; Petroleum Refining

New World Infrastructure Ltd

Transportation and Shipping (except air)

Next Media Ltd

Printing, Publishing, and Allied Services

Ningbo Huaxiang Electronic Co

Transportation Equipment

Ningbo Tech-Bank Co Ltd

Food and Kindred Products

Noble Group Ltd

Wholesale Trade-Nondurable Goods

Norstar Founders Group Ltd

Transportation Equipment

North Asia Strategic Hldgs Ltd

Wholesale Trade-Durable Goods

O2New Technology Ltd

Electronic and Electrical Equipment

Oceanbase Group Ltd

Electronic and Electrical Equipment

ONFEM Holdings Ltd

Construction Firms

Pacific Andes Intl Hldgs Ltd

Wholesale Trade-Nondurable Goods

Pacific Basin Shipping Ltd

Transportation and Shipping (except air)

Paul Y Construction Co Ltd

Construction Firms

Paul Y International Ltd

Business Services

PCCW Ltd

Telecommunications

Pegasus International Holdings

Leather and Leather Products

PetroChina Co Ltd

Oil and Gas; Petroleum Refining

Poly Investments Holdings Ltd

Electronic and Electrical Equipment

RC Group(Holdings)Ltd

Prepackaged Software

RCG China Holdings Ltd

Business Services

RH&A Acquisition Corp

Business Services

Rich Concept Technology Ltd

Business Services

Rich Theme Holdings Ltd

Chemicals and Allied Products

Rojam Ent Hldg Ltd

Motion Picture Production and Distribution

SAIC

Transportation Equipment

Salus Controls-BVI

Measuring, Medical, Photo Equipment; Clocks

Samson Holding Ltd

Wood Products, Furniture, and Fixtures

SDIC Zhonglu Fruit Juice Co

Food and Kindred Products

Seapower Resources Intl Ltd

Transportation and Shipping (except air)

Selangor Gold Ltd

Rubber and Miscellaneous Plastic Products

Semiconductor Manufacturing

Printing, Publishing, and Allied Services

Shanda Interactive Ent Ltd

Business Services

Shandong Nanshan Alum Ind Co

Metal and Metal Products

Shanghai Baosteel Group Corp

Metal and Metal Products

Shanghai Electric Group Co Ltd

Machinery

Shanghai Guangzhao Plant

Agriculture, Forestry, and Fishing

Shanghai Haixin Group Co Ltd

Textile and Apparel Products

Shanghai Indl Hldg Ltd

Tobacco Products

Shanghai Intl Port(Grp)Co Ltd

Public Administration

Shanghai Kaikai Group Co Ltd

Textile and Apparel Products
Shanghai Oriental Pearl Co Ltd
Radio and Television Broadcasting Stations
Shanghai Pudong Intl Airport
Oil and Gas; Petroleum Refining
Shanghai Tyre & Rubber Co Ltd
Rubber and Miscellaneous Plastic Products
Shanghai Worldbest Co Ltd
Textile and Apparel Products
Shangri-La Asia Ltd
Hotels and Casinos
Sharp Focus International Ltd
Electronic and Electrical Equipment
Sharp Gain Profits Ltd
Rubber and Miscellaneous Plastic Products
Shell Elec Mfg(Hldg)Co Ltd
Electronic and Electrical Equipment
Shengli Oilfield
Oil and Gas; Petroleum Refining
Shenyang Machine Tool Co Ltd
Machinery
Shenzhen Nanshan Power Stn Co
Electric, Gas, and Water Distribution
Shougang Concord Intl Entrp
Metal and Metal Products
Shui On Constr & Materials Ltd
Construction Firms
Sichuan Shuanghong Displayer
Electronic and Electrical Equipment
Sino Union Petro & Chem Intl
Chemicals and Allied Products
Sinochem
Oil and Gas; Petroleum Refining
Sinochem Corp
Oil and Gas; Petroleum Refining
Sinochem International Co Ltd
Wholesale Trade-Nondurable Goods
SINOCHEM Petro Expl & Prodn
Oil and Gas; Petroleum Refining
Sinopec
Oil and Gas; Petroleum Refining
Sinopec Corp
Oil and Gas; Petroleum Refining
Sinopec Corp Qingdao Br,China
Oil and Gas; Petroleum Refining
Sinopec Intl Petro Expl,Prodn

Oil and Gas; Petroleum Refining

Sinopec Shengli Oil Field

Oil and Gas; Petroleum Refining

Sinoriver International Ltd

Construction Firms

SNP Leefung Holdings Ltd

Printing, Publishing, and Allied Services

Solartech Intl Hldg Ltd

Electronic and Electrical Equipment

Sonavox Intl Holdings Ltd

Electronic and Electrical Equipment

Spreadtrum Communications Inc

Electronic and Electrical Equipment

STAR Pharmaceutical Ltd

Drugs

Starlight Intl Hldgs Ltd

Electronic and Electrical Equipment

STELUX Holdings Ltd

Miscellaneous Retail Trade

Sundiro Holding Co Ltd

Transportation Equipment

Suntech Power Holdings Co Ltd

Electronic and Electrical Equipment

Suntech Power Int Ltd

Electronic and Electrical Equipment

Tack Fat Grp Intl Ltd

Textile and Apparel Products

Tai Ping Carpets Intl Ltd

Textile and Apparel Products

Tan Chong International Ltd

Wholesale Trade-Durable Goods

TCC Hong Kong Cement Holdings

Stone, Clay, Glass, and Concrete Products

TCC International Holdings Ltd

Stone, Clay, Glass, and Concrete Products

TCL Commun Tech Holdings Ltd

Communications Equipment

TCL Corp

Electronic and Electrical Equipment

TCL Electrical Appl Sales Co

Retail Trade-Home Furnishings

TCL Group

Communications Equipment

TCL Intl Hldg-TV & DVD Player

Electronic and Electrical Equipment

TechCap Holdings Ltd

Health Services

techpacific.com Ltd

Prepackaged Software

TechTronic Industries Co Ltd

Electronic and Electrical Equipment

Machinery

Tectron Pacific Ltd

Rubber and Miscellaneous Plastic Products

Tencent Holdings Ltd

Business Services

The9 Ltd

Prepackaged Software

Tianjin Tasly Grp Co Ltd

Drugs

Tiger Enter(Giordano Holdings)

Textile and Apparel Products

Tingyi(Cayman Islands)Hldg

Holding Companies, Except Banks

Titan Petrochemicals Group Ltd

Transportation and Shipping (except air)

Tom Group Ltd

Holding Companies, Except Banks

TOM Online Inc

Telecommunications

Tom.com Ltd

Business Services

Tommy Hilfiger Corp

Textile and Apparel Products

Tommy Hilfiger Holdings Ltd

Textile and Apparel Products

Tongfang Co Ltd

Business Services

Tonghua Grape Wine Co Ltd

Food and Kindred Products

Top Form(BVI)Ltd

Textile and Apparel Products

Top Victory Industries Ltd

Miscellaneous Manufacturing

TPV Technology Ltd

Computer and Office Equipment

Trinity Textiles Ltd

Retail Trade-General Merchandise and Apparel

Tsingtao Brewery Co Ltd

Food and Kindred Products

UDL Holdings Ltd

Business Services

Unisplendour Corp Ltd
Electronic and Electrical Equipment
United Pacific Industries Ltd
Electronic and Electrical Equipment
UniVision Engineering Ltd
Business Services
VanceInfo Technologies Inc
Business Services
Varitronix Investment Ltd
Electronic and Electrical Equipment
Vastrich Corp Ltd
Transportation and Shipping (except air)
Venturepharm Laboratories Ltd
Drugs
Vodatel Networks Holdings Ltd
Telecommunications
VST Holdings Ltd
Wholesale Trade-Durable Goods
Vtech Holdings Ltd
Communications Equipment
Walcom Grp Ltd
Food and Kindred Products
Watsons Water
Chemicals and Allied Products
Web Connection(China.com Corp)
Business Services
Weifang Yaxing Chemical Co Ltd
Chemicals and Allied Products
Western Mining Co Ltd
Mining
Wisearn Group Ltd(Gold-Face)
Holding Companies, Except Banks
Wonder Auto Ltd
Transportation Equipment
WuXi PharmaTech(Cayman)Inc
Drugs
Xian Yuen Titanium Resources
Textile and Apparel Products
Xinhua Finance Media Ltd
Advertising Services
Xinjiang Chalkis Co Ltd
Food and Kindred Products
Xinjiang Zijin Mining Co Ltd
Mining
Xinxing Ductile Iron Pipes Co
Metal and Metal Products

Xinyu Hengdeli Holdings Ltd

Measuring, Medical, Photo Equipment; Clocks

Yangtzekiang Garment Mnfg Co

Textile and Apparel Products

Yanzhou Coal Mining Co Ltd

Mining

YGM Trading Ltd

Wholesale Trade-Nondurable Goods

Yue Yuen Industrial(Hldg)Ltd

Rubber and Miscellaneous Plastic Products

Yugang International Ltd

Wholesale Trade-Durable Goods

Yunnan Chihong Zinc

Mining

Zhuzhou CSR Times Electric Co

Electronic and Electrical Equipment

Zijin Mining Group Co Ltd

Mining

ZTE Corp

Communications Equipment

2- List of Indian firms

3i Infotech Ltd

Business Services

Aban Loyd Chiles Offshore Ltd

Oil and Gas; Petroleum Refining

Accentia Technologies Ltd

Health Services

Action Constr Equip Ltd

Machinery

Aditya Birla Mgmt Corp Ltd

Chemicals and Allied Products

Adlabs Films Ltd

Motion Picture Production and Distribution

Advanta India Ltd

Agriculture, Forestry, and Fishing

Aftek Infosys Ltd

Prepackaged Software

Ajanta Soya Ltd

Food and Kindred Products

AKSH Optifibre Ltd

Metal and Metal Products

Alembic Ltd

Drugs

Allied Digital Services Ltd

Business Services

Allsec Technologies Ltd

Business Services

Alok Textile Industries Ltd

Textile and Apparel Products

Alps Industries Ltd

Wood Products, Furniture, and Fixtures

Amtek Auto Ltd

Transportation Equipment

Amtek India Ltd

Transportation Equipment

Apollo Tyres Ltd

Rubber and Miscellaneous Plastic Products

Ashapura Minechem Ltd

Mining

Ashok Leyland Ltd

Transportation Equipment

Asian Electronics Ltd

Electronic and Electrical Equipment

Asian Paints(India)Ltd

Chemicals and Allied Products

Asian Star Co Ltd

Miscellaneous Manufacturing

Assam Co Ltd

Holding Companies, Except Banks

aurionPro Solutions Ltd

Prepackaged Software

Aurobindo Datong Bio-Pharma Co

Drugs

Aurobindo Pharma Ltd

Drugs

Autoline Industries Ltd

Transportation Equipment

Bajaj Auto Ltd

Transportation Equipment

Batliboi Ltd

Machinery

Berger Paints(India)Ltd

Chemicals and Allied Products

Bharat Earth Movers Ltd

Machinery
Bharat Forge Ltd
Metal and Metal Products
Bharti Airtel Ltd
Telecommunications
Bharti Enterprises Ltd
Telecommunications
Bhushan Steel Ltd
Metal and Metal Products
Bilcare Ltd
Paper and Allied Products
BILT
Textile and Apparel Products
Binani Cement Ltd
Stone, Clay, Glass, and Concrete Products
Biocon Ltd
Drugs
Bombay Rayon Fashions Ltd
Textile and Apparel Products
BPCL
Oil and Gas; Petroleum Refining
BPL Ltd
Communications Equipment
Britannia Industries Ltd
Food and Kindred Products
Cadila Healthcare Ltd
Drugs
California Software Co Ltd
Business Services
Cals Refineries Ltd
Oil and Gas; Petroleum Refining
Cambridge Tech Ent Ltd
Business Services
Carborundum Universal Ltd
Stone, Clay, Glass, and Concrete Products
CCL Products(India)Ltd
Food and Kindred Products
Chambal Fertilisers & Chem Ltd
Chemicals and Allied Products
Champagne Indage Ltd
Food and Kindred Products
Chemplast Sanmar Ltd

Chemicals and Allied Products

Clutch Auto Ltd

Transportation Equipment

Core Projects & Tech Ltd

Business Services

Country Club(India)Ltd

Hotels and Casinos

Cranes Software Intl Ltd

Prepackaged Software

Crest Communication Ltd

Computer and Office Equipment

CRISIL

Business Services

Crisil Ltd

Business Services

Crompton Greaves Ltd

Electronic and Electrical Equipment

Cyber Media India Ltd

Business Services

Cyberspace Infosys Ltd

Prepackaged Software

Cyberspace Ltd

Business Services

Dabur India Ltd

Soaps, Cosmetics, and Personal-Care Products

Dabur Pharma Ltd

Drugs

Dhanuka Pesticides Ltd

Chemicals and Allied Products

Dhanus Technologies Ltd

Telecommunications

Dishman Pharm & Chem Ltd

Drugs

Dr Reddys Laboratories Ltd

Drugs

DSQ Software Ltd

Business Services

Dynamatic Technologies Ltd

Machinery

Educomp Solutions Ltd

Prepackaged Software

Eicher Motors Ltd

Transportation Equipment

EIL

Business Services

Elder Pharmaceuticals Ltd

Drugs

Energy Development Co Ltd

Electric, Gas, and Water Distribution

Escorts Ltd

Electronic and Electrical Equipment

Essar Oil Ltd

Oil and Gas; Petroleum Refining

Essar Steel Ltd

Metal and Metal Products

Essel Propack Ltd

Rubber and Miscellaneous Plastic Products

Everest Kanto Cylinder Ltd

Metal and Metal Products

Exide Industries Ltd

Electronic and Electrical Equipment

Faze Three Exports Ltd

Textile and Apparel Products

Financial Tech(India)Ltd

Prepackaged Software

Firstsource Solutions Ltd

Business Services

Four Soft Ltd

Business Services

GAIL

Electric, Gas, and Water Distribution

GAIL(India)Ltd

Electric, Gas, and Water Distribution

Gammon India Ltd

Construction Firms

Geodesic Info Sys Ltd

Prepackaged Software

Geometric Software Solutions

Prepackaged Software

GHCL Ltd

Chemicals and Allied Products

Gitanjali Gems Ltd

Miscellaneous Manufacturing

Glenmark Pharmaceuticals Ltd

Drugs

GMR Energy Ltd

Electric, Gas, and Water Distribution

Godrej Agrovet Ltd

Food and Kindred Products

Godrej Consumer Products Ltd

Soaps, Cosmetics, and Personal-Care Products

Godrej Industries Ltd

Soaps, Cosmetics, and Personal-Care Products

Godrej Sara Lee Ltd

Chemicals and Allied Products

Goldiam International Ltd

Miscellaneous Manufacturing

Goodlass Nerolac Paints Ltd

Chemicals and Allied Products

Granules India Ltd

Drugs

Graphite India Ltd

Electronic and Electrical Equipment

Great Offshore Ltd

Oil and Gas; Petroleum Refining

Greaves Cotton Ltd

Machinery

Greenply Industries Ltd

Wood Products, Furniture, and Fixtures

Greycells Entertainment Ltd

Business Services

GSS America Infotech Ltd

Business Services

GTL International Ltd

Prepackaged Software

GTL Ltd

Business Services

Gujarat Heavy Chemicals Ltd

Chemicals and Allied Products

Gujarat NRE Coke Ltd

Metal and Metal Products

Gulf Oil Corp Ltd

Oil and Gas; Petroleum Refining

Havells India Ltd

Electronic and Electrical Equipment

HCL Technologies Ltd

Business Services

Helios & Matheson InfoTech Ltd

Business Services

Hexaware Technologies Ltd

Educational Services

Hikal Ltd

Chemicals and Allied Products

Himadri Chemicals & Industries

Chemicals and Allied Products

Himatsingka Seide Ltd

Textile and Apparel Products

Hindalco Industries Ltd

Metal and Metal Products

Hinduja TMT Ltd

Business Services

Hindustan Petroleum Corp Ltd

Oil and Gas; Petroleum Refining

House of Pearl Fashions Ltd

Textile and Apparel Products

HOV Services Ltd

Business Services

ICICI Infotech Services Ltd

Business Services

ICICI OneSource Ltd

Business Services

IFGL Refractories Ltd

Stone, Clay, Glass, and Concrete Products

iGATE Global Solutions Ltd

Prepackaged Software

India Nippon Electricals Ltd

Transportation Equipment

Indian Hotels Co Ltd

Hotels and Casinos

Indian Oil Corp

Oil and Gas; Petroleum Refining

Indo Gulf Corp Ltd

Chemicals and Allied Products

Indo Rama Synthetics(India)Ltd

Textile and Apparel Products

Indoco Remedies Ltd

Drugs

Infomedia India Ltd

Printing, Publishing, and Allied Services

Infosys Technologies Ltd

Business Services

ISMT Ltd

Metal and Metal Products

Ispat Industries Ltd

Metal and Metal Products

Jain Irrigation Systems Ltd

Metal and Metal Products

JB Chemicals & Pharmaceuticals

Drugs

Jet Airways(India)Ltd

Air Transportation and Shipping

Jindal Drilling & Inds Ltd

Oil and Gas; Petroleum Refining

Jindal Polyester Ltd

Chemicals and Allied Products

Jindal Steel & Power Ltd

Metal and Metal Products

JK Tyres & Industries Ltd

Rubber and Miscellaneous Plastic Products

JSW Steel Ltd

Metal and Metal Products

Jubilant Organosys Ltd

Drugs

Kale Consultants Ltd

Business Services

Karuturi Global Ltd

Wholesale Trade-Nondurable Goods

Karuturi Networks Ltd

Wholesale Trade-Nondurable Goods

Kirloskar Brothers Ltd

Machinery

Kirloskar Electric Co Ltd

Electronic and Electrical Equipment

KPIT Cummins Infosystems Ltd

Business Services

Larsen & Toubro Infotech Ltd

Business Services

Larsen & Toubro Ltd

Business Services

Logix Microsystems Ltd

Prepackaged Software

Lupin Ltd

Drugs

Macmillan India Ltd

Printing, Publishing, and Allied Services

Mahindra & Mahindra Ltd

Transportation Equipment

Mahindra Consulting Ltd

Business Services

Manugraph India Ltd

Machinery

Marico Ltd

Soaps, Cosmetics, and Personal-Care Products

Marksans Pharma Ltd

Drugs

Mascon Global Ltd

Business Services

Mascot Systems Ltd

Prepackaged Software

Mastek Ltd

Business Services

Matrix Laboratories Ltd

Drugs

Megasoft Ltd

Business Services

Melstar Information Tech Ltd

Prepackaged Software

Minda Corp Ltd

Transportation Equipment

Minda Huf Ltd

Transportation Equipment

Minda Industries Ltd

Wholesale Trade-Durable Goods

MosChip Semiconductor Tech Ltd

Electronic and Electrical Equipment

Moser Baer India Ltd

Computer and Office Equipment

Moser Baer Photo Voltaic Ltd

Electronic and Electrical Equipment

Motherson Sumi Systems Ltd

Electronic and Electrical Equipment

MphasiS BFL Ltd

Prepackaged Software
Natco Pharma Ltd
Drugs
Nava Bharat Ventures Ltd
Metal and Metal Products
Nettlinx Ltd
Business Services
Nicholas Piramal India Ltd
Drugs
NIIT Global
Business Services
NIIT Ltd
Educational Services
NIIT Technologies Ltd
Business Services
Nirma Ltd
Soaps, Cosmetics, and Personal-Care Products
Nitin Fire Protection Indus
Miscellaneous Manufacturing
NTPC
Electric, Gas, and Water Distribution
Oil & Natural Gas Corp Ltd
Oil and Gas; Petroleum Refining
ONGC
Oil and Gas; Petroleum Refining
ONGC Videsh Ltd
Oil and Gas; Petroleum Refining
Onmobile Global Ltd
Telecommunications
Ontrack Systems Ltd
Prepackaged Software
Opto Circuits (India) Ltd
Measuring, Medical, Photo Equipment; Clocks
Orchid Chem & Pharm Ltd
Drugs
Orient Information Technology
Prepackaged Software
Oswal Group
Textile and Apparel Products
Panacea Biotec Ltd
Drugs
Paramount Communications Ltd

Metal and Metal Products

Patni Computer Systems Ltd

Business Services

Pentamedia Graphics Ltd

Motion Picture Production and Distribution

Pentasoft Technologies Ltd

Business Services

Pidilite Industries Ltd

Chemicals and Allied Products

Plethico Pharmaceuticals Ltd

Drugs

Polaris Software Lab Ltd

Prepackaged Software

Poly Medicure Ltd

Measuring, Medical, Photo Equipment; Clocks

Praj Industries Ltd

Machinery

Prime Focus Ltd

Motion Picture Production and Distribution

Prithvi Information Solutions

Business Services

Punj Lloyd Ltd

Construction Firms

Pyramid Saimira Theatre Ltd

Motion Picture Production and Distribution

Quintegra Solutions Ltd

Business Services

Prepackaged Software

R Systems International Ltd

Business Services

Rain Calcining Ltd

Oil and Gas; Petroleum Refining

Rain Commodities Ltd

Stone, Clay, Glass, and Concrete Products

Rain/CII holdings Inc

Oil and Gas; Petroleum Refining

Ranbaxy Laboratories Ltd

Drugs

Rashtriya Chem & Fertilizers

Chemicals and Allied Products

Raymond Ltd

Textile and Apparel Products

Rediff.com India Ltd

Business Services

Refex Refrigerants Ltd

Wholesale Trade-Nondurable Goods

Reliance Coal Resources Pvt

Electric, Gas, and Water Distribution

Reliance Communications Ltd

Telecommunications

Reliance Industries Ltd

Textile and Apparel Products

Reliance Life Sciences{RLS}

Drugs

Rohit Ferro-Tech Ltd

Metal and Metal Products

Rolta India Ltd

Business Services

Rolta TUSC Inc

Business Services

RSWM Ltd

Textile and Apparel Products

S Kumars Nationwide Ltd

Textile and Apparel Products

S Kumars Synfabs Ltd

Textile and Apparel Products

Saksoft Ltd

Business Services

Sakthi Sugars Ltd

Food and Kindred Products

Salora International Ltd

Electronic and Electrical Equipment

Sanmar Holdings Ltd

Chemicals and Allied Products

Sasken Communication

Telecommunications

Satyam Computer Services Ltd

Business Services

Satyam Infoway Ltd

Business Services

Shasun Chemicals & Drugs Ltd

Drugs

Shilpa Medicare Ltd

Drugs

Shipping Corp of India Ltd
Transportation and Shipping (except air)
Shree Ganesh Forgings Ltd
Metal and Metal Products
Shrenuj & Co Ltd
Miscellaneous Manufacturing
Sical Logistics Ltd
Transportation and Shipping (except air)
Sify Ltd
Business Services
Silverline Technologies Ltd
Business Services
Sintex Industries Ltd
Rubber and Miscellaneous Plastic Products
Softsol India Ltd
Prepackaged Software
Sona Koyo Steering Systems
Transportation Equipment
Sonata Software Ltd
Business Services
Spanco Telesystems & Solutions
Telecommunications
Spentex Industries Ltd
Agriculture, Forestry, and Fishing
Sql Star International Ltd
Prepackaged Software
SRF Ltd
Chemicals and Allied Products
Steel Authority of India Ltd
Metal and Metal Products
Sterling Biotech Ltd
Chemicals and Allied Products
Sterlite Industries(India)Ltd
Metal and Metal Products
Sterlite Technologies Ltd
Metal and Metal Products
Strides Arcolab Ltd
Drugs
Subex Azure Ltd
Prepackaged Software
Subex Systems Ltd
Prepackaged Software

Sujana Towers Ltd

Machinery

Sun Pharmaceuticals Inds Ltd

Drugs

Sundaram Fasteners Ltd

Miscellaneous Manufacturing

Sundram Fasteners Ltd

Transportation Equipment

Suprajit Engineering Ltd

Transportation Equipment

Suzlon Energy Ltd

Machinery

Swaraj Mazda Ltd

Transportation Equipment

Tanla Solutions Ltd

Telecommunications

Tata Chemicals Ltd

Chemicals and Allied Products

Tata Coffee Ltd

Food and Kindred Products

Tata Communications Ltd

Telecommunications

Tata Consultancy Services Ltd

Business Services

Tata Iron & Steel Co Ltd

Metal and Metal Products

Tata Motors Ltd

Transportation Equipment

Tata Power Co Ltd

Electric, Gas, and Water Distribution

Tata Steel Ltd

Metal and Metal Products

Tata Tea Ltd

Food and Kindred Products

Tech Mahindra Ltd

Business Services

Teledata Informatics Ltd

Prepackaged Software

Thermax Ltd

Metal and Metal Products

Torrent Pharmaceuticals Ltd

Drugs

Tricom India Ltd

Prepackaged Software

Triton Corp Ltd

Business Services

TVS Autolec Ltd

Machinery

UCAL Fuel Systems Ltd

Machinery

Unichem Laboratories Ltd

Drugs

Uniphos Enterprises Ltd

Chemicals and Allied Products

United Breweries Ltd

Food and Kindred Products

United Phosphorus Ltd

Chemicals and Allied Products

United Spirits Ltd

Food and Kindred Products

Usha Beltron Ltd

Electronic and Electrical Equipment

Usha Martin Ltd

Metal and Metal Products

UTV Software Commun Ltd

Radio and Television Broadcasting Stations

Vaibhav Gems Ltd

Miscellaneous Manufacturing

Videocon Appliances Ltd

Electronic and Electrical Equipment

Videocon Industries Ltd

Electronic and Electrical Equipment

Videocon International Ltd

Electronic and Electrical Equipment

Videsh Sanchar Nigam Ltd

Telecommunications

VIP Industries Ltd

Leather and Leather Products

Visesh Infotecnics Ltd

Business Services

Visesh Infotecnics-Business

Business Services

VisualSoft Technologies Ltd

Prepackaged Software

Vivimed Labs Ltd

Drugs

Voltas Ltd

Machinery

Welspun India Ltd

Textile and Apparel Products

Welspun-Gujarat Stahl Rohren

Metal and Metal Products

Williamson Magor & Co Ltd

Food and Kindred Products

Wipro Infrastructure

Machinery

Wipro Ltd

Business Services

Wipro Spectramind Svcs Pvt Ltd

Business Services

Wipro Technologies

Business Services

WNS(Holdings)Ltd

Business Services

Wockhardt Ltd

Drugs

Zensar Technologies Ltd

Prepackaged Software

Zicom Electronic Security Sys

Communications Equipment

Zodiac Clothing Co Ltd

Textile and Apparel Products

List of Indian firms

3i Infotech Ltd

Business Services

Aban Loyd Chiles Offshore Ltd

Oil and Gas; Petroleum Refining

Accentia Technologies Ltd

Health Services

Action Constr Equip Ltd

Machinery

Aditya Birla Mgmt Corp Ltd

Chemicals and Allied Products

Adlabs Films Ltd

Motion Picture Production and Distribution
Advanta India Ltd
Agriculture, Forestry, and Fishing
Aftek Infosys Ltd
Prepackaged Software
Ajanta Soya Ltd
Food and Kindred Products
AKSH Optifibre Ltd
Metal and Metal Products
Alembic Ltd
Drugs
Allied Digital Services Ltd
Business Services
Allsec Technologies Ltd
Business Services
Alok Textile Industries Ltd
Textile and Apparel Products
Alps Industries Ltd
Wood Products, Furniture, and Fixtures
Amtek Auto Ltd
Transportation Equipment
Amtek India Ltd
Transportation Equipment
Apollo Tyres Ltd
Rubber and Miscellaneous Plastic Products
Ashapura Minechem Ltd
Mining
Ashok Leyland Ltd
Transportation Equipment
Asian Electronics Ltd
Electronic and Electrical Equipment
Asian Paints(India)Ltd
Chemicals and Allied Products
Asian Star Co Ltd
Miscellaneous Manufacturing
Assam Co Ltd
Holding Companies, Except Banks
aurionPro Solutions Ltd
Prepackaged Software
Aurobindo Datong Bio-Pharma Co
Drugs
Aurobindo Pharma Ltd

Drugs

Autoline Industries Ltd

Transportation Equipment

Bajaj Auto Ltd

Transportation Equipment

Batliboi Ltd

Machinery

Berger Paints(India)Ltd

Chemicals and Allied Products

Bharat Earth Movers Ltd

Machinery

Bharat Forge Ltd

Metal and Metal Products

Bharti Airtel Ltd

Telecommunications

Bharti Enterprises Ltd

Telecommunications

Bhushan Steel Ltd

Metal and Metal Products

Bilcare Ltd

Paper and Allied Products

BILT

Textile and Apparel Products

Binani Cement Ltd

Stone, Clay, Glass, and Concrete Products

Biocon Ltd

Drugs

Bombay Rayon Fashions Ltd

Textile and Apparel Products

BPCL

Oil and Gas; Petroleum Refining

BPL Ltd

Communications Equipment

Britannia Industries Ltd

Food and Kindred Products

Cadila Healthcare Ltd

Drugs

California Software Co Ltd

Business Services

Cals Refineries Ltd

Oil and Gas; Petroleum Refining

Cambridge Tech Ent Ltd

Business Services

Carborundum Universal Ltd

Stone, Clay, Glass, and Concrete Products

CCL Products(India)Ltd

Food and Kindred Products

Chambal Fertilisers & Chem Ltd

Chemicals and Allied Products

Champagne Indage Ltd

Food and Kindred Products

Chemplast Sanmar Ltd

Chemicals and Allied Products

Clutch Auto Ltd

Transportation Equipment

Core Projects & Tech Ltd

Business Services

Country Club(India)Ltd

Hotels and Casinos

Cranes Software Intl Ltd

Prepackaged Software

Crest Communication Ltd

Computer and Office Equipment

CRISIL

Business Services

Crisil Ltd

Business Services

Crompton Greaves Ltd

Electronic and Electrical Equipment

Cyber Media India Ltd

Business Services

Cyberspace Infosys Ltd

Prepackaged Software

Cyberspace Ltd

Business Services

Dabur India Ltd

Soaps, Cosmetics, and Personal-Care Products

Dabur Pharma Ltd

Drugs

Dhanuka Pesticides Ltd

Chemicals and Allied Products

Dhanus Technologies Ltd

Telecommunications

Dishman Pharm & Chem Ltd

Drugs

Dr Reddys Laboratories Ltd

Drugs

DSQ Software Ltd

Business Services

Dynamatic Technologies Ltd

Machinery

Educomp Solutions Ltd

Prepackaged Software

Eicher Motors Ltd

Transportation Equipment

EIL

Business Services

Elder Pharmaceuticals Ltd

Drugs

Energy Development Co Ltd

Electric, Gas, and Water Distribution

Escorts Ltd

Electronic and Electrical Equipment

Essar Oil Ltd

Oil and Gas; Petroleum Refining

Essar Steel Ltd

Metal and Metal Products

Essel Propack Ltd

Rubber and Miscellaneous Plastic Products

Everest Kanto Cylinder Ltd

Metal and Metal Products

Exide Industries Ltd

Electronic and Electrical Equipment

Faze Three Exports Ltd

Textile and Apparel Products

Financial Tech(India)Ltd

Prepackaged Software

Firstsource Solutions Ltd

Business Services

Four Soft Ltd

Business Services

GAIL

Electric, Gas, and Water Distribution

GAIL(India)Ltd

Electric, Gas, and Water Distribution

Gammon India Ltd

Construction Firms

Geodesic Info Sys Ltd

Prepackaged Software

Geometric Software Solutions

Prepackaged Software

GHCL Ltd

Chemicals and Allied Products

Gitanjali Gems Ltd

Miscellaneous Manufacturing

Glenmark Pharmaceuticals Ltd

Drugs

GMR Energy Ltd

Electric, Gas, and Water Distribution

Godrej Agrovet Ltd

Food and Kindred Products

Godrej Consumer Products Ltd

Soaps, Cosmetics, and Personal-Care Products

Godrej Industries Ltd

Soaps, Cosmetics, and Personal-Care Products

Godrej Sara Lee Ltd

Chemicals and Allied Products

Goldiam International Ltd

Miscellaneous Manufacturing

Goodlass Nerolac Paints Ltd

Chemicals and Allied Products

Granules India Ltd

Drugs

Graphite India Ltd

Electronic and Electrical Equipment

Great Offshore Ltd

Oil and Gas; Petroleum Refining

Greaves Cotton Ltd

Machinery

Greenply Industries Ltd

Wood Products, Furniture, and Fixtures

Greycells Entertainment Ltd

Business Services

GSS America Infotech Ltd

Business Services

GTL International Ltd

Prepackaged Software

GTL Ltd

Business Services

Gujarat Heavy Chemicals Ltd

Chemicals and Allied Products

Gujarat NRE Coke Ltd

Metal and Metal Products

Gulf Oil Corp Ltd

Oil and Gas; Petroleum Refining

Havells India Ltd

Electronic and Electrical Equipment

HCL Technologies Ltd

Business Services

Helios & Matheson InfoTech Ltd

Business Services

Hexaware Technologies Ltd

Educational Services

Hikal Ltd

Chemicals and Allied Products

Himadri Chemicals & Industries

Chemicals and Allied Products

Himatsingka Seide Ltd

Textile and Apparel Products

Hindalco Industries Ltd

Metal and Metal Products

Hinduja TMT Ltd

Business Services

Hindustan Petroleum Corp Ltd

Oil and Gas; Petroleum Refining

House of Pearl Fashions Ltd

Textile and Apparel Products

HOV Services Ltd

Business Services

ICICI Infotech Services Ltd

Business Services

ICICI OneSource Ltd

Business Services

IFGL Refractories Ltd

Stone, Clay, Glass, and Concrete Products

iGATE Global Solutions Ltd

Prepackaged Software

India Nippon Electricals Ltd

Transportation Equipment

Indian Hotels Co Ltd

Hotels and Casinos

Indian Oil Corp

Oil and Gas; Petroleum Refining

Indo Gulf Corp Ltd

Chemicals and Allied Products

Indo Rama Synthetics(India)Ltd

Textile and Apparel Products

Indoco Remedies Ltd

Drugs

Infomedia India Ltd

Printing, Publishing, and Allied Services

Infosys Technologies Ltd

Business Services

ISMT Ltd

Metal and Metal Products

Ispat Industries Ltd

Metal and Metal Products

Jain Irrigation Systems Ltd

Metal and Metal Products

JB Chemicals & Pharmaceuticals

Drugs

Jet Airways(India)Ltd

Air Transportation and Shipping

Jindal Drilling & Inds Ltd

Oil and Gas; Petroleum Refining

Jindal Polyester Ltd

Chemicals and Allied Products

Jindal Steel & Power Ltd

Metal and Metal Products

JK Tyres & Industries Ltd

Rubber and Miscellaneous Plastic Products

JSW Steel Ltd

Metal and Metal Products

Jubilant Organosys Ltd

Drugs

Kale Consultants Ltd

Business Services

Karuturi Global Ltd

Wholesale Trade-Nondurable Goods

Karuturi Networks Ltd

Wholesale Trade-Nondurable Goods

Kirloskar Brothers Ltd

Machinery

Kirloskar Electric Co Ltd

Electronic and Electrical Equipment

KPIT Cummins Infosystems Ltd

Business Services

Larsen & Toubro Infotech Ltd

Business Services

Larsen & Toubro Ltd

Business Services

Logix Microsystems Ltd

Prepackaged Software

Lupin Ltd

Drugs

Macmillan India Ltd

Printing, Publishing, and Allied Services

Mahindra & Mahindra Ltd

Transportation Equipment

Mahindra Consulting Ltd

Business Services

Manugraph India Ltd

Machinery

Marico Ltd

Soaps, Cosmetics, and Personal-Care Products

Marksans Pharma Ltd

Drugs

Mascon Global Ltd

Business Services

Mascot Systems Ltd

Prepackaged Software

Mastek Ltd

Business Services

Matrix Laboratories Ltd

Drugs

Megasoft Ltd

Business Services

Melstar Information Tech Ltd

Prepackaged Software

Minda Corp Ltd

Transportation Equipment

Minda Huf Ltd

Transportation Equipment

Minda Industries Ltd

Wholesale Trade-Durable Goods

MosChip Semiconductor Tech Ltd

Electronic and Electrical Equipment

Moser Baer India Ltd

Computer and Office Equipment

Moser Baer Photo Voltaic Ltd

Electronic and Electrical Equipment

Motherson Sumi Systems Ltd

Electronic and Electrical Equipment

MphasiS BFL Ltd

Prepackaged Software

Natco Pharma Ltd

Drugs

Nava Bharat Ventures Ltd

Metal and Metal Products

Nettlinx Ltd

Business Services

Nicholas Piramal India Ltd

Drugs

NIIT Global

Business Services

NIIT Ltd

Educational Services

NIIT Technologies Ltd

Business Services

Nirma Ltd

Soaps, Cosmetics, and Personal-Care Products

Nitin Fire Protection Indus

Miscellaneous Manufacturing

NTPC

Electric, Gas, and Water Distribution

Oil & Natural Gas Corp Ltd

Oil and Gas; Petroleum Refining

ONGC

Oil and Gas; Petroleum Refining

ONGC Videsh Ltd

Oil and Gas; Petroleum Refining

Onmobile Global Ltd

Telecommunications

Ontrack Systems Ltd

Prepackaged Software

Opto Circuits (India) Ltd

Measuring, Medical, Photo Equipment; Clocks

Orchid Chem & Pharm Ltd

Drugs

Orient Information Technology

Prepackaged Software

Oswal Group

Textile and Apparel Products

Panacea Biotec Ltd

Drugs

Paramount Communications Ltd

Metal and Metal Products

Patni Computer Systems Ltd

Business Services

Pentamedia Graphics Ltd

Motion Picture Production and Distribution

Pentasoft Technologies Ltd

Business Services

Pidilite Industries Ltd

Chemicals and Allied Products

Plethico Pharmaceuticals Ltd

Drugs

Polaris Software Lab Ltd

Prepackaged Software

Poly Medicure Ltd

Measuring, Medical, Photo Equipment; Clocks

Praj Industries Ltd

Machinery

Prime Focus Ltd

Motion Picture Production and Distribution

Prithvi Information Solutions

Business Services

Punj Lloyd Ltd

Construction Firms

Pyramid Saimira Theatre Ltd

Motion Picture Production and Distribution

Quintegra Solutions Ltd

Business Services

Prepackaged Software

R Systems International Ltd

Business Services

Rain Calcining Ltd

Oil and Gas; Petroleum Refining

Rain Commodities Ltd

Stone, Clay, Glass, and Concrete Products

Rain/CII holdings Inc

Oil and Gas; Petroleum Refining

Ranbaxy Laboratories Ltd

Drugs

Rashtriya Chem & Fertilizers

Chemicals and Allied Products

Raymond Ltd

Textile and Apparel Products

Rediff.com India Ltd

Business Services

Refex Refrigerants Ltd

Wholesale Trade-Nondurable Goods

Reliance Coal Resources Pvt

Electric, Gas, and Water Distribution

Reliance Communications Ltd

Telecommunications

Reliance Industries Ltd

Textile and Apparel Products

Reliance Life Sciences{RLS}

Drugs

Rohit Ferro-Tech Ltd

Metal and Metal Products

Rolta India Ltd

Business Services

Rolta TUSC Inc

Business Services

RSWM Ltd

Textile and Apparel Products

S Kumars Nationwide Ltd

Textile and Apparel Products

S Kumars Synfabs Ltd

Textile and Apparel Products

Saksoft Ltd

Business Services
Sakthi Sugars Ltd
Food and Kindred Products
Salora International Ltd
Electronic and Electrical Equipment
Sanmar Holdings Ltd
Chemicals and Allied Products
Sasken Communication
Telecommunications
Satyam Computer Services Ltd
Business Services
Satyam Infoway Ltd
Business Services
Shasun Chemicals & Drugs Ltd
Drugs
Shilpa Medicare Ltd
Drugs
Shipping Corp of India Ltd
Transportation and Shipping (except air)
Shree Ganesh Forgings Ltd
Metal and Metal Products
Shrenuj & Co Ltd
Miscellaneous Manufacturing
Sical Logistics Ltd
Transportation and Shipping (except air)
Sify Ltd
Business Services
Silverline Technologies Ltd
Business Services
Sintex Industries Ltd
Rubber and Miscellaneous Plastic Products
Softsol India Ltd
Prepackaged Software
Sona Koyo Steering Systems
Transportation Equipment
Sonata Software Ltd
Business Services
Spanco Telesystems & Solutions
Telecommunications
Spentex Industries Ltd
Agriculture, Forestry, and Fishing
Sql Star International Ltd

Prepackaged Software

SRF Ltd

Chemicals and Allied Products

Steel Authority of India Ltd

Metal and Metal Products

Sterling Biotech Ltd

Chemicals and Allied Products

Sterlite Industries(India)Ltd

Metal and Metal Products

Sterlite Technologies Ltd

Metal and Metal Products

Strides Arcolab Ltd

Drugs

Subex Azure Ltd

Prepackaged Software

Subex Systems Ltd

Prepackaged Software

Sujana Towers Ltd

Machinery

Sun Pharmaceuticals Inds Ltd

Drugs

Sundaram Fasteners Ltd

Miscellaneous Manufacturing

Sundram Fasteners Ltd

Transportation Equipment

Suprajit Engineering Ltd

Transportation Equipment

Suzlon Energy Ltd

Machinery

Swaraj Mazda Ltd

Transportation Equipment

Tanla Solutions Ltd

Telecommunications

Tata Chemicals Ltd

Chemicals and Allied Products

Tata Coffee Ltd

Food and Kindred Products

Tata Communications Ltd

Telecommunications

Tata Consultancy Services Ltd

Business Services

Tata Iron & Steel Co Ltd

Metal and Metal Products

Tata Motors Ltd

Transportation Equipment

Tata Power Co Ltd

Electric, Gas, and Water Distribution

Tata Steel Ltd

Metal and Metal Products

Tata Tea Ltd

Food and Kindred Products

Tech Mahindra Ltd

Business Services

Teledata Informatics Ltd

Prepackaged Software

Thermax Ltd

Metal and Metal Products

Torrent Pharmaceuticals Ltd

Drugs

Tricom India Ltd

Prepackaged Software

Triton Corp Ltd

Business Services

TVS Autolec Ltd

Machinery

UCAL Fuel Systems Ltd

Machinery

Unichem Laboratories Ltd

Drugs

Uniphos Enterprises Ltd

Chemicals and Allied Products

United Breweries Ltd

Food and Kindred Products

United Phosphorus Ltd

Chemicals and Allied Products

United Spirits Ltd

Food and Kindred Products

Usha Beltron Ltd

Electronic and Electrical Equipment

Usha Martin Ltd

Metal and Metal Products

UTV Software Commun Ltd

Radio and Television Broadcasting Stations

Vaibhav Gems Ltd

Miscellaneous Manufacturing

Videocon Appliances Ltd

Electronic and Electrical Equipment

Videocon Industries Ltd

Electronic and Electrical Equipment

Videocon International Ltd

Electronic and Electrical Equipment

Videsh Sanchar Nigam Ltd

Telecommunications

VIP Industries Ltd

Leather and Leather Products

Visesh Infotecnics Ltd

Business Services

Visesh Infotecnics-Business

Business Services

VisualSoft Technologies Ltd

Prepackaged Software

Vivimed Labs Ltd

Drugs

Voltas Ltd

Machinery

Welspun India Ltd

Textile and Apparel Products

Welspun-Gujarat Stahl Rohren

Metal and Metal Products

Williamson Magor & Co Ltd

Food and Kindred Products

Wipro Infrastructure

Machinery

Wipro Ltd

Business Services

Wipro Spectramind Svcs Pvt Ltd

Business Services

Wipro Technologies

Business Services

WNS(Holdings)Ltd

Business Services

Wockhardt Ltd

Drugs

Zensar Technologies Ltd

Prepackaged Software

Zicom Electronic Security Sys

Communications Equipment

Zodiac Clothing Co Ltd

Textile and Apparel Products

Market effect and innovative capability development in cross-border M&As: an empirical study on Chinese listed manufacturing firms

Xiaobo Wu; Jing Li; Yu Gao
School of Management, Zhejiang University,
866 Yuhangtang Road, Hangzhou, Zhejiang Province, 310058, P. R. China
Lijing89@zju.edu.cn

Abstract

Encouraged by "go global" policy, many Chinese firms take the advantage of the international environment, accelerate the ODI activities, especially cross-border merger and acquisition (M&A), and bring the firms to a higher level of international status and the capabilities.

Aimed at investigating the influence of such activities, present study focuses on the market effect and the relative innovative capability improvement. Sample firms are selected from listed firms on China's A share stock market during period of year 2008 to 2011. And event analysis is adopted to process data. Based on statistics, cross-border M& A activities induce the relative strong positive market effect of the firm taking it. On the other hand, taking the perspective of capability, the innovative capability is proxied by the patent statistics. Before and after the M&A event, firm-specific innovative capability changing trend can be portrayed. There shows improvement in patents afterwards, but not significantly.

Keywords: manufacturing firm; cross-border M&A; market effect; innovative capability

1. Introduction

It is widely accepted that emerging economies are playing relatively more vital role in the outward direct investment (ODI) activities, especially China. Through the process of internationalization, overseas export and FDI, has effectively bring in the advanced knowledge and organization management experience, which largely improved the capability and confidence in global trade of Chinese small- and medium-sized enterprises(SMEs), which in turn make them motivated to absorb more benefits from the bigger outside world. It is also apparent that Chinese SMEs are becoming more active global players in the process.

In general, since Chinese enterprises as later comers, they are extremely in need of supportive resources, like strategic assets, rare natural resources or broad market, rather than seeking efficiency (Buckley, Cross, Tan, Xin, & Voss, 2008). In order to achieve steady growth through ODI, Chinese firms themselves have more alternatives to make decisions on, including the types of internationalization, and the host countries over the world. On the other hand, different from state-owned enterprises SOEs who are more interested in natural resources to represent the objectives of home government(Luo & Tung, 2007), private SMEs tend to equip themselves with the strategic assets, promoting their technologies and skills to fulfill their further goals.

More and more studies are focusing on the Chinese ODI within global context. There're some scholars conducted their research on institutional framework(Peng, Wang, & Jiang, 2008). Some regard knowledge transfer as important phenomenon in this process. China is a new emerging economy that keeps growing rapidly but still lack of high-tech industries and Chinese enterprises does not have much innovation capability. Thus, from the capability perspective, as Chinese firms always catch up the competitors in developed countries, the absorptive capacity plays a significant role.

The phenomenon that emerging country MNCs as latecomers to international business, are mostly staying at the stage of catching up with developed-market MNEs in technological capabilities to have access to international competition(Mudambi, 2008). The ODI motivation represents the intention of the firm to expand its network worldwide and get useful knowledge for competition, while the firm embedded in global network will find the network benefits them a lot with the new knowledge.

In the following parts, the section 2 present the reviews related literatures around M&A performance and capability improvement, and the hypotheses derived from the relationships and basic theory. Section 3 talks about the research methodology, revealing the sampling and measures. Section 4 and section 5 focus on the discussion and limitation parts.

2. Literature review and hypotheses

According to plenty of empirical method, scholars have proved that the motivations of Chinese firms ODI include natural resource seeking, technology sourcing, market, diversification and strategic asset (Cai, 1999; Deng, 2007). Especially, at the early stage, MNCs in emerging country tended to invest in developed countries to acquire top technology, which can be learned to complement its competitive disadvantage (Pananond & Zeithaml, 1998). Market seeking and asset seeking are two distinct but complementary motives behind emerging economy's ODI. Rasiah, Gammeltoft, and Jiang (2010) pointed out the technology-seeking as the more important motive in the current ODI wave, and along with this trend, the home emerging country governments can benefit the successful investment outflows in terms of regulating policy.

On the other hand, the outflow of investment always chooses the locations, or host countries with a proper institutional environment, such as low tax(Hongkong and Carribean) (Morck, Yeung, & Zhao, 2008), the culture and the market scale. In general, the home country with the larger scale market, and geographically closed to the mainland, may attract more outflow of Chinese firms (Buckley et al., 2007; Cheng & Ma, 2007).

It is to be stressed that an appropriate entry mode should be chose for a MNC to adapt to the general and industry environments(Andersen, 1997; Pan & Tse, 2000). However, such choice is influenced by the mixed effect of host-country policy, firm size and previous international experiences, including the firm's international strategy(Harzing, 2002). The choice also depends on the capital market situation. When the market is in downturn that may lead the firm value underestimated, the investor would like to choose M&A to achieve expansion at low cost (Harris & Ravenscraft, 1991).

2.1 M&A performance

For ODI activity, the main concern is that whether such activity can bring the shareholders enough value as a value-creation strategy (Markides & Ittner, 1994; Morck & Yeung, 1992; Shimizu, Hitt, Vaidyanath, & Pisano, 2004). And with more and more scholars focusing on such MNC topic, the foreign researchers on M&A mainly built the paradigm of M&A performance, including the long-run financial performance, or the stock market response, which is based on the assumption of efficient market theory. It is also demonstrated that there exist diverse wealth effects between cross-border and domestic M&As due to the capital market imperfection (Danbolt, 1995; Fatemi & Furtado, 1988) . However, a similar study conducted in Switzerland found no difference between national and cross-border mergers, against some empirical findings(Lowinski, Schiereck, & Thomas, 2004).

Further in the transaction, the benefit for the acquirer and target are also in difference. For most target firms involved in such activities, the empirical findings show both pro and con side to this core question. Kiymaz (2003) have reported positive abnormal returns for the acquiring firms, while the results of Corhay and Rad (2000) and Aw and Chatterjee (2004) reflect the negative returns for them. With a meta-analyses of post-acquisition performance (King, Dalton, Daily, & Covin, 2004), it is indicated that those acquiring firms' performance does not change positively with the acquisition activity, but negatively influenced.

On the basis of foreign work, domestic scholars did further work in Chinese context. Most researches with Chinese listed companies confirm to the findings of positive returns. However, the samples chosen by domestic scholars are mostly by the end of 2006, which is a little bit earlier.

In terms of the factors affecting the cross-border M&As abnormal returns, taxation, target home country characteristics, acquirer industry characteristics, and acquirer and acquisition features all stay therein(Markides & Ittner, 1994). This findings are consistency with what Morck et al. (2008) have found.

As a result, it is proposed that:

H1: the cross-border M&As can bring the Chinese listed companies positive effect.

2.2 Knowledge acquisition and innovative capability

It is from 1978 that the Chinese private firms began to step onto the stage of history and national economy. During the 30 years, private firms are confronted with kinds of difficulties from the regulation power, capital disadvantage, governance, etc.. The entrepreneurs, however, gradually show their leadership and foresight in building their firms' capability.

Since X. Li (2011) examined the effect from the source of external technology on innovation capability in Chinese State-Owned high-tech enterprises, the result indicated that the importing foreign technology, with the help of in-house R&D, can facilitate innovation. There's a certain number of scholars confirmed this relationship between in-house R&D and external technology acquisition (Aggarwal, 2000; Braga

& Willmore, 1991; Deolalikar & Evenson, 1989). Further, without the in-house R&D, foreign technology didn't positively impact Chinese medium and large size firms in stimulating productivity(Hu, Jefferson, & Jinchang, 2005). Such situation is similar in developed countries (Arora & Gambardella, 1990; Cassiman & Veugelers, 2006; Lokshin, Belderbos, & Carree, 2008). It is also suggested that Forming international joint ventures (IJVs) with MNCs from advanced economies as an organizational approach to building up their innovative capabilities(J. Li & Zhou, 2008)

With the globalization trend, the domestic market and resources are confronted with difficulties to meet the demand of organic development. That's an important reason for the MNCs in emerging countries to emphasize the international expansion and regard it as springboard to obtain strategic asset and reduce the restriction from the institutions(Deng, 2009; Luo & Tung, 2007).

For this, the hypothesis can be proposed as following:

H2: the cross-border M&As can improve the Chinese listed companies' innovative capability.

3. Methodology

3.1 Method

The present study aims to adopt the methodology common to financial research, namely event study. Through the response on the stock market, we can have a picture about the basic trend and change of the activity.

For this, we especially select the enterprises with greenfield investment as comparison sample in the same time period. The sources of this article data are obtained from the website of the Shanghai Stock Exchange (SSE), Shenzhen Stock Exchange(SZSE) website, the CSMAR database as well as the Ministry of Commerce database. To process the data, Excel and SPSS software is adopted.

(1) The definition of event

We define the listed companies' decisions to make outward direct investment as the event. Usually for listed companies, such major issues notice will be announced on the company website to enable investors to acquire information. As the samples are collected from the A share stock market, so regard the CSI 300 index as the benchmark index for calculation of the normal rate of return. If the sample company is suspended during the estimation window or the event window, the standard market rate of return will be regarded as the sum of rate of return during and one day after the suspension.

(2) The event window and the estimation window

We select short-term event window (-5, 5) as the event window; select 105 days before to 1 day before the event day (-105,-6) as the estimation window.

(3) The research procedure

According to CAPM, we calculate the relationship of daily rate of return between market and sample companies.The formula is as follows:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \quad \text{..................} \quad (1)$$

R_{it} is the amount of change of stock i on day t, and R_{mt} is that of the Market index on day t, with ε_{it} as the random error.

According to daily market rate of return of event window,we calculate the daily rate of return of sample companies. We can get the daily abnormal return with actual yield minus the normal rate of return. That is:

$$AR_{it} = R_{it} - E(\widetilde{R_{it}}) = R_{it} - R_{mt} \quad \text{..............} \quad (2)$$

AR_{it} is the abnormal return of stock i on day t, $E(\widetilde{R_{it}})$ is the normal return of stock i on day t according to the market model.

The average of daily abnormal return of sample companies is AAR, that is:

$$AAR_t = \frac{1}{N}\sum_{i=1}^{N} AR_{it} \quad \text{..........................} \quad (3)$$

We examine the AAR whether they are significantly different from zero with t-statistic test.

On the other hand, to represent the innovative capability, the patent statistics during the period from 2005 to 2011, are adopted. With this data, the trend of the innovative capability development can be described. Furthermore, regarding the event as a strategic point, it is also possible to compare the situation before and after this event.

3.2 Sample

2005 was a landmark year for China's capital market. The stock equity division reform that began in 2005 brings fresh air to the stock market, “same shares same rights" could promote the stock market playing an effective role in the allocation of resources, but also better reflect the extent of the reaction of market events. Because of this, in order to exclude the impact of stock equity, the samples are selected in the A-share market which had completed the shares reform in 2006.

We regard the first announcement of M&A (and greenfield investment) as the event. Therefore, if related transactions exist in the listed company announcements and the transactions is the main content of the announcements, the company published the announcements maybe included in the sample set.

These samples also need to meet the following criteria, or they will be excluded:

(1)Due to the differences between financial enterprise accounting system and general enterprise accounting system, the samples consist of non-financial enterprises;

(2) There are 106 trading days before announcement date for the listed companies;

As this study examine the effect of foreign investment announcement, we should avoid publishing announcement having a significant impact on the company in the event window, such as annual reports, semi-annual, quarterly and other periodic financial reports as well as other announcements affecting investors' judgments..

After searching in the SSE and SZSE website with the key words like “acquisition”, "joint venture", "foreign investment", and "M & A", finally 52 samples is obtained, with 20 of them cross-border M&As, the others greenfield investment .

4. Results and discussion

4.1 market effect

Time window	Total AAR	t	Cross-border M&A AAR	t	Greenfield investment AAR	t
-5	-0.465	-1.325	-0.646	-1.443	-0.347	-0.684
-4	-0.394	-1.116	-0.292	-0.858	-0.278	-0.508
-3	-0.259	-0.815	-0.711	-1.718	0.023	0.052
-2	0.032	0.086	0.544	0.920	-0.183	-0.361
-1	0.638	1.419	0.968	1.292	0.255	0.444
0	0.233	0.531	0.775	0.994	-0.074	-0.138
1	1.178	2.168	2.089	2.072	0.351	0.552
2	-0.256	-0.771	-0.830	-1.487	0.073	0.176
3	-0.200	-0.649	0.070	0.133	-0.228	-0.582
4	0.467	1.086	0.237	0.427	0.373	0.604
5	0.383	1.141	0.573	0.951	0.156	0.387

Figure 1 the wealth effect of both cross-border M&A and greenfield investment

From the data of this study, we can see that when the announcement is introduced at day 0, there is a slight fluctuation in the stock price but not significant, while in the first day after that, the stock price rose significantly and the market effect is significantly positive, although at the rest of the time accompanied by certain fluctuations. As a result, it is possible to indicate that the market did not react in time to the foreign investment in listed companies’ announcement. There exists a certain lag effect, which to some extent reflects the lack of market effectiveness. This anomaly existed in the market, and we attempt to use the behavioral finance theory to interpret it, namely, the gradual diffusion effect of message. It means that the market reaction to new information is gradually released. When the good news is published, investors are so skeptical and hesitated that the stock price cannot totally response to it, leading to an inadequate response to the announcement. As an emerging market, the development of China's market is not so mature that investors can not completely rationally analyze the market news and are unable to make it clear that whether the market news is good or not. Also there is often a conservative ideas and attitudes when investors making investment decisions. These factors lead to a fact that the announcement effect doesn’t influence the whole market and will postpone the effect. The Chinese investors may have a better understanding of outward direct investment (ODI), but may not know much about the “go global” strategy and show a more conservative attitude to the judgment of the announcement.

Regarding of entry mode, among developed countries, direct investment is usually in the form of cross-border mergers and acquisitions. Overseas greenfield investment for domestic companies in China, establishing a new wholly-owned company or a factory is always kind of have the shortcomings like long duration to make it practicable, and slow effect. For most enterprises, cross-border M&As can greatly shorten the investment cycle of the project, and can directly obtain the original resources owned by the company being acquired, and can reduce the foreign direct investment market risk to some extent. Therefore, it can be said that cross-border M&As is a more popular and more convenient way to investment, therefore the China market also has a more intense reaction over cross-border mergers and acquisitions.

On the whole, the ODI announcements near the announcement period will indeed bring positive effects to listed companies, and the effects cross-border M&A announcements brought is stronger and more significant than that of Greenfield. Therefore the H1 is supported.

4.2 Innovative capability

To illustrate the M&A innovative capability development, it is applicable to present the trend of M&A acquirers with patent statistics during the period from 2005 to 2011. The first step is deleting those examples with no patent statistics for so long a time.

We can directly find the statistics changing mode for every company, from the table. It seems that, most of the sample companies are not influenced by the M&A activity. More than half of them have to face the declining trend, which goes against the common belief. However, it should be taken into account that the end of the time period is too close to the current research, which will lead the long-run effect concealed or suspended. Nevertheless, for some typical cases, there still exists an upward trend. It is very impressive for such phenomenon. In this perspective, H2 is supported partly, and not very significant.

	2005	2006	2007	2008	2009	2010	2011
C1	445	579	503	**334**	**274**	**251**	133
C2	3	6	11	**22**	19	6	1
C3	27	20	43	79	141	**175**	80
C4	1	1	0	0	**0**	6	6
C5	24	27	**66**	79	81	71	16
C6	4	0	8	13	9	**5**	1
C7	2	1	0	0	**0**	0	0
C8	2	8	33	64	69	**72**	40
C9	11	12	11	7	**14**	41	28
C10	0	0	0	2	2	**5**	5
C11	6	6	9	**11**	6	0	0
C12	4	33	46	34	31	**37**	32
C13	0	0	0	0	0	**2**	2

Figure 2 the patent statistics of selected company samples

Note: The bold numbers reflect the year that M&A activities take place

5. Conclusion and limitation

With the event study, we can draw a conclusion that in emerging countries, the ODI activities will exactly bring the acquirers benefit of growth, especially the M&As, which is also noticed by a lot of companies and making them into practice. That's why more and more companies choose this mode to go abroad to improve their capability. From the evidence of certain companies, it can be inferred that the innovative capability is gradually built with the absorptive capability in time.

However, the drawbacks are still revealed. For example, the sample size is limited as the time period is short. And the current study is focusing on the market effect too much, which needs to modify in the future.

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Institution, Innovation, and internationalisation: A study of outward foreign direct investment of Chinese telecommunication equipment manufacturers

Yue Tina Xu

For all correspondence: Dr. Yue Tina Xu, Hull University Business School, Cottingham Road, Hull, HU6 7RX, the U.K., E-mail: y.xu@hull.ac.uk.

(Acknowledgement: The study thanks Da Lei for his effort in helping organising case and industry information.)
Da Lei, Macroeconomic Researcher, Special terminal department, Shanghai Great Wisdom Co., Ltd., China, E-mail: Email: walter.lei@outlook.com

Abstract

This study explores the formation of outward foreign direct investment (OFDI) decisions of the Chinese telecommunication equipment manufacturers. Drawing insights from the institutional perspective and argument regarding the role of innovation in global value chain integration, and the tradition theory of foreign direct investment (FDI), the study attempts to identify indigenous factors that influence the OFDI decisions and firms' competiveness. The results show both similarities and differences in OFDI decisions in terms of motive, mode and location choices by three leading firms, they are: Huawei Technology Corporation (Huawei), Zhongxing Telecom Equipment Corporation (ZTE), and Fiberhome Telecom Technology Corporation (Fiberhome). This expletory study provides additional attempt to evidence how multiple perspectives need to be adopted for identifying antecedences behind OFDI decisions of emerging market enterprises (EMEs). The primary findings help us to draw managerial and policy implications.

Keywords: OFDI, Institution, Global value chain, Innovation, China
Paper type: Exploratory multiple case studies

1. Introduction

The fast development of the outward foreign direct investment (OFDI) from emerging market enterprises (EMEs) has attracted tremendous research attention over the past decade. The emergence of such Chinese firms as Lenovo, Huawei, Gilly and Haier reveals a lasting determination of EMEs in catching up with their developed countries' rivals. Their route of internationalisation seems to challenge the conventional views on the weak competitiveness of EMEs. Yet, the conclusions concerning antecedences of their competitiveness vary greatly. Some studies suggest EMEs as serious players are able to challenge firms from developed countries (Demirbag *et al*., 2009; Luo and Tung, 2007). Others doubt the long-term competitiveness of these firms hence the seriousness of this claim has been exaggerated (e.g., Collinson and Rugman, 2007). Along this line of debate, this study aims to explore contextual conditions to better understand the sources of decisions patterns and competitiveness of EMEs.

While the need for indigenous management research is beyond any dispute, there are currently very few studies that analyse concrete implications for discovering interesting and relevant research questions, theory building, and data collection (e.g., Tsui 2004; Cheng *et al*., 2009). Numerous empirical studies on the Chinese OFDI already suggest the crucial influence of indigenous factors in shaping particular pattern of OFDI decisions (e.g., Buckley *et al*., 2007; Buckley *et al*., 2008; Boisot and Meyer, 2008; Child and Rodrigues, 2005; Luo *et al*., 2010; Morck *et al*., 2008; Yiu *et al*., 2007; Ramasamy *et al*., 2010). These studies, however, either address macro or micro related factors. In comparison, the industry-specific context as well as the interacting effect among factors at different levels has been largely ignored. Within our limited research capacity of this paper, we decide to put more attention on the study of contextual fabric of the home country-based conditions first. Our questions as: ***How do home country indigenous factors determine OFDI decisions patterns and competitiveness of Chinese multinationals?***

2. The development of Chinese telecommunication industry

The telecommunication industry in China achieved rapid growth during the last two decades. It is has been chosen as the research setting for this study. There are several studies on the telecommunications industry in China from diverse perspectives (e.g., Yam *et al*., 2004; Mu and Lee, 2005) but with less focus on OFDI decisions. This session reviews the development of the industry in three sub-contexts, these are: institutional changes, integration with global supply chain, and development of leading firms. The review highlights the fact that factors at the macro, industry and micro levels may co-exist and influence OFDI decision patterns and potential competitiveness.

2.1 Institutional changes

Chinese telecommunication industry has experienced three key stages of institutional changes over the past decades. Stage 1 (1949-1997) is regarded as the monopoly period started with the establishment of the China Ministry of Posts and Telecommunications (CMPT) in 1949. In this stage, CMPT vertically controlled industrial activities via strict regulations in many aspects. Although economic reform in 1978 promoted more market-oriented policies for the industry, the dominating position of CMPT and its influence remained. As a result, manufacturers, operators and end users forming a simple value chain in China.

Stage 2 (1998-2001) underwent remarkable institutional reform. During this period, China combined the Department of Electronic Industry and Department of Posts and Communication together to be the Department of the Information Industry. This action aimed to manage the telecommunication industry more effectively. In 1998, the Ministry of Information Industry Technology (MII) was later set up to take over the regulatory function of CMPT. In 1999, China's State Council approved the telecommunication reform program under which China Mobile Communication Corporation was established. This reform was followed by the entry of more players[1] into the competition.

Stage 3 (2002-present) evidenced further restructuring of the industry (see Figure 1). For example, in 2002, China Telecom was split into two major carriers; they are the Southern Telecom and the Northern Netcom. China State Council allocated nine provinces and Beijing

[1] This is the beginning of a series of major reform measures in telecommunication sectors. Meanwhile, China Satellite Communication Co. Ltd (China Satcom), China Network Communications Group Corporation (China Netcom), China Jitong Network Communications Co. Ltd (China Jitong), China Railway Communication Co. Ltd (China Railcom) and other several telecommunication operators were founded in this period. At this stage, China's telecommunication industry entered into a real competitive stage.

city to China Netcom and the operation of 21 southern provinces to China Telecom. In 2008, six telecommunication operators were consolidated further into three corporations; they are China Telecom Group, China Unicom Group and China Mobile Group. These operators all set up full-service for the fixed, mobile and broadband users and gradually established their own networks and services at the national level.

2.2 Integration with global value chain

Based on the OECD report (2011, pp.358), China has become the top communication equipment exporter in the world. As Chinese domestic value chain evolves firms become more specialized and more integrated into the global value chain network. In a more developed value chain (see Figure 2), more specific value-added activities are developed. The primary upstream suppliers can be telecommunication equipment manufacturing related raw materials, the electric, steel, plastic, also primary products such as the chips, electronic components and the software to help to manufacture the telecommunication equipment.

The equipment manufacturers develop into systems equipment manufacturers and terminal equipment manufacturers. Systems equipment manufacturers provide base station equipment, switches, routers and other system network equipment; terminal equipment manufacturers provide users with telephone, cell phone, adapters and other devices. By products, they can provide traditional telecommunication operator carrier network equipment (fixed and exchange network, transmission network and mobile internet devices), traditional communication terminals (mobile phone), and WideBand data network (including routers products and other products (fixed line terminals).

The products reach to the end users thorough the telecommunication operators or directly reach to the end customers via agents. Network operators occupy crucial position in the value chain. They gain benefit via their own client resources, brand reputation, network strength and network supporting systems. Their competitiveness comes from distinctive value-added services or applications for customers. This may include the operation and maintenance of mobile transmission network, service to maintain network quality. In addition, operators take responsibilities for providing customers with web portal, personalized management and adaptive equipment and data.

2.3 Development of key equipment and service providers

The global market telecommunication equipment industry is still dominated by firms from the developed markets. These include Cisco, Ericsson, Alcatel-Lucent, Nokia Siemens Networks, Juniper Networks and Motorola. They are all the strong competitors to the Chinese telecommunication equipment firms in both Chinese markets and overseas markets. However, the following three Chinese equipment providers draw our attention by their global integration progress.

Huawei Technologies Corporation (Huawei) was established in 1988 in Shenzhen, China’s special economic zone, as a 100% employee owned private enterprise. It is a leading global telecommunication solution provider. Its business includes mobile, broadband, IP, optical networking, services and terminal fields. Huawei committed to provide converged solutions that enable its end users to enjoy the same communication experience at anytime, anywhere via any terminal equipment. Huawei's products and solutions already developed in over 100 countries and served for 45 of the World’s top 50 operators, along with over two billion users worldwide (Huawei, 2010).

Zhongxing Telecom Equipment Corporation (ZTE) was established in 1985 in Shenzhen. ZTE is China's largest listed telecommunication equipment company in Hong Kong and Shenzhen (ZTE, 2008). State-owned enterprises control 51% stock share of the firm, while private equity accounted for 49 %. ZTE is owned by the government but operated by private individuals. It is one of the leading companies providing integrated communication solutions to more than 140 countries and regions. Its business includes innovative technology and product solutions for telecom operators, and provides voice, data, multimedia and wireless broadband for users worldwide.

Fiberhome Telecommunication Technology (Fiberhome) was established in 1999 as a fully state-owned telecommunication equipment enterprise. As one of China's leading communication equipment and network solutions providers, it focuses on solution development of communication network access. It is also a major Chinese network infrastructure provider; its product covers optical network, optical cable and broadband optical access, with leading market share in most segments. It has been involved in developing China's national standards and industry standards through over 200 projects. Fiberhome represents successful state-owned enterprise in expanding international market. It already set up over 10 overseas offices, and its product entered into more than 60 countries and regions.

3. Theoretical background: OFDI decisions and competitiveness

3.1 Motives

The motives of internationalisation have been extensively explored in theory. For example, Hymer (1976) suggested three key motives for firms to internationalise: to exploit competitive advantage, to diversify and to neutralize competitors. Bartlett and Ghosal (1989) suggested that efficiency seeking, the increase of responsiveness and leverage of knowledge are the major motives. Dunning (1993) drew upon previous studies and suggested four key motives, i.e. resource-seeking, market-seeking efficiency-seeking and strategic asset-seeking motives. Studies on firms from the developing economies (e.g., Wells, 1986; Teece, 1986; Lecraw, 1993) argued that the main motivation from these countries is to seek lower labor and material costs, to approach new market and to save transportation costs. Deng (2004, 2007) believed that motivation of China's OFDI is mainly for obtaining strategic resources, access to technology and management skills.

A dominant assumption in analyzing motivations of internationalization is that enterprises already possess certain advantages such as technology and product knowledge. In other words, the motives of these firms are in using existing advantages to meet the needs of foreign markets (Dunning, 2006). However, Child and Rodrigues (2005) suggested that compared to the mainstream theory of foreign direct investment (FDI), competitive advantage may not be the prerequisite for Chinese enterprises to invest overseas. They argued that the main purpose of Chinese OFDI players is to form competitive advantages. As revealed by the report from UNCTAD (2006), multinational companies from developed countries usually conduct efficiency seeking foreign direct investment, but Chinese enterprises investing abroad in order to seek market and strategic assets.

Louis (1983) proposed the theory of small scale technology, and he believed that the competitive advantages of multinational corporations in developing countries are mainly threefold: small scale production technology for small markets, advantages of national product in overseas and low-cost product marketing strategy. A key idea behind this argument is that even the technology is less advanced, and firms have smaller business scope, enterprises from developing countries can still possess competitive advantages in certain regions if they could specify their motives based on their advantages. In line with this argument, some scholars suggested ownership-specific advantages of Chinese firms mainly derive from their network (Morck *et al*., 2008; Buckley *et al*., 2007) and based on the home country (Rui and Yip, 2008; Rugman and Li, 2007). Such advantages tend to disappear once firms move their operation out of the home country. This is because unlike other factors of production, institution-based factors tend to be internationally immobile (Mudambi and Navarra, 2002).

3.2 Location

Dunning (1988) pointed out location advantages determine whether investing enterprise may benefit from low cost and risks under the host country's government policies and social culture. This means, for each value adding activity, managers have the choice of either keeping the activity at home, or locating it in a foreign country or replicating it. Enterprises can adapt and use location-specific advantages in two aspects: one is host country's immovable factors such as abundant natural resources, geographical location and convenient; the other is host's country's political and economic systems, such as favorable conditions and good infrastructure. For the latter, host country institutional conditions relative to the home country institutional conditions may have determining impact on the cost of value creation.

Linking the above argument with the institutional perspective (North, 1990) it is believed firms' strategy is shaped by the home institutional environment which is formally and informally enforced by government and its agents (Scott, 2002). This is why institutional differences determine unique advantages of enterprises from different countries (Peng *et al*., 2008; Meyer *et al*., 2009). However, such non-market advantages receive little attention in past literature (Cuervo-Cazurra and Genc, 2011). Porter (1980) argued that operating internationally requires firms to determine where to locate value chain activities in different markets and also to decide how to link these activities; this process requests continuous configuration of value creation activities which may vary along a continuum from centralized to decentralize, hence identifying specific advantages or disadvantages.

Obviously, different motives require totally different locational needs (Dunning, 1998). Dunning (2009, pp.22) argued the main location advantages of countries at the earlier stage are 'their possession of natural resource and/or of low cost labour'. With the accumulation of overseas experiences, the impact of locational factors on firms' advantages gradually decreased and OFDI may extend to other developing countries. Finally, in order to obtain more advanced technology, firms begin to invest in developed countries. It is often assumed that EMEs tend to select locations that resemble their home market institutional conditions. In this way, they are able to better integrate ownership-specific conditions with location-specific advantages.

3.3 Mode

The choice of foreign market entry mode has been investigated in literature from different angles and also with different and contradicting results. Multinational companies have firms-specific assets, namely, specific ownership advantages. When these specific assets trade across organisational boundaries, transaction costs occur whether it is in the market or organisations (Johanson and Vahlne, 1977). With this argument, entry mode choice has to meet the objective of minimizing transaction costs and maximizing the effectiveness of long-term risk adjustment (Hymer, 1976). The process of making OFDI decisions is to balance the degree of control and resource commitment.

Okoroafo (1997) held different view from Johnson and Vahlne (1977) and believed firms choose foreign market entry modes not with regards to an increasing knowledge in international markets but to the context of specific situation. For example, firms need to overcome host country's political and cultural obstacles, so establishing joint ventures with local partners can be preferred. A joint venture can make the parent company get less discriminatory treatment by the host government, and in this way companies can better adapt to local culture through local partners (Meyer, 2001; Yiu and Makino, 2002). In case FDI involves more proprietary assets or there is a higher probability of opportunistic behavior, then an entry mode with a high degree of control needs to be considered (Gatignon *et al*., 1988; Gomes, 1989; Hennart, 1991). Okoroafo (1997) concludes that a non-incremental or zigzag foreign market entry mode patterns can be usually observed in empirical investigations.

The above argument challenges the view that path of internationalisation follows an incremental process (Johanson and Vahlne, 2006). For example, Mayrhofer (2004) reviewed 26 empirical studies on foreign market entry modes and found that nationality of firms tend to have an impact on the choice of the foreign market entry mode. Such non-market factors add complexities in decision-making. A particular entry mode is chosen because the decision can be subject to regulatory and ethical constrains, as well as firms' different degree of dependence on environment and resources (DiMaggio and Powell, 1983; Meyer and Rowan, 1977; Meyer, 2001).

4. Research Design

In order to understand how OFDI decisions are formed, we adopt exploratory case study method at this primary stage of research. Yin (1984, pp.23) defined case study as 'an empirical inquiry that investigates a contemporary phenomenon within its real-life context'. We select three leading telecommunication equipment manufacturers for our primary exploration. They are: Huawei, ZTE, and Fiberhome. Multiple data sources including annual report, official released material, official website and existing academic research literatures, as well as official data were collected. These three firms were chosen as they have grown quickly in the past twenty years transferring from small firms into large multinationals (see Table 1).

5. Cross case comparison of OFDI decision patterns

5.1 OFDI driven by innovation performance in domestic market

The three cases show that successful experience and performance in domestic market drives their overseas expansion. All three firms show strong intention of seeking larger market share, cost reduction and strategic assets both in domestic and international markets.

Huawei: The firm initially occupied remote rural and low-end markets which are not interested by its international competitors (Rui and Yip, 2007). In 1990, Huawei invested its entire profit into research and development (R&D) to develop its own telephone switches. Its first digital switches product-HJD-48 was based on a mixed effort of imitation and innovation. Although most of the import digital switches in China sold more than 200 dollars per line, Huawei decided to sell HJD-48 less than half of the average price. This strategy made HJD-48 one of the best-selling digital switches in China at that time (Xing, 2005). This strategy allows Huawei to achieve economies of scale and brand recognition.

ZTE: The firm's achievements were also based on its self-developed products succeed in the domestic market. In 1990, ZTE developed the first digital program-controlled exchange equipment-ZX500 with independent intellectual property rights. The success of ZX500 provides ZTE with stable source of income. ZTE then invest capital in the development of new digital switching system, and develop ZX500-A, which is perfectly applicable to the telecommunication market in rural area. ZX500-A not only has low-cost advantage compared to foreign suppliers, but also fully meet the needs of rural end equipment. In 1993, the program controlled switch-ZXL2000 lead ZTE to a further success in domestic market. By the end of 2011, the installed base accounted for 18% of the whole market of new products (include foreign products) in rural area.

Fiberhome: Success in domestic market is also found in the case of Fiberhome. Its major products such as optical network and optical cable were fully accepted by major telecommunication operator; its 40G DWDM product have been successfully adopted nationally. Fiberhome becomes the world's top ten manufacturers of fiber optic cable line which strengthens its position as major telecom equipment suppliers. Meanwhile, in the international market, Fiberhome also achieved success in cooperating with major multinational telecommunication operators such as Telefónica, Telecom Italia and Telecom Malaysia Berhad. Its network and service system have been fully radiated in Africa, South America, Middle East and other areas (Fiberhome, 2010).

5.2 OFDI started from the developing markets first

Although at different stages of internationalisation process, Huawei, ZTE and Fiberhome have different choices of foreign markets their presence in global market follows a similar geographical route. At the initial stage, they all entered into locations relatively easy to operate. Their internationalisation processes show that they all choose African and/or Asian countries as their primary foreign markets. For example, Huawei's first step is Hong Kong and Russia; ZTE's initial choice is Bangladesh and Pakistan; Fiberhome started from India and Indonesia. These countries and regions either have established strong political relationships with Chinese government, such as Pakistan and African countries, or have close geographical distance, such as Hong Kong and Russia.

All three cases evidence the importance of accumulating international experiences and technological capabilities when they operate in the developing countries. This finding is in line with the argument by Child and Rodreigues (2005) that Chinese enterprises have no competitive advantage or just have advantages in certain parts. Before fully entering into developed markets such as Europe and North America, Huawei and ZTE have participated into developing countries' business for around ten years; in comparison, Fiberhome remained most of its overseas business in those developing markets still.

At the developing stage, Huawei and ZTE entered into developed market seeking growth opportunities and advanced technology. Taking Huawei's R&D center in the Silicon Valley as an example, the cluster of high-tech enterprises in the Silicon Valley facilitates Huawei with the access to advanced technologies and R&D resources. These strategic assets are not available at home country or in other developing market. The decision allows Huawei to obtain technological information in the host market. This finding is in line with Lecraw's (1993) view that firms from developing countries invest in developed countries to obtain advanced technology and seek large markets after they accumulate sufficient experience in developing countries. In comparison, Fiberhome seems moving slowly in acquiring technology through OFDI in developed markets.

5.3 OFDI facilitated by multiple choices of entry modes

All three cases show that exporting is the common strategy to enter into foreign markets. They all choose to start their business from exporting. The characteristic of exporting is low-risk with fast market access.

Strategic alliance such as R&D alliance is the common entry mode choice for all three cases. For example, since 1997, Huawei has established joint R&D centers with international giants such as Motorola, IBM, Intel and Altera. Meanwhile, ZTE cooperates with high-tech firms such as Sprint Next to improve its technology capacity. Fiberhome R&D is based on government research projects. It is looking for opportunities to cooperator with world leading telecommunication firms to improve its research capability (Fiberhome, 2009). As Li, (2003) and Mathews (2006) described alliances provide platforms of acquiring advanced technology.

Huawei, ZTE both have chosen joint ventures to improve efficiency of internationalisation process. For example, in 1997, Huawei encountered difficulties in attracting customers by itself. It formed a joint venture with Umberto Konzern Telecom Company. In comparison, Fiberhome still relies mainly on exporting to expand new market.

6. Analysis: impact of home country indigenous factors

6.1 Institutional factors

Institutional conditions introduce competition pressure, preferential policies, and also future uncertainties in the Chinese telecommunication industry. Against the same institutional environment, the three firms respond with different strategic choices in terms of motive, location and mode choices, resulting in different competitiveness.

First, liberalization policy changes competition landscape of China's telecommunication market which introduced immense competition pressure to the domestic players. On one hand, international communication equipment giants carved into Chinese domestic market injecting great competitive pressure on domestic firms. On the other hand, domestic telecommunication operators, due to their monopolistic position have strong bargaining power in the value chain.

As the result, Chinese domestic telecommunication equipment manufacturers have to pursue oversea markets. As demonstrated by the three cases that they are highly driven by market-seeking motive.

We also note that Chinese government provided favorable policies and subsidies to enhance competitiveness of domestic telecommunication industry. The 1990s is the golden age of China's telecommunication industry. From 1991 to 1999, the industry has a revenue growth rate of 2050 per cent, contrasting to a 375 per cent growth rate of the postal industry (DeWoskin, 2001). Huawei is the typical case that successfully seized these unprecedented opportunities with rapid growth. In 1996, its annual revenue is 2.6 billion RMB, which almost 26 times its revenue in 1992.

Such strong government intervention cause potential institutional uncertainness. For example, in 2002, Huawei's total sales revenue dropped sharply from RMB 25.5 billion in 2001 to RMB 17.5 billion. One of the key reasons for the change was due to the second restructure of Chinese telecommunication industry. In 2002, China Telecom and China Netcom separated and in this year all large-scale investment projects by telecommunication operators slowed down. The telecommunication investment in fixed assets in 2001 is RMB 264.1 billion, but in 2002 this investment figure just reached to half of the investment in 2001(Xinhua net, 2002). To avoid institutional uncertainties, Chinese domestic telecommunication equipment manufacturers have to pursue oversea markets. As demonstrated by the three cases that Huawei is the most active player in OFDI, arguably, part of the reason is that the firm is privately-owned and potential less protected by the government compared with the other two firms.

6.2 Innovation capability

The process of integrating into global value chain reflects whether and how firms achieve competitiveness in global market through enhancing their innovation capability. All three firms keep investing in R&D to upgrade their position in domestic value chain first and then promote further integration at the global level.

Huawei: The firm shows strong commitment to R&D. In 1992, Huawei launched the first large-scale digital program-controlled switches, which was based on independent design and development in China. In the same year, Huawei's revenues reached 100 million RMB. Huawei then decided to re-invest profit into the R&D to develop C&C08, which was the key product helping Huawei established its leading position in China's telecommunication equipment market (Huawei, 2008). Huawei's low-cost advantage is implemented in R&D cost strategy. The average cost of Huawei's R&D employee is about 25,000 dollars per year, much lower than 120,000-150,000 dollars per year by its European competitors. In addition, Huawei's quick response to new technology and customers' request usually cost about three months while many other international competitors need about one year. When bidding in Louis Dreyfus Group Communications' (LDCOM, France) project in 2003, Huawei's solution was just 2/3 of time spent by competitors' plan. Huawei now called it information and communications solutions provider, and possess innovation capabilities to meet specific needs of different customers.

ZTE: The firm shows less independent R&D capabilities but no less committed in pursuing technology breakthrough. It is innovation effort moved from the low-end products to the high-end products. At the beginning, ZTE just exported traditional equipment such as switches, access network and video products; now it focuses more on the high-end products like 10G EPON equipment and CDMA products. It also pays much attention to investing in innovation and R&D with 15 R&D centers established worldwide. For example, to obtain the software technologies in India, ZTE sets up a research center and builds its technical base. In developed countries markets, ZTE prefers to cooperate with local telecommunication operators and provide communication solution in order to launch its products into those markets. For example, in 2007, ZTE became terminal equipment providers when cooperating with Vodafone, Telefonica and Telstra.

Fiberhome: The firm may show less commitment in establishing its own innovation capability, but it also keeps accumulating international experience by providing integrated service-based solution. For example, Fiberhome's IBAS equipment was successfully adopted by Indonesia's network project. In 2002, the optic cable of Fiberhome won the bidding of national trunk line in Myanmar and Iranian. In the same year, Indonesia selected Fiberhome's optical transmission equipment for its national electric power. In 2003, Fiberhome signed a contract with Bhutan Telecom and committed to construct Bhutan's first national SDH main line. Fiberhome was responsible for the whole sets of engineering services from design to opening and maintenance. In 2006, Fiberhome committed to build Ethiopian's first city optical network and provide high-end optical network equipment such as FonsWeaver780. This time Fiberhome beat several international telecommunication leading firms to compete together. Its success was marked a breakthrough in African market. For the high-end telecommunication markets, Fiberhome has cooperated with major multinational operators such as Vodafone, MTN and Telecom Italia, gradually shifting from its own network to the mainstream network in the global value chain.

6.3 Joint effect of institutional conditions and innovation capability on competitiveness

The three cases show that internationalisation path of Chinese telecommunication equipment manufactures co-evolves with institutional changes in the domestic market and their upgrading processes in the global value chain. We conclude their internationalisation process as in three stages: exploration stage, breakthrough stage, and further developing stage (See table 2). We found the timing of their foreign expansion correlated with key domestic institutional changes and innovation breakthrough as demonstrated by their overall performance (see Figure 3, 4 and 5).

This study shows that to understand the institutional changes we have to address the characteristics of specific industry in terms of its value chain structure and dynamics in competition. The three cases reveal the following industry-specific factors which may affect their integration processes with global value chain.

Capital intensity: In order to win larger market share and sustain future development, telecommunication equipment providers have to make huge investment in product development, marketing, service provision and new technology. Their success requires strong financial resources; otherwise it will be difficult to achieve growth and development in innovation capability.

Fixed customer base: There tend to be only few telecommunication operators in the industry. For example, there are only China Telecom, China Mobile and China Unicom as the main operators in China. They are the main customers of telecommunication equipment providers. Obviously, changes in their demand have the determining effect on the survival of equipment providers.

Oligopolistic market: Although competition in telecommunication equipment market is intense, compare with other industries, the industry tend to be highly concentrated. Regulators can have strong impact on the market entry barriers. As a result, certain large player, under the government protection, may manipulate competition and get the true competitive players out of the competition.

Frangibility to technology bottleneck: Telecommunication industry develops fast with the emergence of new technology and innovation. When certain technology becomes outdated, the demand for related telecommunication equipment can decrease dramatically thus introducing great impact on the survival of equipment providers.

The above characteristics request proper function of the government policy in creative health competition environment. Shenzhen special economic zone is the birthplace of both Huawei and ZTE. We recognize favorable policies provided by Chinese government to these firms. These include the permission of Huawei's private ownership and ZTE's private operating system. In early 1990s, Huawei and ZTE are the only telecommunication equipment manufacturers in domestic market (DeWoskin, 2001). The government encouraged telecommunication operators like China Telecom to give procurement contracts to Huawei, ZTE and Fiberhome. Huawei was in Chinese government's assistance projects in Africa and Asia. Through the close relationship with the government, these firms enjoy privileges such as bank loans and land. However, arguably, the negative effect of government preferential policies may reduce the incentive to build global competitors. The relative slow movement of Fiberhome, due to its state-ownership indicates this concern.

7. Conclusions

Chinese multinationals will undoubtedly be more involved in internationalisation process and become a key source of promoting world economic growth. Therefore, the study of internationalisation of Chinese enterprises requests development of theoretical view to explain existing development. In the context of telecommunication industry, this study explores three leading Chinese equipment and service providers. We found that these firms have different time length and varying degrees of internationalisation sharing similarities and differences in strategic response to institutional conditions and innovation development. Huawei and ZTE are successful cases and Fiberhome is relatively less developed.

One indigenous factor is the distinctive institutional conditions. A few operators formed the oligopolistic competition structure. Innovation capability is another indigenous factor in China. Due to the fast development of telecommunication technology firms need to build up innovation capability to support their survival and development. The study proposes an integrated view to identify antecedences behind the OFDI decisions hence projecting how competitiveness EMEs can be in a long-term competition.

The study is still at the primary stage. During data collection, since Huawei is not a publicly listed company, ZTE and Fiberhome both have government background; the officially released information may not be comprehensive. The next step of this study will focus on further data collection of OFDI performance and strategists at the firm-level. More theoretical effort is needed to suggest how different perspectives can be merged in an integrated theoretical framework.

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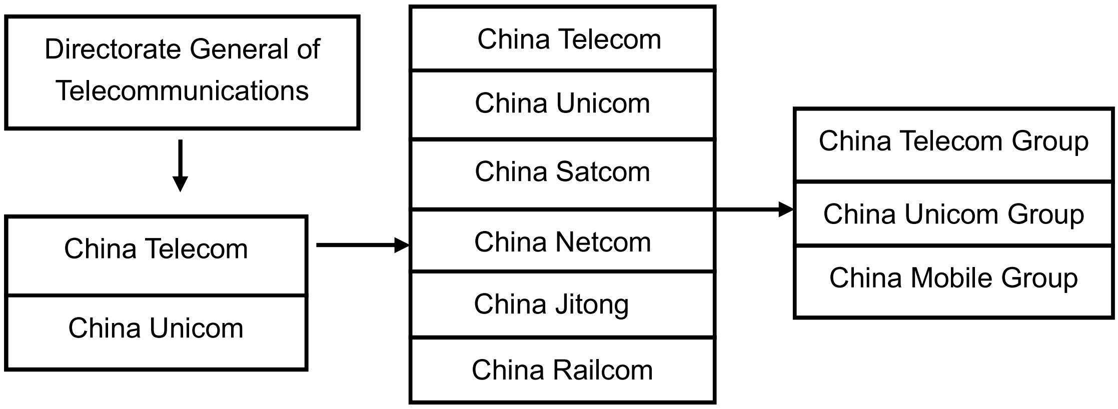
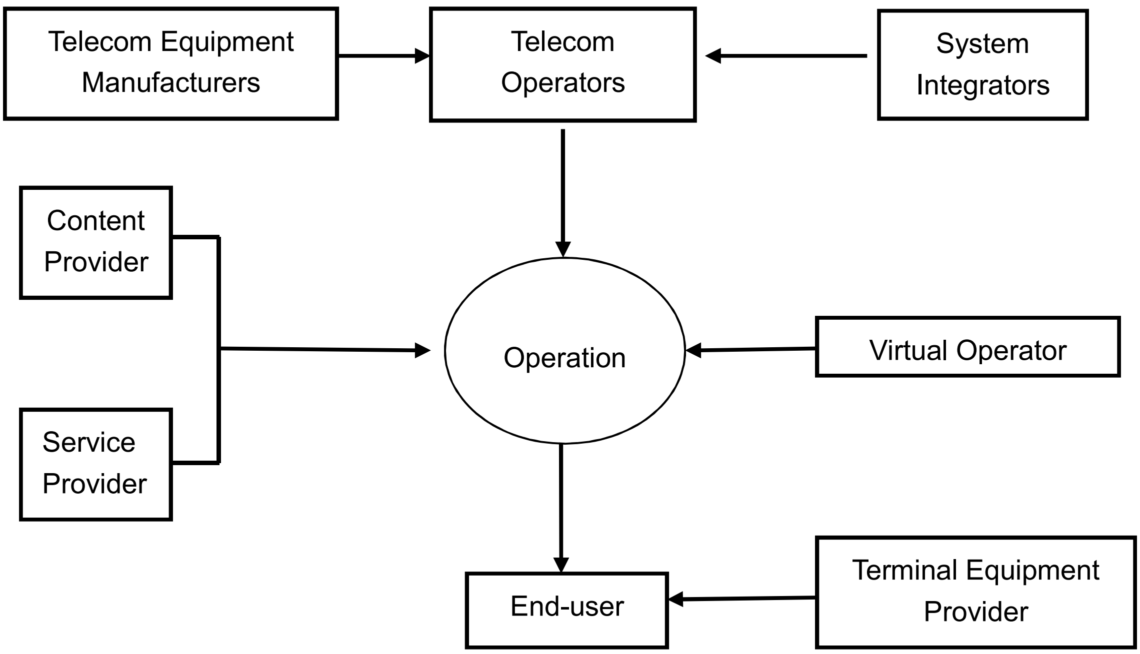
Figure1 Chinese telecommunication industry structure at the present



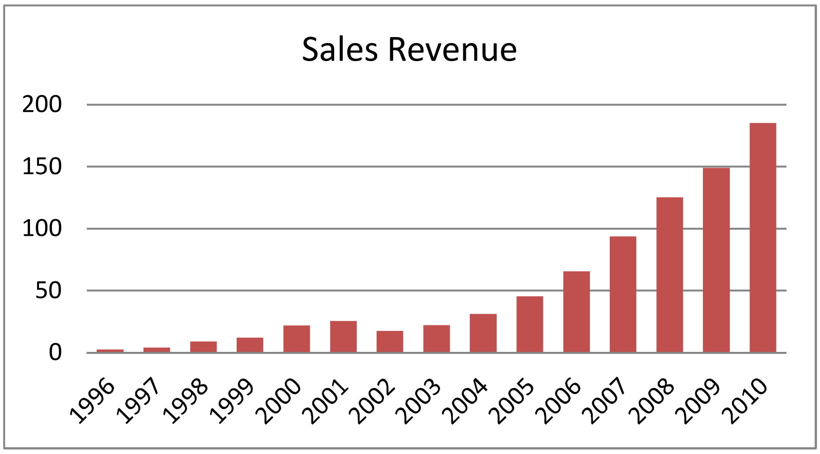
Source: Edited by author based on Zheng (2010: 283)

Figure 2 Value chain structure of Chinese telecommunication Industry at present



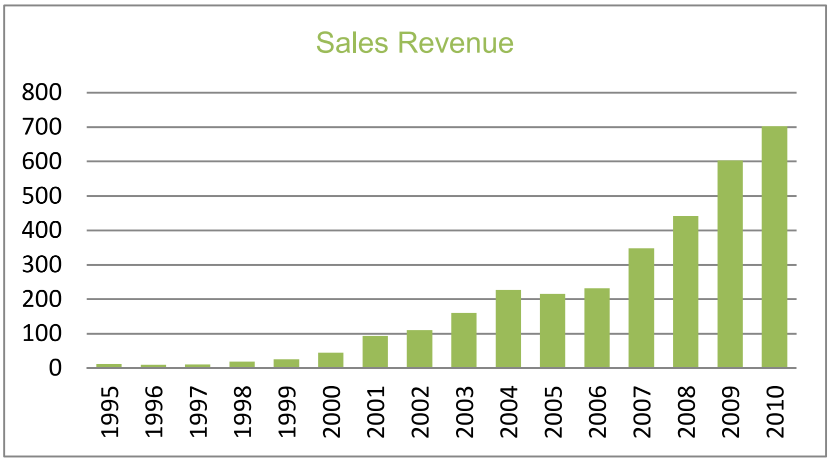
Source: Modified based on Wang and Zhao (2009:129-131)

Figure 3 Huawei sales revenue (1996-2010)



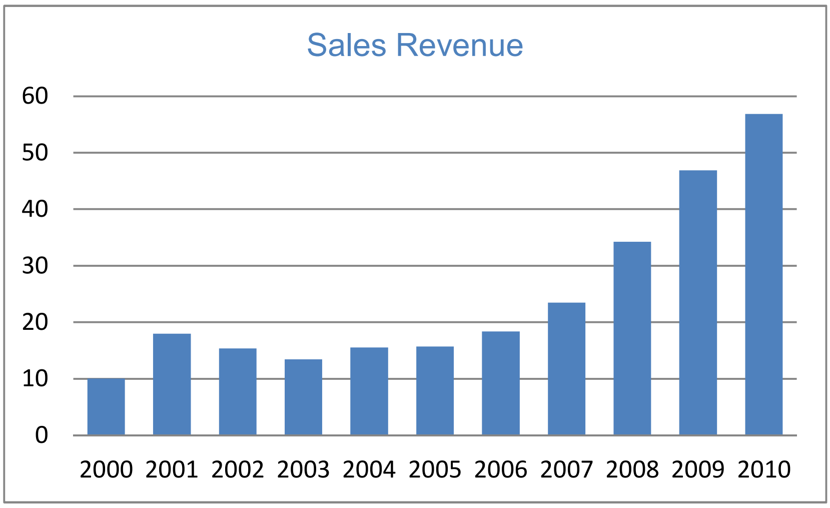
Source: Huawei Annual Report (1996-2010)

Figure 4 ZTE sales revenue (1995-2010)



Source: ZTE Annual Report (1995-2010)

Figure 5 Fiberhome sales revenue (2000-2010)



Source: Fiberhome Annual Report (2000-2010)

Table 1 Case profile

	Huawei	**ZTE**	**Fiberhome**
Establishment	1988	1985	1999
Ownership	privately-owned	state-owned but operated privately	fully state-owned
Current overseas presence (as of 2010)	22 overseas regional department, more than 100 branches, 17 research centers worldwide	15 R&D institutions worldwide (more than 30,000 domestic and foreign R&D staff focuses on technology innovation)	10 overseas offices and its product entered into more than 60 countries and regions.
Performance (as of 2010)	Total revenue 28.98 billion dollars	Operating income reached 70.26 billion RMB, in which the international operating income reached 38.06 RMB)	Operating income reached 5.58 billion RMB
Commitment to R&D world widely	N/A	30,000 domestic and foreign R&D staff focus on technology innovation, 1863 international patent applications	N/A
Industry position	World leading communication equipment manufacturers	World's fifth-largest telecom equipment manufacturers	Major telecom equipment suppliers nationally and internationally

Source: based on annual reports (1999-2011)

Table 2 Comparison internationalization process by stages

Case name	**Exploration stage**	**Breakthrough stage**	**Further developing stage**
Huawei	1996-1998	1999-2001	2002-present
ZTE	1995-1997	1998-2001	2002-2004, 2004-present
Figberhome	1999-2003		2004- present

Source: Concluded by the author based on annual report over years

Capabilities and competitiveness of Chinese state owned manufacturing enterprises: What has been learned over 20 years and what remains to be learned.

Kirit Vaidya and Matthew Hall
Aston University, Aston Business School, Aston Triangle
Birmingham B4 7ET, Birmingham UK,
k.g.vaidya@aston.ac.uk (corresponding author) and m.j.hall@aston.ac.uk

Jinsheng He
Tianjin University, College of Management and Economics, 92 Weijin Road, Nankai District, Tianjin, China,
jshe@tju.edu.cn

Xudong Gao
Tsinghua University, Department of Innovation and Entrepreneurship, Beijing 100084, China,
gaoxudong@sem.tinghua.edu.cn

David Bennett
Chalmers University of Technology, SE-412 96 Gothenburg, Sweden,
david.bennett@chalmers.se

Abstract

Technological capabilities in Chinese manufacturing have been transformed in the last three decades. However, the extent to which and how domestic market oriented state owned enterprises (SOEs) have developed their capabilities remain important questions. The East Asian latecomer model has been adapted to study six Chinese SOEs in the automotive, steel and machine tools sectors to assess capability levels attained and the role of external sources and internal efforts in developing them. All six enterprises demonstrate high competence in operating established technology, managing investment and making product and process improvements but differ in innovative capability. While the East Asian latecomer model in which linking, leveraging and learning explain technological capability development is relevant for the companies studied, it needs to be adapted for Chinese SOEs to take account of types of external links and leverage of enterprises, the role of government, enterprise level management motives and means of financing development.

Keywords: Chinese manufacturing, latecomer strategies, capability development.

1. Introduction

China's share of world manufacturing output was almost 19 per cent in 2010 (calculated from UN Statistics Division (undated) data). With this share, China inched ahead of the USA to become the world's largest producer of manufactured goods. There is apparently contradictory evidence on the technological capability of the manufacturing sector in China. The sector employs about 10 times as many people as in the USA to produce a similar level of output. This difference can partly be explained by the concentration of labour-intensive production in China. Nevertheless, given the substantial progress China has made in export performance, notably in the high-tech sectors of telecommunication equipment and automatic data processing equipment and medium-tech sectors such as office machines and electric machinery (Vaidya *et al.*, 2007) and in meeting the growing domestic demand, questions remain on the extent to which Chinese manufacturing is continuing to rely on low labour costs or developing more advanced technological capabilities. Based on conventional statistical evidence, China's proportion of high-tech exports is now higher than that of the EU according to Meri (2009). However, Yuqing Xing (2011) demonstrates that conventional statistics overstate Chinese high-tech capabilities since export data show the whole value of exports of high-tech sectors but the actual value added in China is relatively low and derived from relatively low-tech assembly operations. Further, much of the high-tech production is within foreign enterprises.

Therefore, important questions remain about: (a) how Chinese manufacturing enterprises attain and improve their capabilities, and (b) the levels of capabilities attained by them. A number of authors including Cho *et al.* (1998), Mathews (2001, 2002) and Hobday (1995) identify patterns of technological catch-up in other East Asian countries, notably Korea and Taiwan, which started from manufacturing competence acquired from low-tech labour intensive sub-contracting and progressed to imitation, adaptation and innovation by combining externally acquired know-how, reverse engineering, internal learning and innovation. While export-oriented sectors in China appear to have followed this pattern (Lall and Albaladejo, 2004), the situation is more complex because of the diversity of manufacturing, the importance of the domestic market and the large number of state owned enterprises (SOEs) engaged in manufacturing in China.

Following the initiation of the Open Door policy, China encouraged acquisition of foreign technology and know-how by SOEs through a range of channels including purchasing foreign equipment, licensing, collaborative agreements such as co-production and foreign investment in joint ventures with Chinese enterprises. More recently, some Chinese manufacturing enterprises have been acquiring foreign firms at least partly to gain access to strategic assets including technical knowledge (Xiaobo Wu and Wanling Ding, 2009; Li et al, 2012). As Mathews (2001, 2002, 2006) and Kim (1997, 1998) show, developing internationally comparable capabilities requires progressing beyond reliance on imported technology to deepen firm level capabilities through learning and R&D (Bennett and Vaidya, 2005). Mathews (2002, 2006) highlights the importance of the three Ls, linkage, leverage and learning to explain latecomer strategies for acquiring key resources for attaining competitiveness, especially of enterprises in rapidly changing technologies. This conceptual framework and its relationship with the resource based view (RBV) and dynamic capabilities are developed further and applied in the next section.

While the development of advanced capabilities is evident in Chinese companies such as Konka, TCL, Haier, Huawei and Lenovo in more fast moving technology sectors (for example, see Teagarden and Dong Hong Cai, 2008; Yadong Luo and Tung, 2007), it is the manufacturing SOEs in mature sectors which face greater challenges in improving their capabilities and becoming competitive. The focus of this paper is therefore on how and to what extent domestic market oriented SOEs have developed their technological capabilities.

2. The issues investigated and study approach

In our initial studies in the 1990s, the focus was on the nature, motivations, effectiveness and value of international technology transfer between enterprises from industrialised countries and Chinese enterprises (for example, see Bennett et al, 1997, 1999 and 2001). Mathews (2002) observes that technology transfer is focused on the technology suppliers' perspective. This was not entirely the case in our studies which demonstrated that effective technology transfer required: (a) collaboration over a period of time; (b) that both the parties had the incentive to participate; (c) that Chinese recipients had the absorptive capacity (related to existing resources and capabilities and learning effectiveness), and (c) that the policy environment was conducive for technology transfer.

Since 2000 our research focus has shifted towards understanding the process of capability development of Chinese enterprises as latecomers. We have taken a longitudinal case study approach to track six manufacturing SOEs since the mid-1990s to assess changes in their technological capabilities, the role in the changes of external sources and internal efforts and of policies. The case study enterprises are located in Beijing and Tianjin, two in the automotive sector (Beijing Benz Automotive Co Ltd, a JV subsidiary of Beijing Automotive Industries Holding Co (BAIC) and Tianjin FAW Xiali Automobile Co Ltd), two in the steel sector (Shougang Group Corporation and Tianjin Pipe Corporation (TPCO)), and two in the machine tools sector (BYJC Machine Tool Co Ltd in Beijing and Tianjin Tianduan Press Company Ltd).

We briefly introduce here the adapted and extended East Asian latecomer model which has been used to appraise the technological capability attainment of the case study companies. The starting point is Mathews's (2002) observation that while the RBV paradigm is important for understanding the key distinctive and difficult to imitate resources on which firms rely to develop and preserve their competitive advantages, it does not explain how an enterprise, notably a latecomer, comes to acquire the key resources in the first place. According to Dierickx and Cool (1989), the ownership of key distinctive resources on which competitive advantage is based could be a matter of "luck" or some other non-rational process and not amenable to analysis. While the Dierickx and Cool position is entirely defensible if the focus is on understanding the nature of competitive advantage and how firms prolong it, it is inadequate for explaining how resource poor firms go about "acquiring resources, as a rational and calculated act" (Mathews, 2002, *p476*) to secure competitive positions in highly contested markets.

Mathews distinguishes between latecomer firms which do not possess the resources and capabilities and to compete with incumbents, and established followers who may have requisite resources and capabilities but prefer to enter a market later. Mathews then argues that East Asian latecomers have pursued a strategy of capturing resources which were then internalized and turned into dynamic capabilities which Teece *et al.* (1997) defines as 'the ability to integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments'.

The gaining of dynamic capabilities for latecomers required a repeated sequence of *linking* with firms which have some knowhow to offer through *leverage* (some advantage that the latecomer firm offers) and internal *learning* processes using knowhow leveraged from links and from other sources to progress from lower level technologies to higher levels (the 3 Ls or LLL in Mathews, 2006). The repeated sequence to progress is necessary because typically it is easier to leverage lower level technology than more advanced. Further, the capability to use and adapt technology at the early stages may also be lower. We refer to this process as the *inverted RBV process* and use it as a basis for our case study investigations. It is *inverted* because it purports to explain the process of acquisition of key resources while the RBV takes them for granted. In this sense, the inverted RBV process could also be seen as a process of gaining and strengthening dynamic capabilities in the specific context of catching up by latecomers.

Mathews specifically refers to contracting to assemble based on the leverage of low labour costs as the initial step in this process in some countries though Mathews (2001) identifies three models for leveraging the development of capability, the South Korean model focused on large domestic firms, the Taiwan model under which public agencies acquired new technologies, developed product and process expertise and diffused the technology to enterprises and the FDI model followed by Singapore. Mathews (2001) recognises some features of all three models in China.

While Mathews (2001, 2002, 2006) demonstrate how the inverted RBV process, incorporating the 3 Ls, has been used to develop and combine different technologies and progressing to higher levels, it is less specific on the details on the levels and types of capabilities for a particular technology (though this is implied in starting from sub-contracting or low-tech production, imitation and innovation). In our study, we look at different stages of capability and levels of attainment at each stage as described below (see Table 1). Another difference is that the focus in the earlier studies (e.g. Cho *et al.*, 1998; Hobday, 1995; Kim, 1997) was on high-tech sectors with rapidly changing technologies while the focus in our study is on more mature stable technology sectors.

Further, Mathews (2002) does not include the supportive role of the state for latecomers and nature of the relationship between the state and latecomers which are emphasised in by, for example, Amsden (1988 and 1989) and Wade (1990) for Korea and Taiwan as latecomers. For the capability development of Chinese SOEs, the role of the state is significant. In addition, given the Chinese government's policy after the open door of encouraging technology foreign technology acquisition through different channels, there are likely to be different types of linkages of SOEs with foreign enterprises with implications for leverage and learning and the effectiveness of the latecomer strategy.

As noted earlier, our approach is longitudinal case studies over some twenty years. In addition to the information collected during the 1990s, semi-structured interviews were conducted with representatives of the six companies in 2006 and 2012. Contextual questions about changes in governance, major products and markets, sales, profitability and number of employees were followed by questions about technological capability (e.g. extent and nature of R&D and the number of patents taken out by the company). Company representatives were then asked to identify the most important technologies the company had developed independently and acquired from external sources. Information was also sought on the levels of the technologies developed and used by enterprises (i.e. whether they offered a lead over international or Chinese competitors, were comparable or less advanced).

In the case-study analysis we adopt the East Asian latecomer development model (Bennett and Vaidya, 2005) to comprise four stages with a sequential progression from Stages 1 to 4. For each case the level of capability attained in each of the stages was assessed. The stages and levels are set out in Table 1. Figuereido (2010) uses a classification of capability stages (from basic production to world leading innovation) with some similarities with our approach to examine innovation capability accumulation of latecomer firms in the Brazilian forestry, pulp and paper industries. Our inductive approach has enabled us to investigate: (a) whether there is a sequential and progressive relationship between the stages, (b) whether relying on collaborative relationships (especially JVs) and developing internal capabilities are mutually exclusive, and (c) whether developing manufacturing excellence and innovative competence are compatible (Gao et al, 2007).

Table 1: Capability stages and levels of attainment

	Capability stages: Competence based on knowledge and skills
Stage 1	Manufacturing competence (production including shop floor experience and learning by doing).
Stage 2	Investment competence (installing new production capacity, expansion or modernisation of capacity).
Stage 3	Adapting and stretching competence (engineering and organisational adaptations for continuous and incremental upgrading of products, performance features, and process technology).
Stage 4	Innovation competence (product and process innovation and creation of new technology).
	Levels of attainment
Very High	Comparable with international leading companies in the sector of specialisation.
High	Competence to perform independently with external input and support which the company has decided to buy from outside and which is effectively managed by the company.
Medium	Competence to perform but with substantial external input and support required because of gaps in the company know how. Significant impact on volume and quality without the support.
Low	Low competence to perform with many emerging problems. Still at the learning stage. Requires substantial external input and support without which it would fail.

3. Case analysis

Since the case study companies are in the automotive, steel and machine tools sectors, developments in these sectors and industrial policies influencing them are briefly described as context. All three sectors have experienced rapid growth and China is the largest producer of cars, steel and machine tools (for example, see Tang, 2012 on the auto sector, Yu and Yang, 2010 on the steel sector and Long Nanyao, 2011 on the machine tools sector). During the 1980s and 1990s, the automotive and steel sectors became highly fragmented with many provinces promoting and supporting old and new enterprises. The machine tools sector did not see a similar proliferation of new enterprises but they ware locally protected. The “modern enterprise” reform process initiated in the 1990s reduced the SOEs’ social obligations and facilitated their transformation into more commercially oriented corporatised enterprises (Yi-min Lin and Tian Zhu, 2000). Alongside these reforms, central government started addressing the fragmentation of the key manufacturing sectors. In broad terms, the approach was to identify leading enterprises in each sector and support them in taking over smaller or weaker ones with a view to improving them or rationalising production (Nolan, 2001).

Even when manufacturing output in these sectors was growing in the 1980s and 1990s, it was recognised that China as a latecomer lagged behind in manufacturing knowhow. Following the latecomer model, the broad approach was to learn from more advanced foreign knowhow and use it as a base to develop indigenous capabilities by engaging in product and process development and R&D. However, the specific approaches to learn from foreign knowhow differed between sectors. In the automotive sector, formation of JVs with foreign enterprises was the dominant mode. In the steel sector, the focus was on importing the most advanced production equipment, reverse engineering and R&D. In the machine tools sector, a wide range of modes of foreign technology acquisition, purchase of equipment, licensing, co-production and JVs have been used, to be complemented by internal efforts.

In the sectoral context outlined above, Tables 2 and 3 summarise the case study findings with Table 2 outlining developments in governance, restructuring and production and Table 3 presenting the technological capability appraisal based on the framework introduced in section 2. All case study companies have been influenced by the “modern enterprise” reform referred to above. Tianjin Tianduan is the smallest case study enterprise and a subsidiary of a holding company, formerly a Tianjin Municipality line ministry. Tianjin FAW Xiali is also a subsidiary of a larger company but of one of the largest Chinese automotive groups formed under the restructuring of the automotive sector. BAIC (Chinese parent of Beijing Benz), BYJC and Shougang are large group enterprises. TPCO was created in 1989 by Tianjin municipal administration with central government support to produce pipes for the oil and gas sector to reduce import dependence. While TPCO has made rapid progress as a producer and in its technological capabilities (Table 3), it has needed very substantial financial support and restructuring to convert debt into shares owned by state asset holding companies. All enterprises have seen rapid growth in sales over the period (Table 2). However, only Shougang and TPCO, both steel companies have exports of any size. BYJC has overseas sales but from Waldrich Coburg, its German subsidiary acquired in 2005.

All the case companies have attained **Very High** manufacturing competence (Table 3) implying either having attained internationally comparative competence or approaching it. Investment competence is also **High** or **Very High** in the companies as evidenced by the management of capacity expansion and location change implemented by the case companies. All the case companies stated that they acquired the most advanced equipment for their new plants. Shougang Group had the capacity to design and construct some of the plant while TPCO collaborated with a supplier of equipment in developing it.

Stage 3 capability in Table 2 refers to adaptation as well as development of processes and products relying on known technology with limited innovation. This is a departure from Bennett and Vaidya (2005) which specify process and product adaptation as Stage 3. This modification is an outcome of the inductive case study approach during which it has been observed that all the companies have developed products based on a combination of acquired knowhow and internal learning and adaptation without engaging in a high level of innovation. We argue that the adaptive and development capabilities require manufacturing and investment competences which deepen understanding of production processes and product features.

The stages approach implies that “Stage 4: Innovation” is sequentially dependent on the previous stages. Having acquired stages 1 to 3 capabilities, all case companies recognise the need for R&D and have internal R&D complemented by links with research institutes or universities. We categorise Tianduan, Shougang and Tianjin Pipe in the **High to Very High** category because of the level of their R&D activity and the number of patents they have registered. They are not in the unequivocal **Very High** category because all three acknowledged that there were some vital technologies in which they lagged behind international leaders. With the acquisition of Waldrich Coburg, BYJC has the potential to attain **High** to **Very High** innovation competence but keeping the German subsidiary at arm’s length may impose constraints. Of the two auto companies, BAIC has a more ambitious R&D programme but the companies are not strictly comparable because Tianjin FAW Xiali is a subsidiary of a large group and innovative initiatives are likely to be at the group level. Nevertheless Tianjin FAW Xiali does appear to have a strong product development programme with its own R&D and development activities supported by the parent company, FAW.

4. Conclusions and future work

Returning to questions posed at the end of section 2, the progressive relationship between stages holds up with the following caveat. Product development can take place without ground breaking innovation and could therefore either be subsumed in Stage 3 competence or be added as an additional stage between stages 3 and 4. This raises a broader question about the nature of industrial innovation in the latecomer context which requires further investigation. On the issue of compatibility between JVs and developing internal capabilities, three of our case companies (BAIC, Tianjin FAW Xiali and BYJC) show that these are not mutually exclusive. All three demonstrate internal learning and progress in innovation though their learning from JVs is limited as noted below.

These three companies have been categorised lower in their attainment of Stages 3 and 4 competences than the other three case companies. Therefore, there is evidence to support the hypothesis that the pace of capability development is slower with foreign JV participation, though less sharply than demonstrated by Gao (2011). On the third question of manufacturing versus innovation competence, according to the sequential capability development model, the latter has to be built on Stages 1 to 3 competences and an understanding of the market and valued product features derived from these. Arguably, Stages 1 to 3 are necessary but not sufficient conditions for developing high levels of innovative capabilities for mature sectors. They may be less important for sectors with short product life cycles or disruptive technologies. Therefore, an important question is the ingredients in addition to stages 1 to 3 learning required for innovation capability.

Table 2: Case study companies: Background, governance and general information

Sector	Company	Background and governance	Products, sales, exports and profits
Auto	Beijing Benz Automotive Co Ltd and BAIC	A JV between Beijing Automotive Industries Holding Co (BAIC) and Daimler AG with the ownership split 50:50 (new agreement in 2004). Originally, the first Sino-foreign automotive JV (Beijing Jeep) between Beijing Automobile Works (now subsidiary of BAIC) and American Motors (later acquired by Chrysler Corporation). The Chrysler Daimler merger in 1998 gave Daimler entry into the JV. Chrysler exited the JV after the failure of Chrysler Daimler merger in 2007.	Until 2005 JV production of American Motors/Chrysler SUVs (Jeep Cherokee, Grand Cherokee). Low production volume in 2005 (25,000 vehicles) because of high cost (including import duty) of imported components and concerns about military use of some technology. After 2004 investment and capacity expansion to assemble Mercedes Benz C and E Class and GLK. Future expansion to include an engine plant and R&D centre (both firsts out of Germany for Mercedes). Production increased from 26,000 in 2006 to 93,000 in 2011. Expected to be 300,000 to 350,000 by 2015. JV's profit in 2011 was RMB3.9b (billion).
	Tianjin FAW Xiali Automobile Co Ltd	Formerly, Tianjin Micro-Car Factory which became Tianjin Automotive Industrial (Group) Co in 1997 and was listed on the Shenzhen Stock Exchange in 1999. In 2002, it became a subsidiary of FAW (First Auto Works) Group, one of the largest five auto enterprises in China, as a part of restructuring of the automobile sector. A JV with Toyota started in 1999 and has now become part of collaboration between FAW and Toyota.	Formerly Xiali produced cars based on the 1987 Daihatsu Charade which were very popular in China as taxicabs. Newer versions launched in the 1990s. A model based on Toyota Yaris introduced after 2000. There is a continuing programme of new small low priced cars aimed at the young and non-metropolitan customers. Total production of 130,000 vehicles in 2005 was almost entirely for the Chinese market. Production in 2009 was 214,000. Sales and profit in 2009 were RMB8.57b and RMB 176m (million) respectively (both estimated to be higher in 2011). A new powertrain plant with a capacity of 400,000 was completed in 2008. A new assembly plant opened in 2011 has increased production capacity to 400,000 with further expansion in progress.
Machine tools	BYJC Machine Tool Co Ltd	Formerly Beijing No 1 Machine Tool Works. In the 1990s started transitioning from a traditional SOE to commercial orientation. Core enterprise in the restructured machine tool sector in Beijing. Since 2000, JVs with Japanese, Korean and French firms and acquisition of German co-production partner, Waldrich Coburg.	Continues to manufacture milling, boring and drilling machines of various types including machining centres and super heavy machines. Works with customers to install production lines. Total sales value in 2005 was RMB1b (over 3 times that in 1997) and about RMB3.3b in 2011. Some of the increase may be because of acquisitions and restructuring.
	Tianjin Tianduan Press Co Ltd	In the 1990s an enterprise under the Tianjin Ministry of Machinery Industry. By 2012, a restructured subsidiary of Tianjin BENEFO Machinery & Electric Holding Group Ltd - formerly the Tianjin Machinery Industry Bureau. Reportedly, company management shares in profits through 20% share ownership.	The company is the largest producer of hydraulic presses in China (40% market share) and produces presses of varying capacities and meeting special requirements such as heavy presses and presses for aircraft panels and glass fibre. Sales revenue in 2005 was RMB260m with a profit of RMB2m. In 2010 the respective figures were RMB676m and RMB18m.
Steel	Shougang Group Corporation	In the mid-1990s, one of the largest Chinese steel manufacturers identified to be the core of a restructured national steel sector. Freedom to make investment decisions, vertically integrate backwards into mining and logistics and forward into trading. Now a conglomerate with complex cross-ownerships and a number of subsidiaries engaged in steel and non-steel sector activities. Number 295 in the Global Fortune 500.	An integrated iron and steel enterprise involved in extraction and processing of iron ore, steel production and heavy equipment manufacture. In the 1990s, steel production was lower grade. In 2006, steel production was 12.5mt (million tonnes) (constrained by relocation of Beijing steel plant). In 2010-11, annual steel production increased to 30mt through the new coastal plant at Caofeidian coming on stream and acquisition of other steel producers as part of restructuring. Lower value added long products reduced to one-third of total production. By 2015, Group plans to produce 40mt of total crude steel output per year.
	Tianjin Pipe Corporation (TPCO)	Created by Tianjin Municipal Government in 1989 and under Municipal Government ownership. Heavily indebted to municipality and banks until late 1990s when debt was converted to equity. Since 2005 Tianjin Economic & Technological Development Area (TEDA) and other state owned entities are shareholders but TPCO also benefits from some low interest rate loans.	An integrated steel plant specialising in pipes for the oil and gas sector. In 2005, a wider range of products with improved quality and large expansion of production of seamless pipes. About 3-fold increase in production between 1997 and 2005 (1.4mt). Production and sales in 2010 about 2.7 million tonnes valued at about RMB17b (adversely affected by US anti-dumping action). Exporting to many oil producing countries. Many major international oil companies are customers. Profit in 2005 about 5% of sales. Before the US anti-dumping action in 2012, profits were in the RMB2b to RMB3b range.

Note: RMB is Renminbi, Chinese currency. US$1 was approximately RMB6.4 in July 2012.

Table 3: Case study companies: Assessment of capability development

	Capability stages			
Company	**Stage 1: Manufacturing**	**Stage 2: Investment**	**Stage 3: Adaptation**	**Stage 4: Innovation**
Beijing Benz (JV) & BAIC	**Very High** in JV with Daimler AG and in BAIC with accumulated experience of manufacturing different types of vehicles (passenger cars and commercial and military vehicles).	**Very High** in JV. Investment in assembly and engine plant in collaboration with JV partner. **High** in BAIC with a range of past and current investment projects for different types of vehicles.	Not relevant for the JV with foreign knowhow. **High** in BAIC – evidence of development of vehicles based on acquired technology (e.g. military vehicles, models based on SAAB designs including electric vehicles).	Not relevant for the JV not engaged in innovation. **Medium to High** in BAIC. Independent development of military vehicle claimed. BAIC has set up an electric vehicle subsidiary, R&D base and supply chain. Prototypes of "new energy" vehicles were shown in 2011.
Tianjin FAW Xiali Automobile Co	**Very High** competence in operating established technology through experience of manufacturing components and assembly (2.4 million cars).	**High:** Demonstrated by the substantial implemented and continuing investment programme (assembly and major component manufacture).	**High:** Demonstrated by competence to adapt and develop models based on imported technology. Supported by own R&D department and that of FAW for advanced engine development.	**Medium:** Long established R&D programme for model design and development of small economy cars based on established technology.
BYJC Machine Tool Co Ltd	**Very High** competence in operating established technology augmented by acquisition of Waldrich Coburg and exchanges of staff with JV partners.	**High:** Managed installation of new factory outside Beijing. Other investment projects related to restructuring continuing.	**High:** Product and process adaptation and development (assembly lines with JV partner), especially super heavy milling machines in collaboration with foreign subsidiary.	**Medium to High:** Company has 5 pragmatic patents (see note). Prefers not to patent important technologies. Waldrich Coburg operates independently with separate R&D.
Tianjin Metal Forming Machine Tools General Works	**Very High** competence in operating established technology and managing suppliers of components. Capacity to learn quickly when new equipment is introduced.	**High:** Managed construction of new factory. Normal reliance on suppliers when new equipment is introduced. Most advanced foreign equipment installed.	**Very High:** Increased the range of products and capacity of presses. Restructured the business to outsource standard components to focus on producing key components and assembly. Work with customers to design presses to meet specific requirements.	**High to Very High:** Developed specialist presses for aircraft panels, glass fibre and nuclear power station component, requiring high precision. Company owns 540 (80%) of patents in the sector (of which 30% are "invention" patents – see note).
Shougang Group Corporation	**Very High** competence demonstrated by fully comprehensive management of operations in the old and new and recently acquired plants.	**Very High:** Management of new plant construction. Blast furnaces designed and constructed by design and engineering subsidiary. Most advanced steel rolling mills installed. An 80 tonne ladle furnace (to produce purer steel) was purchased and then 2 copies made.	**Very High:** Since early days, reliance on internal development and adaptation of technology and purchase of imported technology when necessary (Nolan and Yeung, 2001). Very high ability to adapt and develop processes and products and large improvements in environmental protection.	**High to Very High** level of research competence and a continuing programme of internal and cooperative research with universities, research institutes and companies. Between 1986 and 2006, ranked fifth among Chinese companies in registering Chinese patents.
Tianjin Pipe Corporation (TPCO)	**Very High** competence in fully integrated steel production and pipe manufacture. Increase in range of products with limited external support and problem solving for customers.	**High:** Expansion of production capacity with normal support from equipment suppliers, installation of seamless pipe capacity, and collaboration with supplier in designing new equipment. New 500,000 tonne plant being constructed in Texas.	**Very High:** Increase in range of products for the oil and gas sector and diversification into other products (e.g. low and high pressure cylinders). Designing customised products. Obtained international certifications for products.	**High to Very High:** Has developed own proprietary TP (Tianjin Pipe) products. By far the leading Chinese innovator with most national "invention" patents in the sector. Developments since 2006 include high grade steel pipes and special pipe connectors. Research in new areas being undertaken to diversify.

Note: There are different types of patents in China. An "invention" patent is granted for a new technical solution relating to a product or process. "Utility" or pragmatic product development patents are for new shape or structure of a product made to change functionality and not just for aesthetics.

The repeated sequences of linking, leverage and learning in the inverted RBV process which Mathews put forward as the process of developing key resources and capabilities by latecomers appears to be relevant for the case study companies. However, to complement the 3 Ls of Mathews (2006), we propose 2 Ms, ***money*** (to represent access to financial resources) and ***motivation*** (to reflect what drives SOEs to develop their capabilities, especially innovation). ***Money***, the financial resources required for capability development may be generated by the enterprise, borrowed commercially or provided by the state either directly or through banks at subsidised rates or otherwise. ***Motivation*** is more complex and includes government objectives at the national and local levels and enterprise level objectives which may be pecuniary or government approval or recognition which may bring added advantages to the enterprises and their managers.

The most important leverage for the case study companies are the access they offer to the Chinese market or finance and policy support for purchasing technology. Market access has been instrumental in developing JVs and other collaborations with foreign firms (e.g. BAIC, Tianjin FAW Xiali, BYJC Machine Tools Co and Tianjin Pipe, the last in collaborating with an equipment supplier). Examples of purchasing knowhow are BAIC for SAAB technology, Tianjin FAW Xiali for earlier purchase of Daihatsu / Toyota technology, the purchase of advanced foreign machinery by Tianjin Tianduan and Shougang and the purchase of Waldrich Coburg by BYJC.

BAIC’s JVs and BYJC’s earliest JV have had limited technological capability development impact on the Chinese companies beyond demonstration effects at a general level and in management practices. However, the cash generation and profitability of the JVs (***money***) has enabled the firms to engage in capability development by other means since different types of linkage and leverage have not been mutually exclusive. The learning has been facilitated by linkage and leverage and the 2 Ms, ***money*** to finance learning and R&D and ***motivation*** in the form of national and local government strategies for the sector and promotion of R&D, for example by linking recognised sectoral research centres to enterprises (e.g. for Tianjin Tianduan and TPCO).

Most of the enterprises appear to have expanded their production and sales profitably over the period and have therefore demonstrated capacity to contribute financially to their learning efforts. However, some enterprises such as TPCO, although highly successful in process and product development have a heavy debt burden and therefore are reliant on policy level motivation for financial support in the form of low interest loans and low returns to shareholders. At the enterprise level, important motivation is to operate profitably. However, an additional form of motivation is managerial (for example, see Williamson, 1974) under which it is in the interest of the managers of SOEs to be in charge of larger and more diversified enterprises. The objectives of SOE managers will also be influenced by government objectives and policies on sector restructuring, profitable operation and innovation. For example, if government policy is to rationalise a sector by reducing the number of enterprises, managers will pursue a strategy of expansion to be among the larger enterprises. If government policy focus is on innovation and enterprises engaged in innovation are favoured, this will influence enterprise level decisions.

The general findings in this study require more detailed micro-level investigations to understand the nature and relative importance of the 3 Ls and 2 Ms in the capability development processes and the associated accumulation of skills. More specifically we need to develop and test hypotheses on the relationship between manufacturing and innovative capabilities, the role of skills and human capital in innovation, the relative importance of enterprise level and policy level motivation in innovation, the interaction between internal innovation activities and external influences and learning and innovation models adopted by the enterprises.

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Explore ERP and informality: international manufacturers in China

Yucan WANG
Aston University, Aston business School, operation and information department
Aston Triangle, Birmingham, B4 7ET
Wangy38@aston.ac.uk

Andrew Greasley
Aston University, Aston business School, operation and information department
Aston Triangle, Birmingham, B4 7ET
a. greasely@aston.ac.uk

Pavel Albores
Aston Business School
Aston University
Aston Triangle
Birmingham, B4 7ET
p.albores@aston.ac.uk

ABSTRACT

The paper aims to conceptualize informality in ERP systems (ERPs) for manufacturers. The findings suggest manufacturing firms with a certain degree of informality, including loose structured design, socio-emotional committee and employee involvement, remedy inflexibility of ERP. This is achieved by overcoming the inflexibility of 'fixed design' enterprise systems with ongoing updating of frontline personnel's experience. However, the majority of manufacturers still have negative attitude to the use of informal systems with ERP system, because of the risks of overcoming tradeoffs, such as efficiency and flexibility.

Key words: ERP, informal, international manufactures

1. Introduction

Many manufactures realize the benefits of enterprise resource planning (ERR), which improves efficiency by reducing process cycle time, producing documentation quickly, and eliminating errors and duplicated process design (Moon, 2005). However, there is increasing awareness of shortcomings of ERP systems, because many companies are confronted any risks at post-implementation stage, when using, maintaining and enhancing their ERP systems. Thus there are much research emphasizes on the critical role of making ongoing improvements of systems by frontline employees in the ERP post-implementation stage (Gallagher etal., 2011, Peng and Nunes, 2009).

The theory of motivating employees participating in key business processes covered by those studies. Krackhardt and Hanson (1993) defines the informal organisation as one in which work is based on social networks that employees from across functions and divisions use to accomplish tasks quickly. The benefit of informality is that it involves employees and leads to increased flexibility in meeting business needs (Morand, 2005). Recently, literature on enterprise social software (enterprise 2.0) also suggests that informal structured communication supports flexibility and helps deal with uncertainty (McAfee, 2009).

Most of current ERP researches just focus on successful factors for implementation (Ifinedo et al., 2010, Peng and Nunes, 2009) without revealing the how to understand frontline users' perceptions and how to use them effectively when ERP is on work . To fill the gap, the study is to explore a hybrid system with both ERP and informal communication systems to enhance the interactions with frontline users when ERP is on-going using. The following paper will conceptualize the hybrid system of informality and ERPs is in the manufacturing domain .

2. Explore theoretical perspectives on informal & social-technology in multiple-sites manufacturing research

The section will discuss the relationship between informal concept and ERP researches in manufactures in the past researches.

2.1 Informal concepts

The term of informal (its accompanying noun informality) is originally from organization management theory, and refer to describe the emergent patterns of business behaviour that are relatively "loose", "spontaneous", more "casual social intercourse and comportment (Morand, 2005). Rules of conduct imply informal and implicit consents, such as customs, traditions, conventions, ethics, and authoritative relations. Usually, informality is use to describe a firm, which is loose, flexible, embeds human practices, rather than practical, holistic or logical (Kaman et al., 2001). Nowadays, it is broadly used to describe key a trait for enterprise social software. In a summary, there are four key characteristics of informality based on organization structure, communication method and leadership

Organization structure: week structure Informality benefits for improving internal organization to abolish hierarchical structured (Cook, 2010). The development of cooperative communications are through informal relationship that is irrespective with formal organization structure. Also, it provides high context of social satisfaction, because employees could have unexpected interactions based on their psychological and social needs. Additional, the social interactions enable to motivate employees to flexible design their works through their creativities that break routines and tedious jobs. Consequently, firm enables to establish social commitment in an organization including a sense of job involvement, loyalty and belief of values in the organization. Experiences and intuitions might be more valuable, as they are developed from daily operations in bottom level of organization.

Communication method: cooperative clime What is behind of informal communication? "Trust" plays critical role in the informal network. Interpersonal trust between social participants leads to informal interactions based on social arrangement and emotional loyalties. Trust network coordinate all participants in social networks, and increases the feeling of intimacy and connectedness between colleagues (Zhao and Rosson, 2009). So the communication is the bottom-up approach. The typical social productions are Wikipedia and Lindux operating systems that will achieve cooperative through collective influences of participations (Bruno, 2010).The informal process might be inappropriate due to manual errors. Thus the frequently and more people enragement in social interactions through informal systems will improve communications more precisely.

Leadership approach: participant empowerment The informality highlight the contributions of all participants and they could have equal rights to construct a best business solution (Sarini et al., 2010). Thus it is to spur employees adapt knowledge-intensive management, rather follow rigid business norms. Social software enables open and unstructured online communication that motivates spontaneous interactions between social participants to filter and refine the information with more effectively and precisely (MaAfee, 2008). Front-line employees participate in modifying the work procedures, even their behaviours could influence on designing and changing working methods. The informal and unstructured process management is supported by communication and cooperation social software (Cook, 2008). Communication software allows individual level interactions that people could question or opinion and gets response from others, such as discussion forums and blogs. Cooperation social software could share information along with process to construct something in the process of sharing knowledge.

2.2 social-technical research of ERPs in manufacturing firms

The limitation of past manufacturing research highlights on how to increase production performance by using enterprise systems, rather than social interactions. However, manufactures suffer for rigid designed ERPs. ERPs generates production plans through MRP system, which has fixed lead time to plan for purchasing order and production order, and cannot flexibly respond to changes on lead time (Moon and Phatak, 2005). All of these features of ERPs therefore result in material shortage or over-ordering or producing may directly lead to delay or cease of production (Chen 2001). Latest researches becomes to realise the importance of informal systems to provide better communication people and enterprise systems, as technologies are never fully "stabilized" or "complete", and people always invents new materials, establishes new standards or modifies their contents (Orlikowski 2000). For example, Lee and Gebauer (2006) highlight the usage of flexibility to support business processes to accommodate uncertainties in the competitive markets in a communication technology manufacturing firm. An informal communication software (it called as "processpedia") is used in a manufacturing firm benefits flexibility and helps deal with uncertainty because of the involvement of experienced employees (Bruno et al., 2010). To support of the combination of enterprise systems and social systems, sociomaterial theory (Orlikowski and Scott, 2008) states "humans and technologies entities entail each other in practice, and both of them are intrinsic of an organization to every day activity". It is shorted for " technology-in-practice' concept, which fundamental supports this research of ERP and informal systems can be combined together to use.

3. Methodology

The paper presents empirical studies of four manufacturing firms through semi-structured interviews of IT managers, senior managers and key users. Triangulation of multiple investigation as a crucial component of rigorous case study method benefits to heighten confidence in results (Eisenhardt, 1989). Following the theme, information of the research is corroborated by other data sources to ensure its' validity, including company's handouts, websites, presentations, system figure and organization chats. The data analysis is done by Nvivo software .

Table 1 shows context information of each case, including ERP implementation and organization condition. The sample was designed so broad, including food, display, water heaters and electronic manufactures in China. Most of them are middle and large firms with more than 1000 employees. The large batch of production orders motivates all of them implemented ERP package systems. Only Yurun is a Chinese local manufacturing firm. And the rest of them are Chinese subsidiaries of international companies, whose ERPs are required by headquarter (HQ). All the firms are implemented ERPs for a long time. Moreover, Yurun and A.O smith improved their ERPs in the 2000s, and their ongoing improvements were made by technology department or ERP project team. Most of them are implemented standard ERP software package of SAP® or QAD, while only LG's ERPs are fully customized for the branch in China. Most of these firms are used production, procurement and planning functions of ERPs in order to facilitate smooth operation. Yurun is a traditional firms with all ERP functions, which also includes logistics, sales and finance. LG and Sharp simplify the functions of manufacturing sites with only production related modules in ERPs. But Sharp used e-purchasing system through electronic data interchange (EDI) platform to reduce supply chain risks. If Sharp received a change of production orders , the system can the request raw materials or change the purchasing orders to suppliers immediately. A.O smith is a innovative firm, and invents new applications of ERPs to reduce market uncertainty. CRM system (A.O smith calls them as 3C) and store management system interact with sales office effectively to predict production orders and to evaluate performance of each sales office with real-time sales information. All of these additional (EDI, 3C) systems are supported to remedy the limitation of rigid designed ERPs, which have fixed lead time to purchasing order and production orders.

Most of manufactures are not familiar with informal systems. Only LG used of informal systems which works on Bulletin Board System (BBS) web platform to arrange informal group (IG) entertainments. IG is a unofficial organization with groups of people who have common hobbies, for instance, they have swimming group, photographic group, electronic game group etc… After then, IG improves the collaborative works of employees from different departments. Thus in this company, they called the website as "collaboration". When HR mangers draw process flow for ERPs, he uploaded the process flow the website, and he retrieved feedbacks from all members of tourist group, including production department, technology department, administrative staff and general manger.

In order to investigate informal natures of these firms, the interviews are designed based on three key characteristics of informality: organization structure, communication method, leadership approach. The organization structure of Yurun and A.O smith are hierarchical, while LG and Sharp are based on flat organization structure, who emphasis on team-work. Yurun and Sharp's communication method is top-down with formal and rigorous leadership approach, as they are patriarch-based management. What is more, Sharp is only treated as an international factory of HQ. The systems and productions orders are assigned by HQ. LG and A.O smith's internal communication atmosphere are open, and encourage employees join in key business. Both of their management philosophies highlight of respecting commitment to employees. Moreover, LG proposed fun workplace and effective communication with employees as its' management slogan.

Table 1: Investigate informal organization context in Chinese manufacturing firms

	Yurun	**LG**	**A.O smith**	**Sharp**
Production type	Food (meat process)	Display Technologies applied in digital,	Water heaters	Electronic equipments (i.e. televisions,

		communication devices		projectors, LCD televisions)
Year of creation	1993	2002	1996	1996
No. of employees	3000+	1000+	1000+	1000+
Capital structure	Local Chinese manufacturer	Sole corporation, subsidiary in the Southeaster of China	Sole corporation, subsidiary in the Southeaster of China	Sole corporation, subsidiary in the Southeaster of China
Start of adoption year	1996 2006 (2nd implementation)	2002	1999 2009 (2nd implementation)	1997
Adoption method	SAP standard software + ongoing improvement by IT dept.	Customized system based on Oracle by sub-company (phased)	QAD+ self-development to make continuous improvements by ERP project team (phased)	SAP (standard software of headquarters)
Functional coverage of the ERPs	Production, purchase, plan, logistics	Procurement, material mgt. , production+ HR	Production, purchase, plan, material mgt., finance, sale + CRM (3C)+ store mgt. system	Production , purchase ,planning, EDI
Informal systems	need	Use	no	need
Organization structure	Hierarchical	Team work & loose structured with informal groups	Hierarchical	Team work
Communication method	Top down	Bottom up	Bottom up	Top down
Leadership	Formal, rigorous	Empowerment	Empowerment	Formal, rigorous

Table 1: Cross company context, ERP, informal comparison

4. Implications of combining informality and ERP in manufactures by sociomaterial approach

Based on four case studies, the following will summary the concepts of informality for manufacturers, and make implications of adoption ERP with informality.

4.1 Conceptualize informality for manufactures

Work in practice The first dimension we use to define informality for manufactures is "technology-in-practice" concept, which is introduced by Orlikowski and Scott (2008). And they highlight an ad hoc process for knowledge-intensive management. Yurun needs of informal, as the company's system development is not as fast as the other firm. It used MRP II in the 1990s, and then changed to use ERP in early of 2000s. IT department's staff are not knowledgeable enough. However, the hierarchical structure make end-users are not allowed having frequent interactions with senior managements. Thus end users cannot solve the problems when they use the system. IT manager talked about they met problems due to lack of informality. *"The logistic system systemic analyses and calculates weight of each production lot. However, in practice the company has made mistakes on delivery. For example, the delivery carrier found initial system designer had forgotten to calculate the size of delivery box. Sometimes, workers arrange the delivery job by themselves. Nearly half year, senior managers noticed the problem and started to discuss with Information Department to enhance logistic system."* Informal in the manufacturing firm means needs to bring in knowledgeable workers' practice experiences, and make timely changes.

User flexibility There are two type of IS flexibility: (1) flexibility-to-use, (2)flexibility-to-change. The former one is defined as providing range of process requirements into information system (IS), while the latter one is required to change a given IS(Gebauer and Schober, 2006). Sharp achieved high quality IS support from HQ, and they implemented EDI to support e-procurement system. However, even if Sharp used EDI platform to interact with suppliers effectively, the risk due to inflexibility of ERPs is not solved. It is because e-procurement systems only support flexibility-to-change. However, the firm's orders are unpredictable and changeable, which are assigned by HQ. They cannot predict orders accurately. Sometimes they need to work informally to react to uncertainty. Technical department manager recalled, *"Initially, we had orders for 15 billion units. But two days later, HQ reduced the orders to 10 billion. We changed the purchasing orders to suppliers in e-procurement system immediately. But in China, a supplier need to confirm all the orders with a written contract, even if we changed the e-procurement system. Suppliers is not willing to reduce orders, after a written request to supplier is already set. We received the extra 5 billion raw materials, but we cannot input the information in the system, as the stock information links with MRP planning system. All the production plans might be in a mess. We will add extra material information in system for the following month, so that next month the actual amount of purchasing order is less."*Informality in manufacturers links with "user flexibility" that allows users to flexible change the production order or production process.

Trusted human networks LG is in harmonious working environment. The benefits of informality is unintentionally. Manufacturer B have problems of low quality goods, losing or damaging goods due to delivery, because its' goods are fragile. What is more, HQ required the company implementing "zero inventory" management. IT manager and HR manager talked about how the firm deal with these uncertainties. *"We can either work overtime, or can reschedule production plan. From HR's perspective, work overtime is difficult to convince workers and satisfaction their payment. But plan department are not willing to reschedule production plan, as it complex and waste time to run MRP, and calculating purchasing plan for the whole orders. Sometimes, production department complains that there is not enough production line to do the additional orders. So we have a group called "TASK" to compose few people from different departments to work together and to discuss best solution for the issue. The people in the "TASK" group also links with the other colleagues in the IG group. Thus, there are indeed nearly all the employee sit together to discuss the solution through our "collaboration" platform.* So informal in manufacturer also means to have "trusted human networks" (Zhao and Rosson, 2009) to work collaboratively. The networks here is not merely physical communication platform, but it is an organization clime to support emotional interactions, and establish social relationship. The solution to the uncertainties are occurred through collective members.

Reactive position to uncertainty A.O smith does not need of informal, as the company is with low-uncertainty. The company is able to deal with uncertainty proactively. As the company has world-wide reputation, many retailers eager to get permits to sale their goods. In order to manage the sales offices effectively, they implement store management system to interact sales sites directly. The system contents a large database of historical sales information of each sale office. They used the system to predict demands, and it links with ERP planning systems. If a sale office's business goes downhill, they will close the shop. The actual order is direct retrieved by 3C system. As a retailer places an order through the platform., the system links with ERPs to have timely production plan for actual demand. Production manager said, *"Even if there is some unpredictable orders, the amount is quite small. And their policy is to provide goods for customer in two weeks. Usually, they can finish the work in 2 weeks with over-time work."* So the occurrence of uncertainty is low in this company. Although the company works as similar as A.O smith that encourages empowerment and effective communication for employees, it quite rare that employees talked to senior manager directly. Their work processes are optimized design with frequently improvements by technical departments, because technical department and production department works together and have frequent interactions. Informality occurs when the company is in a reactive role to deal with uncertainty, and also without much support by knowledgeable IT staff.

4.2 informality verse systemization

Figure 1. compare informality vs. systemization of four manufacturing firms

The paper also compares informality and systemization of the four manufacturing firms. Informality refers to knowledge, innovation and experienced based works , while systemization is to operate based on formality and systemic words and numbers.

Formality and systemization role: A.O smith's Chinese branch is relative work formally. Besides traditional ERP manufacturing system, it also consists customer and store management systems to enhance control and monitor performance of each subordinate manufacturing site and sale office. Although the firm encourage people-orientation, it doesn't need any informality, as all the operations are optimized designed and employees have standardized working methods that are support by ERP systems.

Informality and systemization role: LG display Nanjing factory is the opposite side. The firm highlight to build a informal organization. The factory has its ERP systems to optimize manufacturing process within the firm, and aims to achieve zero-inventory management through ERP systems. However, a harmonious social networks is also vital in the firm. Therefore, employees are able to have close relationship and coordinate together to solve the problems or uncertainty that they met, such as the shortage of material.

Part informality and systemization role: Sharp Nanjing branch is part informality but part systemization position. The branch's ERP systems are supported by headquarter. Sharp headquarter has advanced management systems to support each manufacturing firm's daily operation. For example, the manufacturing site does not only have ERP production system, but also purchasing system based on EDI platform. Sharp headquarter is able to supervise both of production process and purchasing process. It is just because Sharp headquarter have centralized authority, it changes of order frequently suffering the manufacturing site has over-inventory problem. In order to effective use of ERP system, Chinese vice-manger allows users input inventory and purchasing information in the ERP system according to purchase order, so MRP system can run normally. The informality here is different. It is a experienced performance, but it does not work in a open and harmonious environment. Leadership of manager determines the factory works informally or formally.

Formality and part systematization role: Yurun Group works formally but it is in part systematization role. Yurun has a standardized working procedures each manufacturing site for production, purchasing, plan, and logistics, which is supported by ERP systems. What is more, operation manger has different viewpoint of informality. ERP systems brings advanced management mechanism for the firm, while informal is risky because employee experienced based changes are with errors and human bias. Therefore the firm works formally and follow system-based rules. However, the firms' ERP systems are only for key business. Finance system is a different system, employees needs to manual input receipts into its' finance system and then develop finance report of each product site manually.

4.3 Sociomateriality implications for adoption ERP with informality

The sociomaterial approach usually advocate symmetry of the social and the material and would even appreciate the active role of the actant, which delivered the concept that technology, work and organization need to be conceptualized separately (Orlikowski and Scott, 2009). And the consistent sociomaterial configurations are contributed to contemporary organization practices. Following the approach, the implications of adoption ERP with informality in manufactures will be discussed in three dimensions: technology, work and organization.

In the technology dimension, combining ERP and informal communication systems could provide a mutual impact on achieving efficiency and flexibility ERP systems are used for seamless transactions in the producing procedures in the manufacturing firms. For example, A.O smith and Sharp are well used of the function of ERP systems to support interactions between upstream and downstream position of their manufacturing supply chain. It is therefore, these firms can improve efficiency with smooth manufacturing processes. However, the traditional ERP system could not supports for "user flexibility" of informality, which allows users to flexible react the changes of external stakeholders. EDI platform of ERP systems only support flexibility operation by gathering quick and efficiency information from suppliers, such as raw material shortage information. But it doesn't support practical users make reaction of the changes in time. However, when a manufacturing firm implements a hybrid system, the risk of tradeoffs performance in operation needs to be considered. For example, Yurun's operation manger has different opinions on the need to support informal and flexibility operations.

"It is not possible implementation flexible or informal activities in our company. Agile business process management might work for other companies. But it does not work here. A small change will need a high cost and long work time in our company, because we have over thousands of factories needs to adapt the change. An inappropriate change is worse than not change."

Skinner (1985) said trade-off is a method to understand business objectives are related to one another. The challenge of trade-off is two constraints of factors could be improved simultaneously. In Yurun, ERP mainly enhances productivity, because it is efficiently to improve products produced per employee or labor costs. The firm does not implement enterprise social system is because flexibility and variety of productions costs more. It is not efficiency for a mature manufacturing firm to undertake the risk that an experienced based small change damages whole production chain. Eventually, in this case the enterprise system cannot be modified in time, which leads to manufacturing firm to surfer inappropriate delivery for nearly 6 month. How to achieve trade-off benefits hinders the usage the combining system.

In the organization dimension, the combination achieves effective and agile business process, which consist both tight and loose structured organization. A.O smith Chinese branch is a example that consist both tight and loose structured organization. The company implemented ERP for a long term, and it has specialized enterprise system team to develop the suitable systems for them. They implemented traditional ERP manufacturing system, and made continuous improvements of system as their organization structure was changed in 2000s. After 2009, the firm changed to only focus on manufacturing works. The sales offices are separated firms who are not belong the firm. In order to coordinate with the sales and customer services, the firm developed its' own CRM system (3C) to effective interact with the sales offices, and retrieve production orders in time. However, the firm does not only use of ERP to effect support of manufacturing process, but also headquarters of A.O smith also respects the suggestions of employees and practical users, which is in a loose structured organization environment. It is thus, the branch has its' own ERP development team, and staff in the Information Department have authority to improve their ERP systems according to changes of the branch. But there is risk to balance between centralized and decentralized control of a firm. Sharp Nanjing branch is centralized controlled by headquarter. As IT manager said, *"our company does not any authority, rather a production factory for Sharp in Japan"*.

Headquarter in Japan send orders to the factory. ERP systems are used for headquarter to monitor and control the production flow, cash flow, and material storage of the factory. However, the unpredictable changes of production orders requires the firm needs to effective react changes of purchasing orders. Chinese environment is specially that people prefers face-to-face interaction, rather than system interactions. So purchasing system is only for record purchasing order. EDI-based platform is only a “decoration” for the firm. “Dinner table contract” is popular to use. Purchase Department manager changes purchasing order when he has a dinner with the suppliers. Usually, suppliers are not willing to reduce orders. Then, the firm pays for over-stocked raw materials when the factory gets the second order from HQ. So the factory have problem of over-inventory, which lead to the factory cannot run MRP system. The only way to solve is to manual modify the stock information. However, over-stock and changing stock information actually doesn’t allowed for Sharp manufacturing site. The more decentralization in the firm, the more risk of none-accurate and time consuming due to input stock information manually. So it is an embarrassing problem for the factory manager how to balance between central and decentralized control .

In the work perspective, a hybrid system benefits improves collaboration and ongoing innovation by participation of frontline users, yet the risk of making decision based on experiences cannot be ignored. LG woks in a harmonious environment. The informal communication system links employees from different departments and different levels, and cooperate together to solve the problems that they met. The links between employees are social relationship, rather than a documented rules. As HR manager recalled, *“he can draw his department ERP system flowchart and set its’ new organization structure by himself. It seems that it is only one person to finish the work, but there are hundreds of employees in IG platform to change and modify his work.”*

But A.O smith and Yurun operation managers both pointed out the usage of informal system might lead the firm is extremely chaotic. Manager might confuse which is suitable to obey, the documented working rule or employees’ experience and intuition?

5.Concuslion and further research

The research is to define the hybrid system of informal and ERPs, based on empirical research from four manufacturing case studies. ERP has the limitation due to fixed design production process, fixed lead time to production plan and purchasing plan. The interviews are designed based on the applications of ERPs and three features of informality in the organization theory, including organization structure, communication method, and leadership method.

The finding suggest that informal systems along with ERPs are defined to bring knowledgeable frontline works with timely improves on systems, to allow users modifying work procedures or production orders, and to support collaborative works among all employees. Also the manufacturers who is with proactive strategy to deal with uncertainty or with many knowledgeable IT staff don’t need a hybrid system with informality.

However, many manufacturing firms still are not willing to implement such hybrid system . In the technology, when a manufacturing firm implements a hybrid system, the risk of tradeoffs performance in operation needs to be considered. In the organization dimension, the combination achieves effective and agile business process, which consist both tight and loose structured organization. But there is risk to balance between centralized and decentralized structure in an organization. In the work dimension, a hybrid system benefits improves collaboration and ongoing innovation by participation of frontline users, yet there is risks of making decision making based on experiences.

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Factors related to local supply base development affecting production localisation in China

Monica Bellgran, Jianyuan Xie

Div. of Product Realisation at the School of Innovation, Design and Engineering, Mälardalen University, Box 325, SE 631 05 Eskilstuna, Sweden
Corresponding author +46 16-153223, monica.bellgran@mdh.se

Abstract

Recent years, foreign manufacturers have extended their manufacturing footprint to include China. According to the World Bank China has overtaken Japan as the world's second-largest economy since 2010. China's growth is largely funded by a continuous manufacturing boom where both domestic industries and infrastructure have developed extensively, facilitating foreign-owned manufacturing companies to locate production in China. An important issue of common interest to all manufacturing companies in the course of localizing production to China is how to develop an efficient supply base. On a basis of interviews with 12 manufacturing entities (comprising eight foreign manufacturers and four local supplier companies) in China from April to July, 2012, this paper investigates factors of importance to supply base localisation in China. The analysis of the empirical and theoretical findings constitutes the bases for increased understanding supporting foreign manufactures in their development of a supply base and sourcing strategy for production in China.

Keywords: China, manufacturing, sourcing, supply base development, production localisation

1. Introduction

Earlier work has investigated the sourcing issues in China from foreign manufacturers' perspectives including sourcing performance and selection (Millington *et al*., 2006b; Mummalaneni *et al*., 1996; Zhang and Goffin, 2001; Humphreys *et al*., 2004), issues of local sourcing (Zhang and Goffin, 2001; Kaiser, 1997; Yan and Gray, 1994, Salmi, 2006) and buyer-supplier relationship (Pressey and Qiu, 2007; Millington *et al*., 2006a; Wang, 2009). In this paper, the question of supply base development and its effect on the decision of localising production in China is investigated from two perspectives: the foreign manufacturing company (buyer/customer) and the local Chinese suppler. Here, an identification and analysis of factors for foreign manufactures to consider when developing the supply base for their China production facilities is presented. The following questions are elaborated on:

- What motivates foreign manufactures to set up production facilities in China, and what relevance does the local supply environment have on the decision making?
- What factors are to be considered when developing a supply base in China?
- How do foreign manufacturers find suppliers for their China production sites? What obstacles are faced when developing a supply base in China and what are the countermeasures?
- What do local Chinese suppliers concern when they cooperate with foreign manufacturers?

The empirical findings show that the Chinese supply market is undergoing change which faces foreign manufacturers with new challenges accompanied by emerging opportunities. This paper demonstrates the supply base development at the different stages of production localisation.

2. Theoretical framework

Globalisation describes businesses' deployment of facilities and operations around the world (Krajewski and Ritzman, 2005). Globalisation refers to the expanding flows of capital, goods, service, and facilities across national border. Globalisation results in international exchanges which brings more exports to and imports from other countries. To move or extend production facilities to another country is an important way to optimize the cost and utility. The decision of production localisation addresses the question of what economic activities should be located where and why. Production localisation strategies normally have long-term impacts on manufacturing companies. A localisation program must be well planned and the communication between the parent company and its subsidiary is crucial (Fryxell, *et al.*, 2004). Factors affecting localisation decisions in international operations have been analysed by e.g. MacCarthy & Atthirawong (2003) who present a fully comprehensive set of factors and sub-factors that affect the international location decisions. They consider "proximity to suppliers" as one of the major factors. The sub-factors are quality of suppliers, alternative suppliers, competition for suppliers, nature of supply process (reliability of the system) and speed and responsiveness of suppliers. The Boston Consulting Group (2008) developed a five-step model to reveal the process of localisation in China and India for foreign automotive manufactures describing a localisation process of most foreign manufactures in China: from being a home player with limited involvement in, and only a few exports to the Chinese market, to a global player based on China serving the world with products.

Forces for and against localising the supply base in China have been discussed by e.g. Eberhardt *et al.* (2004), Kaiser (1997) and Zhou (2004). An analytical framework of forces acting for and against component localisation based on a survey conducted among 27 UK-invested MNC subsidiaries in China has been explored by Eberhardt *et al.* (2004). This framework lists 12 internal forces (the forces within the China venture firm and/or its parent firm) and 15 external forces (circumstantial and/or environmental influences on the China venture) of localisation in China. Millington *et al.* (2006a) have expatiated how the interpersonal connection affect the local sourcing work. A summary of identified forces for and against local supply base localisation can be found in Table 1. Major forces for localisation are here divided into cost reduction, strategic and managerial requirements, avoidance of risk of foreign purchasing, good local supply market environment, nature of supply process (reliability of the system), human factors and others. Major forces against localisation are technology and quality issues, internal management issues, product requirements, culture and communication, potential risks of suppliers' business mentality and others.

Previous studies and literature frequently suggest that the problems with local sourcing in China mostly focus on supplier performance. The three major problem aspects often mentioned are poor quality components, poor performance in delivery as commitment, and delays in the delivery of components (Fryxell *et al.*, 2004; Kaiser, 1997; Mummalaneni *et al.*, 1996).

Table 1. Summary of major forces for supply base localisation based on Eberhardt *et al.* (2004), Kaiser (1997), Zhou (2004), Millington *et al.*, (2006a), Choi and Krause (2006), and Handfield and Nichols Jr., E. L. (2004).

For localisation **Major forces and sub-forces**	**Against localisation** **Major forces and sub-forces**
To reduce costs • low price, short lead-time, warehouse stock, cash-flow factors • to reduce the influence by the quick changes in currency exchange rate	**Technology and Quality issues** • no design authority & testing facilities • lack of component availability: lack of technology or economies of scale • lack of acceptable stable quality levels, linked to lack of QC and production mentality/culture
Strategic and managerial requirements • existing supply link between parent and local Chinese supplier • positive attitude/support toward localisation on behalf of the parent • conductive parent/subsidiary business strategy • to seek for long-term partnership with local supplier	**Internal management issues** • parent company authority oversourcing (global purchasing agreements, contractual sourcing for JVs, in-house sourcing, HQ mindset, no push for localisation/inertia) • length and cost of internal supplier approval procedures
To avoid the risk of foreign purchasing • customs issues • logistics issues • speed and responsiveness of suppliers	**Products requirements** • external component approval authority, incl. customer approval • customer prescription of overseas source
Local supply market environment • industrial clusters • component is available to desired quality levels, • abundant resources and alternatives • competition for suppliers	**Culture and communication** • language barriers • cultural misunderstandings • unfamiliar corporate values
Nature of supply process (reliability of the system) • JIT, lean production	**Potential risks in suppliers' business mentality** • short-termism, myopia • IPR violations
Human factors • keen and diligent local suppliers, • competent purchasing staffs • Improved communication & increased convenience of interaction with suppliers	**Human factors** • incompetence, lack of training, cultural issues, fear of corrupted staff • turnover of staffs affects long-term relationship-building with local suppliers
Other • government influence • improved local supplier search, • JV with Chinese partner	**Other** • delivery performance

3. Research Design and Methodology

This paper is based on a comprehensive literature review and an interview study conducted among twelve companies April - June 2012. The twelve companies consist of eight foreign manufacturers who have production facilities in China and four local suppliers in China doing business with foreign manufacturers, see table 2.

Table 2. Companies ‘information and respondents of the foreign manufacturers in China

ID	Industry	Origin	Length of operation (Years)	Domestic sales in China[1]	Local Sourcing[2]	Respondents
A	Machine engineering	Sweden	1	100%	30%	Purchasing manager China project team
B	Machine engineering	Denmark	4	100%	50%	Plant manager
C	Special materials	USA	6	98%	60%	Purchasing manager
D	Telecom and electronics	USA	10	80%	80%	Purchasing manager
E	Machine engineering	Sweden	6	95%	40%	Purchasing manager
F	Machine engineering	Spain	7	80%	80%	Purchasing manager
G	Chemical	Germany	16	80%	90%	Purchasing manager
H	Automotive supplies	UK	17	70%	60%	Purchasing manager

The manufacturing companies represent various industries which include automotive components, engineering manufacturing, chemicals, telecom and electronics. Most of the interviews were face-to-face interviews while two were telephone interviews. The respondents were mainly from management level; typically plant manager, logistics manager or purchasing manager from the foreign manufacturers’ factories and general manager, key account manager and sales manager from the local Chinese suppliers’ companies. The duration of each interview was between one to two hours, mainly closely to two hours. The foreign manufactures interviewed were all wholly-owned foreign enterprise (WOFE) which is the main investment form of foreign corporations investing in China since 2000 according to Ding and Zhu (2006). The interviews with the foreign manufacturers in China were based on an interview document of organized questions (15-20 questions) comprising 10-14 open questions and 5-6 closed questions. The first part of the interview protocol comprised company background including organisational form, function of the production facility, information of industry and type of products. The second part dealt with supply base development, determination of local suppliers for their production facilities in China, how the supply base was managed, issues concerning relationship with the suppliers and obstacles for supply base localisation. At the end of each interview, the respondents were asked about their general opinion about the China supply market and how they compared the performance of local Chinese suppliers vs. foreign suppliers.

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[1] Percentage of the volume of total production in China
[2] Percentage of the value of total materials purchasing

The Chinese suppliers could be divided into two categories; two of them being WOFEs which had the same background as the foreign manufacturers; and two of them being private companies (see Table 3). Suppliers from state-owned enterprises, i.e. SOEs, were not included because most of the foreign manufacturers in the study had very few cooperation activities with this supplier category due to SOEs' operation policies. Suppliers from WOFE/JV and private companies constituted a major proportion of the Chinese suppliers of the interviewed small and medium manufacturing companies.

Table 3. Companies' information and respondents of the local suppliers in China

ID	Industry	Origin	Length of operation (years)	Owner-ship	Products produced domestically[3]	Respondents
I	Machine engineering	China	10	Private	20%	Sales manager
J	Electronics	Netherlands	10	WOFE	100%	Key account manager
K	Chemical	China	5	Private	100%	General manager
L	Power electronics	Denmark	2	WOFE	50%	Regional sales manager

The interview questions with local suppliers in China consisted of 10-15 questions related to the identities of the suppliers, factors affecting customer selection, obstacles when working together with foreign manufacturers in China and improvement suggestions for those foreign manufacturers building up a supply base in China.

4. Results

The results of the interview study are grouped into different aspects presented below.

Motivation behind production localisation decisions in China

The driving factors for localising production in China according to the respondents in the manufacturing companies were geographical proximity to customer factories, lower overall cost, potential market share, accessibility of resource and supply, and strategic requirements, see Table 4. Five companies stated that they followed their customers to China; "*Our customers moved to China, so we had to establish a factory close to them if we wanted to continue delivering to these customers*." The great potential market and strategic requirements were also frequently mentioned in the interviews. More than one respondent expressed that if China was left out of the discussion about the company's future that would reflect a poor strategic management. At present, the Chinese factories mainly served the Chinese market, between 70 % and 100 % of the products were sold domestically on the Chinese market. However, all of the respondents also stated that they had intentions to enter new markets in East Asia such as Japan, South Korea, Thailand, Taiwan, etc., as well as Australia. The empirical findings further indicated the trend that the domestic percentage of the sales was decreasing along with the time duration the companies have been present in China (see Table 2), which implies an increased proportion of exported products over time. This is consistent

[3] Percentage of values of total products produced within China

with the intention of expanding the scope of market out of China based on the manufacturing in China.

Two respondents from different companies that had been in China over 10 years stated that the low production cost was their main motivation of their supply base development. However, respondents from companies with recent establishments in China stated that the production cost in China was currently not as attractive in comparison with the emerging low cost countries (LCC) in East Asia such as India, Vietnam, and Bangladesh among others. Only one company claimed access to resources to be a driving factor for SBE in China. Other respondents expressed that although access to resources and supply was important it was usually not taken into consideration as much as the other factors.

Table 4. Motivation for production localisation in China

Key motivation for production localisation in China	**Foreign manufacturers**							
	A	B	C	D	E	F	G	H
Geographical proximity to customer's factory	√	√	√				√	√
Lower overall cost					√	√	√	√
Potential market share	√			√	√		√	
Strategic requirements	√			√		√		√
Access to resources and supply					√			

Establishment and development of a local supply base in China

The respondents agreed on the following advantages of local sourcing in China:

- High flexibility of Chinese local suppliers
- Price advantage
- Convenient communication with local suppliers
- Avoidance of custom issues
- Industrial clusters and regional economics providing good supply environments

For example the advantage of utilizing the benefit of being close to industrial clusters and regional economics was suggested by Porter in earlier work (1998). Most of the companies that took part in the study had the intention of extending their local sourcing in China. From the interviews it was clear that implementation of this localisation was challenging, normally due to e.g. concerns about quality and technical level of local products. Only one company showed a clear strategy to maximize the extent of localisation of supply in their Chinese factory (see Table 5). According to the respondents, some resources were not easy to purchase in China for the time being. These resources normally require some certain technology, very extensive testing, and/or high confidentiality (related to the core components).

Table 5. Companies' attitude towards supply base localisation in China

Attitude towards supply localisation	Foreign manufacturers							
	A	B	C	D	E	F	G	H
1. **Very eager** (intension is maximizing the extent of local sourcing)					√			
2. **Moderately positive** (proceeding with cautiousness)	√	√		√		√	√	
3. **Suspicious** (holding a cautious attitude based on longer observation)			√					√
4. **Negative** (local sourcing not considered due to potential risks)								

Make-or-buy discussions were often raised in the Chinese factories for the following reasons, as stated by some of the respondents:

- Internal innovation requires components/materials with high confidentiality
- Required technologies or desired quality is not available on current local market
- The cost of in-house production is cheaper than purchasing components
- Required quantity for relevant components increases considerably

Interesting to note from the study was that some of the components as well as production equipment and machinery that were made in the studied companies' Chinese factories had never been produced in the company's countries of origin.

The early stage of the supply base development, after the decision of the design of the factory was made, seemed to be quite similar among the studied foreign manufacturers. A generalized description of the process was the following: The sourcing activities largely depended on the project team coming from the parent company to Chine with the task of working in the early development phase, i.e. the initial period of the factory setup. The team often consisted of employees from different functional departments of the parent company including production, sourcing and logistics. Employees/experts from the purchasing department were also sent to China to handle all the purchasing questions including many more issues than the traditional ones of finding suppliers for the direct material. In the beginning, the task was also to find indirect suppliers for building the actual factory and for all the equipment needed for production. The facility site was often located in a financial trading zone and rented without lighting or interior facilities included. The sourcing work started with the indirect materials like interior design, electrical insulation, equipment of the office and the relevant purchasing of equipment for production like transfer lines, machines etc. For the direct (production) materials, shipment by sea was often arranged for supplying of material coming from the overseas parent company. Meanwhile, suppliers for the direct materials were investigated. The sourcing engineers first reviewed possible suppliers from the existing data base of the parent company. Those suppliers had been through a number of questions, required certificates and visits. Then a short list was made in which a number of suppliers in the database were remaining (e.g. in one example, 30 % remained on the list). Local staff with experiences from the industry provided information and in some cases, a 3rd-party sourcing council was consulted.

According to the respondents, procurement tasks were normally carried out by multifunctional departments. Departments directly involved were often sourcing, purchasing, production, quality control and R&D. Many respondents explained that the complexity of the involvement was related to how critical the function was, how extensive the value of the components was, and how much support that was needed. The foreign parent companies normally provided support on technical aspects as well. As stated by the respondents, support needed from the manufacturing company's overseas office was for example:

- Overall exploratory investigation and development of local suppliers (at the early stage of the factory setup)
- Technical consultation, typically testing and quality control
- Information collection and audit (of required documents, production process, on-spot investigation)
- Pricing negotiation and contract management

All respondents stated that any new supplier needed the approval of at least one foreign manager to enter their company's supply base. If approval was given it was typically from a purchasing manager or a plant manager. However, if the purchase-value was high or the technical requirement was too complicated, the decision from higher management normally located at the overseas office was often needed.

Obstacles in supply base localisation in China

The empirical study further indicated some obstacles when localising the supply base in China. Manufactures who have limited production volume (normally new comers) always found it difficult to find suppliers of adequate performance. Most of the respondents mentioned that although their companies worked hard to seek for lower costs, they were not looking for the cheapest (or even second or the third cheapest) suppliers. They were looking for suppliers who could deliver good quality products on time. These companies existed in China according to the respondents, however, they normally only cooperated with customers with a considerable volume of demand.

Another obstacle had to do with employee turnover at the Chinese suppliers. This problem was indicated from two different perspectives. One was that competent sourcing staff leaving the company would result in an interruption of relationships with existing suppliers and disturb other network contacts. This was also addressed by e.g. Millington, *et al*. (2006a). The other perspective was that unstable employment of personnel in the production systems of the supplier companies influenced the delivery performance.

A third obstacle was the manufacturing company's fear of being copied by the suppliers. A respondent expressed his concern in the following way: "*Chinese suppliers are faster to deliver samples – this is also a risk because it can mean that they are very fast at making copies.*" Many respondents stressed that they were very careful in the relationship with local suppliers. They also suggested the importance of long-term cooperation with the suppliers.

Other obstacles that were mentioned by the respondents in the study were; poor quality, low education level of operative employees (blue collars) in China, good attitude towards complaints but slow action, cultural differences, poor management, the dilemma of decision authorisation in local purchasing staffs, fear of corrupt behaviour (return commission) and suppliers' loyalty and stability.

Supplier perspective on the customer

The respondents at the supplier companies stated that they preferred customers that have:

- influence in the corresponding industry (market share, volume)
- good reputation (quality, service, business fairness)
- the same technical standards (many industries have different technical standards worldwide)
- professional staffs that can communicate well in the both aspects of technology and business culture.

According to the supplier respondents, foreign manufactures often have a good reputation in quality, service and business fairness, particularly those from US and most countries of Europe. The respondents further mentioned outstanding management and well-trained staff as describing factors of the foreign manufacturing companies. However, three of the supplier respondents still expressed that the production volume and contract value was the most attractive factor for a potential supplier. According to the interviews the production scale of foreign manufactures were considered rather small compared to the many state-owned manufactures and local private manufactures in China, i.e. their volume demands were higher which was advantageous when selecting suppliers. Another drawback for foreign manufactures is in communication and technique standards, as mentioned by the respondents.

The customer's ability to accept the supplier's technical proposals and professional capabilities was mentioned as important by one of the respondents. The reason was that their products applied to the technical standards in Europe. However, many of their products were not applicable to the Chinese customers because of their different industrial standards (normally relevant modifications were needed). So on one hand, such suppliers wanted to cooperate with customers who could support them with the requirements of EU standards, on the other hand, they hoped that these customers were capable of understanding what technical support that was needed from the suppliers and to find good ways of cooperation between supplier and customer. To summarize, the supplier respondents were asked what improvement suggestions they would like to give to the foreign manufacturers (potential customers) who were establishing their local supply bases in China. Here, localizing the R&D function was suggested.

When the supplier respondents were asked to give improvement suggestions to the foreign manufacturers (potential customers) who were establishing their local supply bases in China, localizing the R&D function was suggested.

5. Analysis and discussion

The obstacles reflected by the respondents in our interview study were partly consistent with the survey report of USCBC (2011) which listed top ten issues concerned by US companies with production operations in China. In addition to the obstacles mentioned in our study, the report also mentioned other issues related to the supply base localisation including administrative licensing, gaining business licenses and product approvals, competition with Chinese companies (state-owned or private), standards and conformity assessment, restrictions on foreign investment in China, including ownership limits, transparency, non-discrimination/national treatment (equal treatment with Chinese enterprises), market access in services, including finance, legal, information, and telecom. The obstacles mentioned in the interviews indicate that there are current limitations when localising a supply base in China, and is due to for example status quo of industry development and industrial policy in China. Researchers have also expressed a concern that the rapid growth of China's industry may create problems such as low quality standard and unstable supplier relationship (Zhong and Cheng, 2003).

Compared to many other operations in production localisation, supply base localisation is often considered in a later phase, after the manufacturing has been established; see e.g. Morgenstern (2006). Our empirical findings indicate that an important reason behind this is that at the early stage, the supply for production (equipment, components) largely depended on carry-over from previous resources, often imported from the country of origin (or areas close to the country of origin). This is also a reason as to why the coastal region of east China was chosen. However, with increased maturity of the manufacturing companies in localising production in China, the probability is high that supply base development becomes more and more important. Leveraging varied factors such as cost, technology, policy, competition from external environment etc., working with supply base localisation is an on-going task to include in the manufacturing strategy.

From the interviews it was noted that the extent of supply localisation (measured by the percentage of the value of total materials sourcing, see Table 2) did not have a clear correlation with the manufacturing company's time of operations in China. It rather correlated with technology and quality requirements, government policies and the willingness of the parent company. Government influence is considerably extensive in many industries in China. The company that had the largest extent of supply localisation in the empirical study belonged to a sunrise industry' which was supported by the Chinese government. The support was mainly embodied in government's encouragement in technology innovation and local enterprises' development so that various entities on the industrial chain got a rapid growth. A large range of components and equipment were available at the local market with high quality, competitive price and a considerable scale of production. The company was facing increasingly fierce competition and a large extent of components localisation in China was considered the best way to reduce the cost in order to keep the dominance on the market. It can be noted in the make-or-buy discussions that the local supply market environment provides foreign manufacturers with good possibilities in China; hence a good reallocation of existing resources could be a way towards increased competition.

According to the respondents, the best way to approach the task of selecting Chinese suppliers was by utilizing data from the manufacturing (parent) company's own existing supplier data base, as well as recommendations of external business partners, resources from hiring local staff, and assistance from 3rd-party sourcing councils. These findings are consistent with those stated by e.g. Handfield and McCormanck (2005) who suggested that the best approach is to always get references from anyone who has done similar work in the same country. Other methods mentioned were to search for alternatives via internet, exhibitions, buying commercial information and cold calls of local suppliers.

Supply base localisation at different stages

Many of the studied foreign manufacturing companies experienced a similar process of localisation to that of the five-stage model presented in (BCG, 2004). The foreign manufacturers in the study could all be placed at the stages between being explorers and settlers, characterised as a local production facility with independent operation to a certain extent, see figure 1.

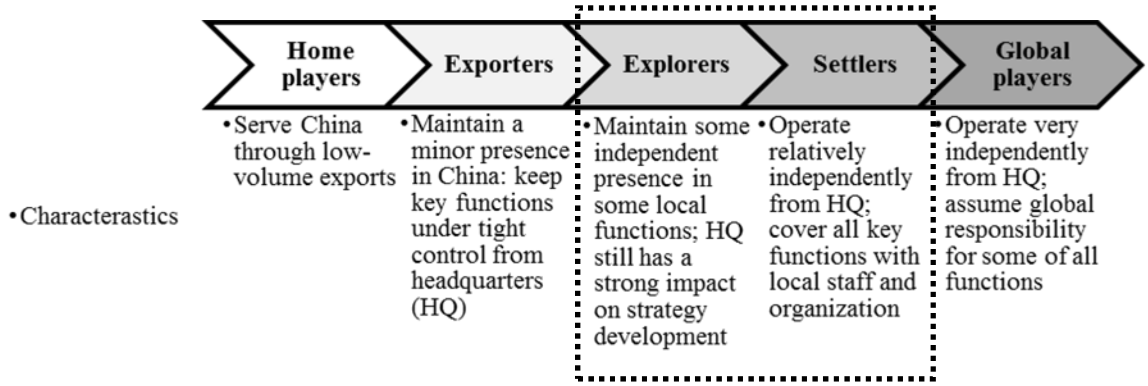

Figure 1. Stages of production localisation (based on the model from Lang *et al.*, 2008)

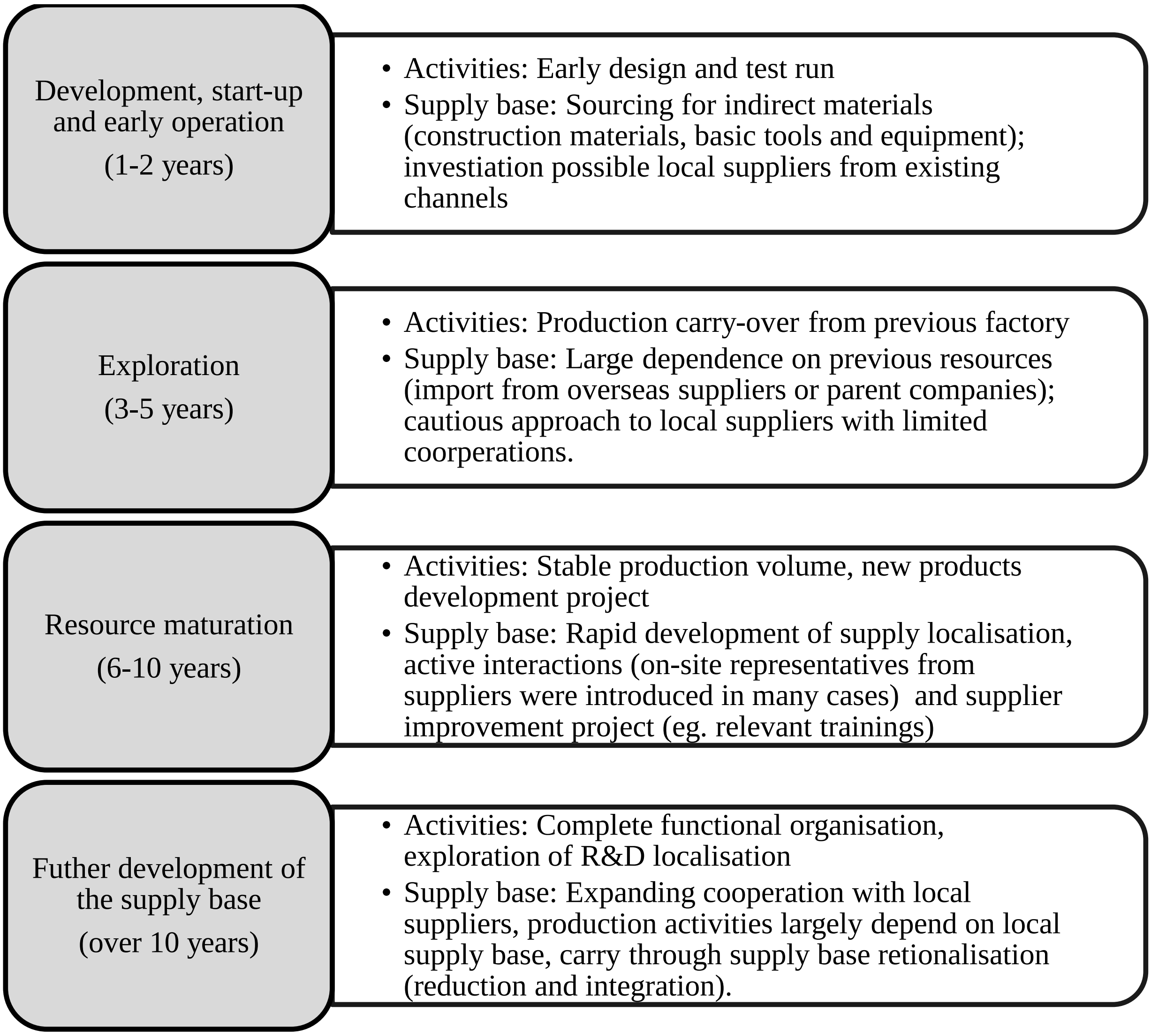

Figure 2. Different stages in the process of developing a local supply base in China

The studied companies had been operating in China from one to 17 years. Their activities were, therefore, of different kind depending on where in the production localisation process each company operated in, see figure 2.

The respondents from supplier companies that took part in this interview study claimed that a considerable work had to do with the first element, i.e. that of choosing customers. Small and medium foreign manufactures found difficulty in securing the cooperation with first-class suppliers. Although this seems difficult to compromise from both sides, experienced sourcing people suggested a few “techniques” like to pick up from the suppliers (usually suppliers are responsible for the transportation to customers in China), to ask for samples if the demand is extremely small. The suppliers also suggested that approaching distributors of the big suppliers could be an option for the small manufacturers, although the idea mainly would apply to some standard components or materials. Another suggestion mentioned by both sides (customer/supplier) was to give the second-class suppliers a chance, since these suppliers could be trained to perform well by the help of their customers, i.e. the foreign manufacturers could help the suppliers with advanced technology and effective management.

Localising R&D in China was suggested by the suppliers in the interview study as a way to further develop their relationship. The reason mentioned was that foreign manufacturers could have different technical standards with Chinese products. When the local products cannot match the standards of foreign manufacturers, it used to take a very long time to deal with, either the local supplier or the foreign manufacturers was going to make necessary change. Considering the limitation of local suppliers’ technical competence, it used to be the foreign manufactures that made changes in order to adapt to the local technical standards. However, the distance and time difference influenced the effectiveness. The importance of a localized R&D function could show a great advantage in efficiency, see for example Sun *et al.* (2007) and Chen (2008) who have analysed R&D localisation in China.

6. Conclusions

To summarize, this research was conceived in order to identify the factors related to local supply base development affecting production localisation in China. Based on interviews with twelve entities in China consisting of eight foreign manufacturers and four local suppliers, an up-to-date investigation has been made of issues that need to be dealt with concerning supply base localisation in China. The findings indicate some early results of interest to e.g. foreign manufactures that have strategic considerations on production localisation in China, particularly SME and those who are at the early stage of production localisation in China. These early findings demonstrate a number of interesting aspects to investigate further since this is an area of high interest to all global manufacturing companies already operating in China, or planning to do so in the near future. Increased understanding and new knowledge is advanta-geous for making relevant production localisation and supply decisions.

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Further Exploration of Dynamic Capabilities: based on a Chinese commercial vehicle exemplar

Xiaozheng Jin (1) and Yongjiang Shi (2)

(1) The Hangkong and Shanghai Banking Corporation Ltd., Hong Kong

(2) Institute for Manufacturing, University of Cambridge, Cambridge, UK

Abstract:

This research paper aims to explore and enrich the process model of dynamic capability. It reviews key definitions and descriptive models of dynamics capabilities and identifies three key research gaps. The paper uses a Chinese commercial vehicle company as an exemplar empirically demonstrating the process of dynamic capabilities during the firm development. It contributes to theory in the following three arenas. Firstly, a five-process framework entitled as “Scanning-Identifying-Positioning-Leveraging-Restructuring” is proposed, which offers insights into the character of dynamic capabilities particularly pertaining to firms from emerging countries like China. Secondly, dynamic capabilities are harnessed through a three level orchestration, namely strategy, value chain and organization. Thirdly, an enabling system was found that is crucial to the development and function of dynamic capabilities in the firm level.

Introduction

The academic work on dynamic capabilities has been flourished since the introduction of the concept over a decade ago. The research focus of dynamic capabilities has been gradually diffused from conceptual discussion to practical applications. Recent academic work has discussed and explored the process side of the concept.

Through extensive literature review, there are three gaps being identified. Firstly, an integrated, systematic and holistic view of dynamic capabilities is needed to consolidate the fragmented conceptualisation, due to the fact that conceptual construction are more appealing in the early stage of dynamic capabilities study. Secondly, empirical studies in the firm level are needed before the concept can be applied to a further extent. There are not many empirical studies to reveal the process yet, lack in-depth accounts of how dynamic capabilities’ mechanisms in the firm level. Thirdly, experiences and practices from the fast emerging countries are needed in order to balance the current priorities given to established countries. From research opportunity perspective, the emerging countries like China, India and Brazil are able to provide excellent observation sites to explore dynamic capabilities and their impact on firm growth and competitive advantage development.

This paper attempts to address these gaps by answering the research question "How do dynamic capabilities help emerging firms achieve rapid growth in the changing environment?" The Chinese commercial vehicle industry was chosen as appropriate to place the inductive case study, including a leading domestic vehicle manufactures. The rest of the paper has been divided into six parts including literature review, research design, a detailed case study in the Chinese commercial vehicle industry, case analysis, research findings, and final conclusions.

Literature Review

Dynamic capabilities has attracted increasing attention within the management scholars since the concept was first introduced by Teece et al (Teece, Pisano et al. 1997) in their influential seminar paper of *dynamic capabilities and strategic management*, as evidenced by citation counts and the amount of programmes at major conferences, by sponsors, such as the Strategic Management Society and the Academy of Management (Mark, Marjorie et al. 2009). Many insightful thoughts and works have been produced during last decade. From the rising interest in this topic, there have been a lot of conceptualisations and interpretations concerning the concept itself.

The main intention to introduce the concept of dynamic capability is to provide an alternative approach to explain the sustainable competitive advantage issues of firms in strategic management. A growing body of evidences, especially at the firm level, indicated that dynamic capabilities are important in explaining how firms can survive and grow in the changing business environment.

Like many things in their growing stage, the concepts of dynamic capabilities have been diversified from the origin of Teece et al (1994 and 1997). There have been many definitions drawn from wide range of disciplines along the conceptualisation process. The Appendix lists major definitions of dynamic capabilities emerged in the past decade.

By summarising those varying definitions, three perspectives have emerged by identifying the key words in each definition. They are ability, activities and process. Such three perspectives aim to reveal the different patterns in viewing dynamic capabilities. One typical criticism over dynamic capabilities is that the concept is endlessly recursive, and non-operational when it is described as "routines to learn routines" (Mosakowski and McKelvey 1997; Williamson 1999; Priem and Butler 2001). Such disadvantage is due to lack of understanding of the inner mechanisms of dynamic capabilities.

The process view considers dynamic capabilities are realised through the management and organisational processes that directly or indirectly change the firm resource base. A number of scholars have conceptualised dynamic capabilities frameworks. However, most are conceptual work based on theoretical thinking with inadequate emphasis on the actual processes in the empirical settings.

Drawing on earlier analysis, Teece further proposed a preliminary framework of dynamic capabilities, which disaggregates dynamic capabilities into three kinds of capacities for analytical reasons, including sensing, seizing and transforming, as demonstrated in the figure 1. This preliminary framework was adopted here in this research as it fits with the definition and can provide a new process based approach to operationalize the concept and capture dynamic capabilities in the firm level. Teece's model of sensing, seizing and transforming also hinted a time dimension. The sensing, seizing and transforming processes are considered as a sequence based.

Drawing from the above literatures, the following figure (Figure 2) demonstrates how dynamic capabilities function in the firm development over time in general.

The basic function of dynamic capabilities is to change the resource base or to create new capabilities in accordance of external and internal environment dynamism. Prior research focuses on the theoretical conceptualisation of the construct, without much emphasis on the inner mechanism of dynamic capabilities, say how dynamic capabilities functions in the firm level to change its resource base, according to the changes from the competitive environment. Therefore this research intends to focus on the black box of dynamic capabilities, as shown in the grey area.

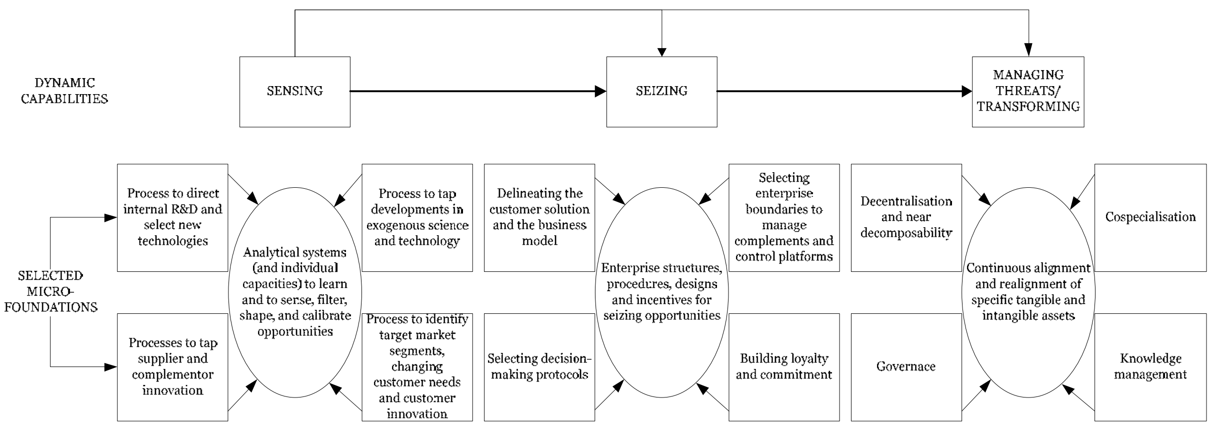

Figure 1. Foundations of dynamic capabilities and business performance (Source: Teece, 2007)

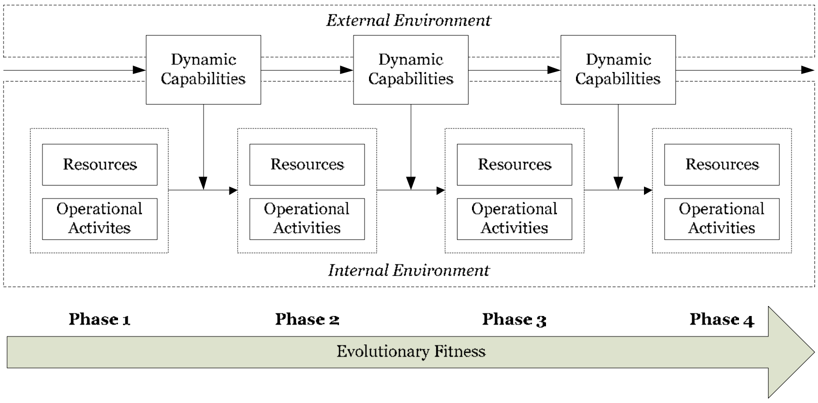

Figure 2. Dynamic capabilities illustration

In summary, through the literature review and analysis, there are three types of gap being identified, namely conceptualization, application, and opportunity. Conceptualisation gaps are identified in the concept development stream, while application gaps look at the use of the concept. The lack of understanding from both sides can limit and impede further progress of the development and application of the concept. And current empirical data demonstrating dynamic capabilities is mainly from emerging industries but not emerging countries. The mainstream research work hasn't engaged with the appealing emerging countries' firms yet.

Research Design

Since the first introduction of dynamic capabilities, the black box of the concept has been revealed gradually in the last decade. However, a systematic and integrated framework based on empirical data should be developed to enable further development. The emerging firms from Chinese commercial vehicle industry somehow provide a new research context to study dynamic capabilities in the emerging firm growth in this changing environment. Following the previous literature review and practice review, research question is raised as below:

What are the processes of dynamic capabilities in emerging firms?

This research question tires to enrich the understanding of the dynamic capabilities through studying the rapid growth of emerging firms.

This research is aimed to propose a process-based framework of dynamic capabilities grounded in empirical data. As dynamic capabilities are concerned with processes and which are continuous and iterative. It will involve an investigation of organisational practices and events over time.

"What" and "how" questions of dynamic capabilities are intimately related and complementary, as two parts together form the complete picture. The "what" question somehow cannot be addressed adequately without considering the "how". Therefore, detailed case study is appropriate to develop an in-depth understanding of those empirical data, as case studies are a good way to examine a phenomenon in its natural setting. It is the ideal qualitative methodology when a holistic, in-depth investigation is needed (Eisenhardt and Martin 2000; Wang, Ahmed et al. 2007).

Chinese commercial vehicle industry has been highlighted as the context of the research. In terms of case selection, the suitable case firms have be chosen according to the following criteria. Firms should be involved in the manufacturing part of the commercial automotive industry. Vehicle assemblers are preferred in the first place, as they involve in the finally production part, which will provide good understanding of the industry as their control over the value chain.

Those criteria above provide a general guidance of case selection, potential case firms could be further identified through market recognition and commercial database. Other sources of information are necessary for the case selection process.

Case Observations

Beiqi Foton Motor Co., Ltd. (hereinafter referred to as Foton), was incorporated in 1996, is the one of largest domestic commercial vehicle manufacturers in China. Headquarter of Foton is located in Changping district, Beijing city. Its holding company is Beijing Automotive Industry Group, a Beijing state-owned conglomerate, which currently controls 37.71 per cent share of Foton. Up to 2011, Foton is staffed with over 32,000 employees and its factory network includes 8 production sites across China.

It is the fastest growing commercial automobile company in China. Without prior experience and advantageous resources in automobile designing, manufacturing and distribution, it just takes Foton a decade to become one of the flagship commercial vehicle manufacturing companies in China. The mission statement of Foton is “striving for better life by means of human-oriented science and technology, driving continuous improvement with passion and innovation”.

Foton is a commercial vehicle manufacturer with full spectrum of products, which means it covers the whole range of commercial vehicle products. The company’s business portfolio covers four business units, light truck, heavy truck, buses and coaches, and multifunctional vehicles. Foton also adopts a multiple brands strategy to manage its product range with 9 brands. In the light truck sector, there are three brands, Forland, Ollin and Aumark. In the medium and heavy truck, there are Auman and Rowor. Its bus and coach sector uses Auv brand. With respect to the multifunctional vehicle sectors, it now has four brands to cover different segments, such as View, Saga, MP-X and SUP.

Table 2 Foton product portfolio and sales volume in 2009

Product business	*Brands*	*Sales volume*	*Share*	*Domestic ranking*
Light truck	Forland, Ollin, Aumark	383,797	75%	1st
Medium and heavy truck	Auman, Rowor	84,641	17%	4th
Bus and coach	Auv	4,002	1%	n/a
Multifunctional vehicle	View, Saga, MP-X, SUP	34,919	7%	n/a

Foton's sales volume has boosted from around 26,000 units vehicles in 1996 to over 600,000 in 2008 continually. Foton became the largest light truck manufacturer in China since 1999 after it was release to the market. In the end of its second five year plan, it sold more than 340,000 vehicles, with a 31.1% annual growth rate. By the end of its third five year plan, it doubled its sales up to over 600,000 units, with 47.1% annual growth rate in 2009. In 2004 and ever since, Foton has become the market leader in the whole commercial vehicle range in China with its diversification strategy. In 2009, Foton became the largest commercial vehicle manufacturer in the world, surpassing Daimler in terms of production volume. In terms of its export business, the company exported 24,443 unit vehicles, ranking the second in the domestic export market with 11.9 per cent market share in 2009. The major export markets are developing countries in Asia, East Europe and Africa.

Table 3 Annual sales growth of Foton from 1996 to 2008

	Sales growth from 1996 to 2008 (1,000 units)												
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Sale Volume (1000 units)	26	50	70	100	106	127	170	260	341	311	344	401	600
Achievement				Domestic light truck No.1									
									Domestic commercial vehicle No.1				

Based on the financial data, it can be suggested that light truck and heavy truck are Foton's two key business units that are critical to the development of the company. The following sector is devoted to the detailed analysis of the development of the company's two SBUs, light truck business and heavy truck business in a chronological manner.

The paper maps Foton key projects in its growth journey. Using the project mapping data, Foton development process and dynamic capabilities are identified.

Case Data Analysis for Constructing Dynamic Capabilities Process

The development of two most important business units in Foton has been analysed respectively. Both businesses have demonstrated how the Foton managed to cope with the dynamisms in the internal and external environments. The development trajectory of each business also has differences. The light truck business depicts how Foton shifted to automobile manufacturing by struggling from low end of the market towards high end, while the heavy truck illustrates how Foton was able to penetrate into the premium heavy truck sector directly at the very beginning and continue to evolve to lead the product development. Both of the business shifts contain two major periods, the establishment of new SBU and the continuous upgrading of existing SBU.

Based on categorisation of the two periods, key events of each business unit are highlighted for further comparative analysis so as to better analyse dynamic capabilities in the firm level.

Those key events highlighted in each phase can be further categorised around the same theme, where a pattern emerged. It can be identified that key events highlighted in each development phase during the establishment of the new SBU are mostly concerned with five themes, namely activities to scan environments, activities to identify opportunities, activities to position company or product in the market or industry, activities to leverage external resources and activities to restructure organisation.

The five themes illustrated the dynamic capabilities processes that enabled Foton to establish new SBU. Based on the highlighted events, key aspects are summarised at the bottom of the company. Scanning involves internal and external environments. External ones include competition, market demand and legislation, while internal one is management issues. The identifying is concerned with market opportunities based on company’s strength, weakness. Positioning further indicates company’s position of product, technology and value chain. Leveraging modifies firm’s value chain and capital resources. The restructuring shapes company structure, human resources and company governance practices.

Table 7 Developing key process and related key aspects of
dynamic capabilities of Foton’s establishment of new business units

	Scanning	Identifying	Positioning	Leveraging	Restructuring
Light truck	Farmyard vehicle business matured	Team assembled to conduct market and industry research	Targeting at entry level light truck	Low cost expansion was adopted to adapt resource base	The company began to foster inter group linkage between marketing and R&D people
	Increasing competition in farmyard vehicle business	Meetings with customers held to collect market data	One Korean model was chosen as benchmarking product	Technology centre was set up with 13 researchers from farmyard vehicle business	An research department was established to be in charge of industry and market review
	Farmyard vehicle excluded from automobile industry by authority	Collecting monthly sales data	Product specs decided	External partners were sought for technology in a contract approach to develop engines.	Service department was set up
	Strong domestic economic growth	Lack of resources in automobile industry	Utilising on resources in BAIG	Acquired one engine model from Hunan Huayu Engine Company and moved the production line back to Zhuchen factory.	Modern corporate governance was adopted

	Promising outlook of automobile industry	"Five Years Three Steps" strategy initiated to enter auto industry	External suppliers were found	Strategic alliances were made to secure key component supplier.	Supportive information system was set up to coordinate between factory and company level
	Increasing incomes of farmers	Light truck industry was chosen	Marketing strategy decided to emphasise on quality, utility and service	Existing production was done in the farmyard vehicle factory.	Process management started systematically
	Rural infrastructure development			Existing farmyard vehicle distribution network was used to establish its sales network at the early stage	
	Mr Wang's vision to enter auto making			An extensive service network was set up to increase its service capability.	
Heavy truck	Internal research department produced industry reports	External consulting firms hired to collect industry and market data	Targeting at premium heavy truck segment	Low cost expansion strategy was set to emphasise external resources	Heavy truck factory set up
	Light truck business stabilised.	Lack of resources in heavy truck industry	Product specs were decided	The cab design was outsourced to a Taiwanese firm Hanyuan.	Factory management system was migrated to SBU management
	Pressure of market competition in light truck business	Established firms experienced weak performance	Initial focus on interior and exterior design to differentiate the product and overall design capability	Key personnel were recruited from Sinotruk and university to form research centre.	Foton started to run the "Saturday Training Program" and "Employee Qualification Education Engineering Program".
	Domestic heavy truck industry restructuring	New "Five Years Three Steps" strategy was set to achieve expansion	Key systems were outsourced from market to ensure low cost and product quality	A technology centre was set up in Taiwan to learn reverse engineering	National call centre was set up
	Strong domestic economy growth and logistic industry development	Heavy truck was chosen	250 external suppliers were found	A technology centre was set up in Japan	
	Rising demand of road transportation		Marketing strategy decided to emphasise on brand, quality and service	Foton acquired Huairou automobile factory in BAIG to base its production.	
	New emission standards adopted		Foton intended to enhance its technology capability along the business development	Key assembling and testing machines were sourced from international companies.	
	Mr Wang's vision to create a great auto firm		International technology resources were to be tapped	The component supply was largely outsourced such as engines and chassis.	
				Tianjin Perking Engines was acquired to be its own engine supply.	
				Invested to develop Auman specific distribution network	
				Existing light truck service network was used to provide timely service to customers.	
				Collaborated with banks to provide dealers financial service	
Key aspects	Competition Market demand Legislation Management	Strength Weakness Opportunity	Product Technology Value chain	R&D/design Production/supply chain Distribution/service Capital	Organisation structure Human resources Governance

The case of Foton provides two small cases as light truck and heavy truck for individual analysis. Each small case can further be divided into two parts based on its development focus, namely the establishment and the continuous development. Those two parts both contributed to the rapid and sustainable growth of Foton. Simultaneous development has also been observed in the two parts of different business units. By cross comparing two parts p, a stabled dynamic capabilities process was revealed.

Scanning → **Identifying** → **Positioning** → **Leveraging** → **Restructuring**

Key aspects	Competition Market demand Legislation Management Technology	Strength Weakness Threats Opportunities	Product Technology Value chain	R&D/design Production/supply chain Distribution/service Capital	Organisation structure Human resources Governance

Figure 5 Dynamic capabilities framework of Foton

In summary, this section has presented the individual case study of Foton. A brief introduction and the milestones of the company development have been given. Light truck and heavy truck have been identified as the key business units in Foton's development. Both has been analysed respectively. Based on the two major period of new business establishment and established business development, a dynamic capabilities framework has been proposed.

Research Findings and Discussions

The aim of this research is to empirically examine, identify and explain the mechanism of dynamic capabilities functioning in the enterprise level. It contributes to enrich the understanding of dynamic capabilities. Based on an empirical case study of a leading commercial vehicle manufacturer in China, the aim was achieved. It makes four findings to the dynamic capabilities literature. These findings from the study form a systematic and integrated view to illustrate what the mechanisms and the deployment process of dynamic capabilities in the empirical settings. Dynamic capabilities played an equally critical role in emerging firm growth.

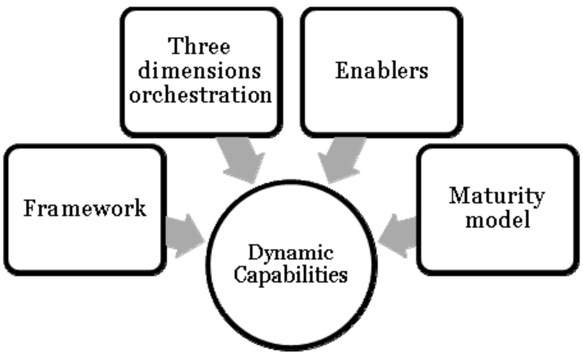

Figure 6 Research findings summary

Core Processes of Dynamic Capabilities

The proposed process-based framework of dynamic capabilities, which first confirms Teece's recent framework with its three core processes, and further extends it by identifying a five process model, including scanning, identifying, positioning, leveraging and restructuring.

Table 8 Core Processes of Dynamic Capability

	Scanning	Identifying	Positioning	Leveraging	Restructuring
Definition	Searching market and technology opportunities and threats from both "local" and "distant".	Recognising potential business opportunities that are most feasible	Further reviewing the identified opportunities based on firm's existing resource to position in the new business.	Exploring and exploiting resources to deliver the expected products or resources to the target market.	Adapt organisational structure to increase operational efficiency and responsiveness
Key Tasks	To systematically monitor and understand the environments where they set to compete	To further identify the opportunities and threats based on its strength and weakness	To get proper position in the value chain by creating the right organisational identity and relationship	To invest in development and commercialisation in the business network to form a value creation chain	To operationally adapt firm's organisation and network in order to increase efficiency and responsiveness
Aspects	Law and regulation Competition Market demand Competition Management	Opportunities Threats Weakness Strength	Product Technology Value chain	R&D/design Production/supply chain Service/ distribution	Organisation structure Governance

Three Dimensional Orchestration

Based on the framework, it has also found that dynamic capabilities are orchestrated by the firm in three dimensions, namely strategy, operational and organisational structure.

Dynamic capabilities are embedded in the process or routines of an organisation. Grounded in the empirical research data, this research takes a solid position to undercover the inner mechanism of dynamic capabilities in the firm context. A linkage between dynamic capabilities process with different dimensions within the firm has been established.

Drawn on the empirical case data, it has been found that there are three dimensions that dynamic capabilities are most actively engaged, namely, strategic dimension, operational dimension, and organisational dimension. These three dimensions hold organisational processes or routines that are most relevant to the orchestration of dynamic capabilities. In turn, core processes of dynamic capabilities have their focus in different levels. Each core process of the dynamic capabilities framework is individually important, but, to optimise its value creation, they must be synchronised. Thus, while managing each component of the process is important, the integration and balancing of components to ensure harmony in the development of company in face of changing environment.

The following figure is to illustrate the orchestration in three dimensions of the firm. This is to reveal a single loop of the processes of dynamic capabilities in the firm, although multiple SBU and different products have been observed along firm development.

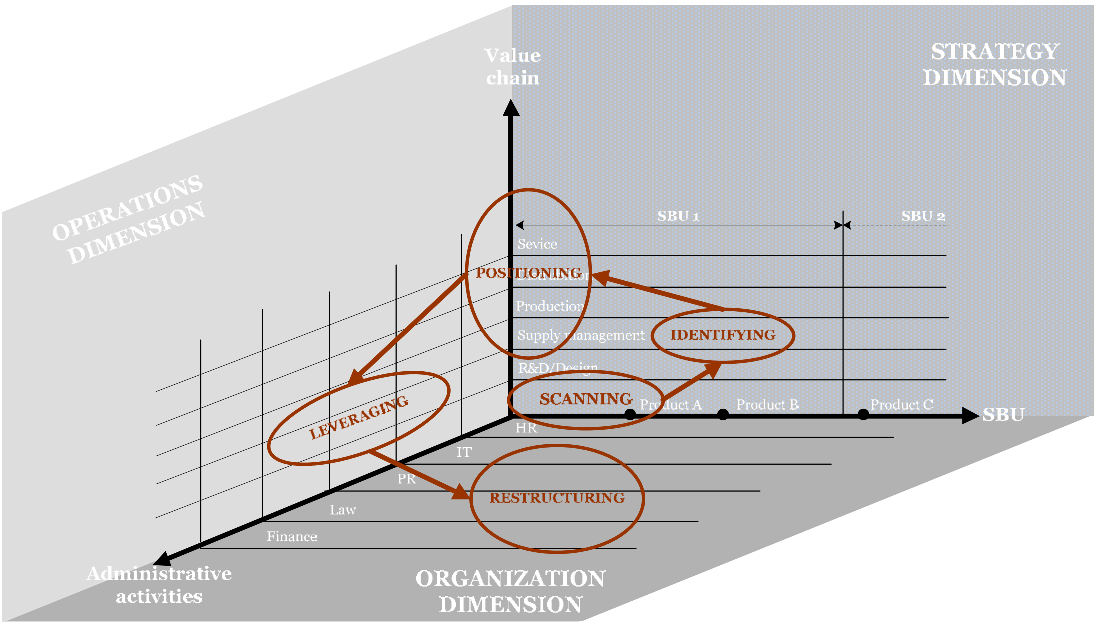

Figure 7 Dynamic capabilities process in three dimensions

Scanning and identifying is mostly relevant to the strategy dimension in the company. As it is about scanning environments and identifying opportunities, most activities from the cases are concerned with senior management, who are responsible for strategy making of the company. In the cases, especially in the early stage of its entrepreneurship, most sensing activities are done by the founder, which played a critical role as a sensor. The founder is responsible for accurately sense changes in the competitive environments, including potential changes in technology, customers, competition and regulation. Key elements in the sensing process supported this argument. In the case of Foton and Sinotruk, the sensing function was gradually institutionalised and moved downwards to organisational departments. The role of senior manager in sensing remains still critical.

Positioning and leveraging is more concerned in the operational dimension. It falls in the premise of operations of the company, involving how the company can orchestrate its resource base. Most activities spotted in the case study are value chain activities, which are easy and clear to identify as it is related to the specific product. It covers the mainly operational activities related to R&D, design, production, supply chain, distribution and service.

Restructuring concerns with the firm internal structure change and its external industry change as demonstrated in the case studies. Hence, the organisational dimension is where transforming process resided.

Key enablers of dynamic capabilities

Dynamic capability is considered as a variable in the firm. The performance of it is influenced by entrepreneuring, networking and learning. They are labelled as enablers in this research to illustrate that those factors influence the performance of dynamic capabilities in the firm level.

Teece originally explained that dynamic capabilities processes are shaped by path and positions (Teece, Pisano et al. 1997). Path refers to firm's evolutionary path, while position mainly refers to firm's assets and industry position. Path and positions are considered as the internal and external forces which enable and constrain dynamic capabilities. Dynamic capabilities are something that a company has to a certain degree.

Table 9 Enablers of dynamic capabilities

Enabling factors	Activities	F	Y	S
Entrepreneuring	• New thinking generating	√	√	
	• Pursuing new initiatives	√	√	
	• Motivating people	√	√	
	• Entrepreneurial inspiration	√	√	
	• Experimentation		√	√
	• Innovative problem solving	√	√	
Networking	• Efficiency of internal coordination and integration	√		
	• Integrating the inputs of distinct entities	√	√	√
	• Interrelating diverse inputs to jointly execute a collective activities		√	
	• Keeping managers informed of collective activities	√		√
	• Capturing synergies among tasks and resources	√	√	√
	• Pattern of collective activities	√	√	√
Learning	• Brainstorming	√		
	• Benchmarking	√	√	
	• Inter-organisation groups	√	√	
	• Repeated practice	√	√	√
	• Experience codification into technology and formal procedures	√	√	
	• Mistake and crisis	√	√	√
	• Dedicated research department to distributing, assigning and sharing knowledge resources	√		

Based on the empirical case, it is found that there is an enabling system constitutes of critical enablers to facilitate the execution or deployment or existence of dynamic capabilities in the firm level. That is, the synchronisation of the each process of dynamic capabilities requires a set of enabling factors to be simultaneously involved in all stage of the dynamic capabilities framework from scanning the external environment for important change to the restructure of the firm’s organisational structure.

The identification process of the enablers is based on the analysis of interview notes. Those activities highlighted have been mentioned by interviewees. A further classification of those activities reveals the three enablers, namely, entrepreneuring, networking and learning as the featuring enablers of dynamically capable firms. These three factors are the cornerstones that enable dynamic capabilities to be developed and performed efficiently and effectively in the firm level. The quality of those enablers in the firms will influence the overall performance of dynamic capabilities.

A preliminary maturity model for DC

As the case studies suggest each process of dynamic capabilities experience some growth. A preliminary maturity model has been proposed to track the maturity status of a firm’s use dynamic capabilities in its development.

Having established the process framework of dynamic capabilities drawn from empirical data, the inner mechanisms have been unboxed. As the process framework of dynamic capabilities is used to analyse how the change happened in the firm level, which mainly focused on new SBU development and its continuous development. Each case firm provides evidences in different SBU developments that there are some process practice has been improved over time within the same company. The use of dynamic capabilities over time has involved sustainable growth of firm. There is a need to have a maturity model to indicate dynamic capabilities of firms.

Maturity model is a set of structured levels predefined to describe how well the practices and processes of an organization can produce required outcomes reliably and sustainably. It is used to provide a place to start, the benefit of a community’s prior experiences, a common language and a shared division and a framework for prioritising actions. There are two types of maturity models, the staged and continuous ones. The stage type sets different predefined levels to indicate a fixed sequence of continuous progress improvement. For example, before reaching certain level, the organisation needs to achieve the previous level successfully in the model. The continuous type uses different levels to describe a sequential order for approaching improvement within key area, yet it allows the selection of the order of improvement that best meets the objectives of the organisation, which gives flexibility to the organisation. In the dynamic capabilities setting, the maturity model is the continuous type. It is because, firstly, the dynamic capabilities framework comprises five processes and a firm can have different levels of maturity in each of the processes included in the model. The continuous type can enable firms to concentrate on the process with a low level of maturity.

Secondly, the empirical data in the case suggests the flexibility in the framework itself, which has been highlighted earlier.
By reviewing the related maturity model, in this research, a four maturity level logic is adopted, as poor practice, better practice, good practice and best practice (Kahn, Barczak et al. 2006). Based on the five processes framework of dynamic capabilities identified in this research, a preliminary maturity model has been further developed, which involves defining the maturity levels to enable comparison and operationalisation.
There are two important criteria in each process, the scope and approach. Scope is used to indicate the content, activities involved in the process. Approach shows the way how the main process is initiated and sustained. Those two criteria are considered to be important in the case studies. The maturity levels of each process of dynamic capabilities have been defined in qualitative description. In this way, the model provides a systematic approach for carrying out benchmarking and performance improvement concerned with the process of dynamic capabilities. It also serves as an aid to the understanding of the concept.

Conclusion
The concept of dynamic capabilities has been proposed as a means for addressing how a firm can sustain competitive advantages over time in the turbulent environments by extend, modify and reconfigure its resource base. The research focus of dynamic capabilities has been gradually diffused from conceptual discussion to practical applications. Recent academic work has discussed and explored the process side of the concept to further open the black box of the concept. More empirical work is still needed.
Following the process stream, this research work focuses specifically on Chinese commercial vehicle industry. It has introduced an in-depth case study at leading Chinese commercial vehicle manufacturer – Foton. The dynamic and vibrant industry environments and company characteristics provide a good context to explore the nature and mechanism of dynamic capabilities in the firm level.
There are four research findings. Firstly, this research develops a process based framework of dynamic capabilities grounded in the empirical settings. The framework includes five phases as scanning, identifying, positioning, leveraging and restructuring. The concept of dynamic capabilities is viewed as sequenced processes that enable firm to address the changing environment to achieve and sustain firm's competitive advantage. Secondly, it is found that in the SBU or new product development level, those five phases of dynamic capabilities entails orchestration in strategic, operational and organisational levels. Thirdly, three enablers – learning, networking and entrepreneuring – have also been identified that are critical to facilitate the functioning of dynamic capabilities on the firm level. Fourthly, a maturity model of dynamic capabilities is constructed, involving aspect and approach of each of the five

sequenced phases. The maturity model can be used as a benchmark for comparison and as an aid to understanding firm's dynamic capabilities.

This research makes several contributions. It is one of the first to investigate the processes of dynamic capabilities from empirical perspective and developing country's experience, which has enriched prior research in producing empirically grounded dimension of the concept. The five findings have constituted a systematic and integrated view, which has extended and consolidated the knowledge of dynamic capabilities. There are limitations in the research. Theoretically, there is still much to learn about the micro foundations of dynamic capabilities in terms of the role of people, such as individual managers, including their cognition and actions. Practically, tools linking dynamic capabilities with firm application remain relatively unexplored. More empirical data input is needed. Therefore, multiple longitudinal case studies on different industries that incorporate testing the process framework, maturity model and audit process may further strengthen and push the development of the research outcome.

Appendix: Definitions of dynamic capabilities

Author	**Definition**
(Teece, Pisano et al. 1997)	The firm's ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments.
(Eisenhardt and Martin 2000)	The firm's processes that use resources – specifically the processes to integrate, reconfigure, gain and release resources – to match or even create market change. Dynamic capabilities are the organisational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die.
(Rosenbloom 2000)	Management leadership as an important dynamic capability.
(Pisano 2000)	Dynamic routines that regulate the search for improved routines.
(Galunic and Eisenhardt 2001)	Dynamic capabilities as the processes through which managers manipulate resources into new configurations as markets change
(Griffith and Harvey 2001)	Creation of difficult to imitate combinations of resources, including effective coordination of inter-organisational relationships on a global basis that provide a firm competitive advantage.
(Lee, Lee et al. 2002)	A newer source of competitive advantage in conceptualising how firms are able to cope with environmental changes.
(Zahra and George 2002)	Change oriented capabilities that help firms redeploy and reconfigure their resource base to meet evolving customer demands and competitor strategy.
(Zollo and Winter 2002)	Learned and stable pattern of collective activity through which the organisation systematically generates and modifies its operating routines in pursuit of improved effectiveness.
(Pierce, Boerner et al. 2002)	Information processing capabilities/managerial capability are of particular importance that may enable firm to identify the nature of the changing market environment and sense opportunities that it holds.
(Zott 2003)	Dynamic capabilities as routine organisational processes that guide the evolution of firm resources and operational routines
(Helfat and Peteraf 2003)	Dynamic managerial capabilities are the capacity of manager to create, extend or modify the resource base of an organisation.

(Winter 2003)	Capabilities that operate to extend, modify or create ordinary capabilities
(Denrell, Fang et al. 2003)	Ability to identify strategic opportunities in a changing environment provides a potential continuing source of competitive advantage.
(Wang, Ahmed et al. 2007)	Firm's behavioural orientation constantly to integrate, reconfigure, renew and recreate its resources and capabilities and, most importantly, upgrade and reconstruct its core capabilities in response to the changing environment to attain and sustain competitive advantage.
(Helfat, Finkelstein et al. 2007; Teece 2007)	Dynamic capability is the capacity of an organisation to purposefully create, extend, or modify its resource base.
(Augier and Teece 2008)	Dynamic capabilities refer to the particular (non-imitable) capacity business enterprises possess to shape, reshape, configure, and reconfigure assets so as to respond to changing technologies and markets and escape the zero profit condition. It relates to the enterprise's ability to sense, seize, and adapt, in order to generate and exploit internal and external enterprise-specific competences, and to address the enterprise's changing environment.

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Sustainability and Risk challenges in food supply chains: An Indian Perspective

Samir Dani *, Babso Kanwar **

**School of Business and Economics, Loughborough University, Loughborough, LE113TU, UK, S.Dani@lboro.ac.uk*

*** ASK Gourmet Consultants Pvt. Ltd, India*
babso@askforfood.in

Abstract
This paper explores the challenges faced by Indian food supply chains. In recent years, global food supply chains have been facing numerous challenges with regards to food safety, sustainability and risks. Consumer preferences across the world are changing and the supply chains have to cater to this demand. Developing countries and especially India introduce a host of new challenges to these supply chains. In this study, semi structured interviews are conducted with senior industry professionals in the Indian food supply chain to gain their perspective regarding the challenges faced by their food supply chains. The paper concludes by presenting important insights regarding the current state of Indian food supply chains.

Keywords: Food supply chains, India, sustainability, risks

1. Introduction

Global food supply chains are under extreme pressure due to ambiguous weather conditions, ambivalent sourcing, high energy prices, poor harvests, increased demand from burgeoning populations and requirements for stringent food safety and traceability. Food supply chains aim at maximising the 'value creation' and are thus heavily reliant on a multi-tiered system involving a number of entities in the process. The basic chain follows a path from the farmer to the retailer with consolidators, logistics providers and manufacturers involved in taking the food from the farm to the fork. However, this is only the basic chain. It is serviced by many other entities such as organisations involved in seeds, pesticides, machinery, information technology, etc. that provide the necessary materials to keep the core supply chain functional. According to Vachon and Klassen (2006), Sustainability, Green and Ethical purchasing are the important factors affecting next generation supply chains (Vachon and Klassen, 2006). The global nature of food supply chains have exposed them to anomalous uncertainties and risks which can starve supply chains of inventory (airport mechanism shut down due to the Icelandic volcano), increased commodity prices (Coffee and Cocoa beans), wide spread food contamination (Chinese Milk scare) causing great chaos, disruption and costs to companies in the recall of these products (Salmonella Peanut Butter recall). Global Outsourcing for manufacturing activities in OEMs has led to several supply chain risks like poor quality, inability to manage demand fluctuations, delayed deliveries, losses due to environmental catastrophes etc. (Tang, 2006). In the modern marketplace, food companies need to be increasingly focused on remaining profitable while overcoming risks and uncertainties and incorporating sustainability. It is thus important to make changes in business processes to create sustainability for the business, environment and society. These three variables (economic, ethical and green) together can form the base of sustainable supply chains (Carter and Rogers, 2008). Pagell and Wu (2009) remark that there are fundamental issues that researchers and academicians need to answer in order to offer supply chain managers prescriptive models of how to create sustainable supply chains.

This research considers the food supply chains within developing countries (in this case specifically, India) and the challenges faced. India provides a good focal point in global supply chains at various points in the chain. This can range from being the source of agricultural produce (at the extreme upstream), to providing good manufacturing capability (as value creator) to an extremely fast growing retail environment. Depending upon the position in the chain companies will face challenges with regards to operating their supply chains profitably and overcoming risks and sustainability challenges. This research endeavours to explore the challenges that are faced by food supply chains in India on account of sustainability and risks.

2. Food Supply Chains

The food supply chain technically spans the entire ‘farmer to fork’ process. Maloni and Brown (2006) suggest that the exact supply chain path for a particular food product depends on the product characteristics, size and market power of the supply chain members. The operation of a food supply chain is complex due to the nature of perishability of the products and the high levels of risk associated with food safety. Recent trends that have influenced food supply chains have been **globalisation, consolidation and commoditisation** (Roth et al. 2008). **Globalisation** refers to the global footprint of the food supply chain. This encompasses not only sourcing of raw materials, but also food processing, packaging and transportation. To fulfil the requirements of the final consumer these activities may span across various countries. **Consolidation** refers to the process of combining as many food categories as well as levels of the supply chain in pursuit of higher margins and efficiency. This has spurred both vertical and horizontal integration within food chains. Young (2002) identifies *changes in customer preferences, IT environmental pressures* and *reductions in global trade barriers* as some of the main reasons behind vertical integration. **Commoditisation** is the consideration of food as a commodity. This leads to pricing based on commodity trading and since commodities are traded as undifferentiated goods competing mostly on price, the traceability back to the farmer may become difficult. The recent food recalls and safety issues (as in the case of the Chinese Milk scare and Peanut butter contamination) have highlighted the challenges faced by food supply chains on account of these trends. Helen Peck (2006) in her report on business reliance in the food business suggested that the drive for efficiency and the just-in-time philosophy used by the industry has progressively reduced stock levels throughout the supply chain - with the resulting damage to its resilience when an emergency occurs. It is also suggested in the study that the consolidation of distribution networks by food manufacturers and the trend towards using 3PL (Third Party Logistics) providers and reducing distribution centres means that the loss of a single site due to events such as a fire or flood could also cause a disruption in the supply chain.

3. Challenges in Food Supply chains

The changing trends in global food supply chains have led to an increase in the complexity of operating and governing these supply chains. The literature available on food supply chains discusses future challenges and variables that will influence the management of these chains. Food safety and recall has been one of the biggest challenges affecting food supply chains in recent years. When food supply chains transcend international boundaries there is an increase in the complexity with regards to compliance with standards and safety culture. Henson (2005) identifies the growing prominence of private standards as against public standards within food supply chains. He argues that this is happening primarily because of the growth of large retailers as leaders in the industry, who in an attempt to achieve product differentiation find public standards either absent or inadequate. The World Trade Organisation has introduced Sanitary and Phytosanitary measures (SPS) as an attempt to deal with the two issues of providing “safe” food at the same time ensuring that the Food standards are not an excuse for protecting domestic producers. It allows countries to set their own standards but states that regulations must be based on science (http://www.wto.org/english/tratop_e/sps_e/sps_e.htm).

One of the challenges with regards to food safety and recall is that of traceability of raw material used in the food supply chain. Traceability within food supply chains has been the focus of several researchers (Kelepouris, Pramatari et al. 2007, Agarwal 2001, Wilson, Henry et al. 2008, Davies 2004, Dupuy, Botta-Genoulaz et al. 2005). Technology development has improved traceability. RFID is being used in some food supply chains however this is dependent upon the technology permeating through the chain. Davies (2004) suggests that the potential benefits that traceability offers are not comparable to the cost of work involved particularly for Small and Medium Enterprises (SME). Currently, technology is directed more towards improving efficiencies rather than for supply chain management (Hill and Scudder, 2002). However, Fritz et. al. (2009) suggests that increased vertical coordination between agri-food supply chains necessitates the use of advance IT systems. Although technology for traceability may not be that prevalent within food supply chains, technology is available for the detection of contamination within food supply chains. There is an increasing trend in using technology to measure contagions.

Food supply chains are under immense pressure to meet regulatory requirements, reduce carbon emissions, reduce energy consumption, have ethical sourcing etc. Customers pay attention to characteristics like country of origin, food miles, ethical sourcing, organic food, carbon footprint etc (Roth, Tsay et al.2008, Henson 2005). These preferences are changing the dynamics of supply chains and are positioned to grow. According to Severson (2012), ‘*People have moved beyond organics, those on the forefront of the local food movement say. Over the last couple of decades, food has become a platform for social issues and environmental causes, a rallying point for improving schools and a marker of cultural status.*’ Consumer tastes are changing and the ready meals and processed food sectors have witnessed unprecedented growth in the past decade with imports highly processed goods showing a 27.6 percent growth between 1996 to 2005 (DEFRA 2007).

4. Sustainability challenges in food supply chains

Sustainability challenges in food supply chains are similar to those of supply chains in other sectors. These challenges are generally governed by the triple bottom line effect (Carter and Rogers, 2008) – economic, environmental and social sustainability. The pursuit of sustainable goals presently is largely governed through the fulfilment of legislation requirements as specified in the respective industrial sectors. Some of the benefits of being sustainable are now being recognised by companies and the motivation to follow sustainable policies is now based on clear economic and social benefits that are accrued by companies. Hence, the steps taken by Tesco to have sustainable buildings and reduce energy in the operations, Wal-Mart to reduce packaging or by Coca Cola to conserve water have clear economic and social benefits with wide ranging environmental benefits.

As environmental, ethical and safety legislations get tougher across international boundaries, configuring supply chains in compliance with these standards and also developing the capability of re-configuring based on changes to standards will be essential. The standards are influenced by the ‘environmental’ and ‘social’ pillars of sustainability. Most standards follow a compliance route to look after the interests of living beings (consumers, workers, and the community) and the environment (waste minimisation, pollution, effluent treatment, etc.). Economic sustainability may feature as a function of supplier selection programs but is not a part of the food standards or safety legislations. However, most companies in food supply chains have to trade off compliance against staying economically sustainable in business. It is observed that the growth of private standards is increasing and crosses local and economic boundaries. These international safety standards are therefore a key to risk minimisation for future supply chains. Also, Traceability emerges as one of the key factors needed to configure future food supply chains. Although traceability is linked to technology (RFID), collaboration and International safety standards, it stands on its own right as a variable to minimise risks in the supply chain.

5. Risks in Food supply chains

Kliendorfer and Saad (2005) defined supply chain risks firstly as risks arising from the problems of coordinating supply and demand and secondly as risks arising from disruptions to normal activities. Christopher and Peck (2003) have categorised risks into five categories based on whether these risks are internal to the firm (Process and control risks) or external to the firm but internal to the Supply network (demand and Supply) and which are external to the network (environmental). There are few papers which deal directly with risks associated with food supply chains however a review through the following (Peck 2006), Agiwal and Mohtadi (Agiwal, Mohtadi 2008), Roth, et.al.(2008), BBC (2005), CNN (2006), Coghlan (2008), Fairclough (2008), Carey, 2007, identified some of the common risks, as shown in Table 1.

Product recall- quality issues	Loss of power	Pandemic
Product recall- food safety	Shortage of Power	Terrorism
Unavailability of raw material	Loss/Disruption in logistics	Natural Disasters
Loss of supplier	Strike action	Loss of IT
Fuel price rise	Loss of premises	Asset price collapse
New food regulations	Increased labour costs/ shortage	Commodity price fluctuations

Table 1: Types of food supply chain risks

In a survey conducted within the UK food supply chain (Dani, Deep, 2009), it was inferred that Loss of reputation (due to food contamination), Loss of power (electrical, oil, etc.), Loss of IT were the risks considered as high by the entities in the food supply chain. It is important to note that one type of risk may lead to other types of risks propagating through the supply chain. For e.g. radiation from the Fukushima nuclear plant, as a result of the onslaught of the Tsunami created unsafe radiation levels in food available in the region. This caused a disruption to the food supply chain originating from the region thus affecting global supply chains that this was a part of.

6. Research methodology

This study focuses on the food supply chains in developing countries and in particular India. It explores whether there are any differences in the challenges faced by food supply chains within developed and developing countries. India provides a very good case due to the growing population, abundance of fresh produce, good manufacturing resources and an ever growing market. The research stems from three research questions:

1. What are the challenges affecting food supply chains in India?
2. What are the risks faced by food supply chains in India?
3. What is the Indian perspective on sustainability in food supply chains?

The research approach is qualitative and conducted in two stages. The first stage includes secondary data analysis and the second stage consists of semi-structured interviews with 10 CEOs and senior industry professionals in the processed food and food retail sector in India. Secondary data in the form of extensive literature review and industry reports from within the field of food supply chains has been utilised for analysis. The analysis of the secondary data provided the questions for the semi structured interviews. The data from the interviews was analysed using ‘contact summary sheets’ as suggested by Miles and Huberman (1984). Relevant units of meaning were extracted from each source. These units were in the form of quotes, words, and examples (as a complete unit). Based on the analysis, the paper strives to get a perspective into the uniqueness of the Indian food supply chain environment.

7. The Indian perspective

Semi structured interviews were conducted with senior industry professionals across 10 food companies. These companies represent both domestic and multinational organisations. Some are multinational brands manufacturing in India and catering to the domestic market. The supply chains for these companies are localised but the objectives are to get the same quality and tastes that are found with their brands globally. Some of the respondent companies are domestic food manufacturers who have their own branded products in the domestic market, whereas the other manufacturers are a part of a global supply chain and provide the value addition (processing) stage and a source of supply for multinational brands. One of the respondent companies is a multinational retail organisation. The only entity not represented in this cohort are the agricultural producers (farmers) however some of the respondent companies have very close links with farms and have provided their perspectives on the challenges faced by agricultural producers too.

The analysis of the data from the respondent interviews provided valuable insights into various aspects of the Indian food supply chain and the unique challenges it faces. Initially the analysis yielded 40 themes (in the form of topics/ sub topics) for discussion. We did a further analysis of these themes and then streamlined these into five main themes for discussion.

1. ***Demand Challenges***
   The industry respondents felt that the Indian consumer markets which are dominated by the ‘corner shops’ have greater affiliation to fresh foods over processed foods. Indian consumers purchase unprocessed food in their primary state that they prefer to cook in their households. However, with the advent of a changing retail landscape, dual income

households, greater urbanization and a younger working generation, the preference towards ready to cook, semi-processed food is on the rise. Many respondents felt like consumer behaviour could be changed to accept newer forms of familiar foods that hold ultimate promise of greater productivity, reduced wastage at farms and better nourishment for the masses. Consumers need to be educated on the usage of things like tomato puree (made using excessive tomatoes that would are often wasted due to lack of proper transport to central markets) and things like vegetarian proteins like Soya (India presently extracts oil from Soya beans and the rest is converted into animal feed, there is very little human consumption in its natural form as a bean).

The respondents also remarked that in a vastly diverse country like India tastes and preferences drastically change in the four corners of the country combined with increasing consumer demand for smaller packs (primarily for economic reasons, it is presently at Rs. 10). The need to customise the taste of the food offering in relation to the consumer is very challenging and is possible only through increased investment and innovation. As markets and supply chains are fragmented, the challenge to create localised, shorter supply chains providing high quality, safe food is even greater.

2. ***Lack of governmental support***

All the respondents unequivocally remarked that the lack of government support on various fronts in the biggest challenge to food supply chains in India. Since the respondents represented the producer-processor perspective, they felt that the **APMC law** in India needs to be modified to give the producer more control in selecting the buyer. The respondents felt that with the required modifications it will also help in solving some of the problems with food wastage in India as one respondent remarked that '*the farmer will be able to take produce to a consumer/value added processor in addition to the mandi (centralised government controlled market) even if he takes a lower price it is better than wasting the produce*.' (e.g.: tomatoes as listed above). This modification can be of benefit to all concerned, it offers producers an influx of technology from buyers will help with better yield and result in a consistent source of supply for companies/buyers. Reardon and Minten (2011) discuss the constraints in the Indian food supply chain on account of slow APMC reforms.

The respondents also discussed the absence of a **'contract farming'** law in India and gave examples where processors had helped producers with quality seeds and farming techniques, only to find that the producer had then sold off the produce to a competitor who was willing to pay a bit higher. They felt that due to the lack of such a law the producer could easily side line the investment and effort put in by the processor to build the source of supply and work with the competitors instead.

The respondents discussed various challenges with regards to the lack of governmental support including:

- *As prices for most commodities are controlled by the government, ad-hoc policies can have drastic affect on companies with the price of raw materials fluctuating tremendously.*
- *adopting global standards (there is confusion about the FSSAI and not enough inclusion of companies to allow broader discussion)*
- *ineffective government controlled public distribution systems,*

- *interstate taxation and the absence of a national tax framework (for most it's like working with 27 countries rather than 1, the GST will be very welcome and is long overdue)*
- *archaic labour laws*
- *bureaucracy and corruption within civil administration,*
- *lack of public-private partnerships and incentives for them,*
- *severe lack of infrastructure and apathy towards investment in back end services*

Reardon and Minten (2011) mention that a number of constraints hinder Indian food supply chains 'limits *on private-sector procurement, storage, and sales to traders—Storage Control Orders under the Essential Commodity Act; regulatory and fiscal uncertainty and transaction costs, such as double taxation for interstate movement*.' Deshingkar, et. al. (2003) discuss the need to safeguard the interests of small farmers and mention that contracts should be formulated to protect the interests of small and marginal farmers and these should be easily understood.

3. ***Operational Challenges***

The food processors represented in the sample discussed various operational challenges that they face to maintain the high quality, safe and traceable food to the consumer. The following operational challenges were identified:

- *lack of processing technology (even at the most basic farm level where this will increase output)*
- *lack of logistics and warehousing infrastructure*
- *complicated, multi-level, long supply chains*
- *increasingly high cost of clean fuel/energy*
- *poor food safety culture and a deficiency of skill across the industry*
- *lack of awareness of the FSSAI (Food Safety Standards Act of India)*
- *ad-hoc policy change*
- *lack of traceability in the upstream chain,*
- *productivity is lower than market demand,*
- *fluctuations in commodity and fuel process,*
- *too much government intervention/control over some commodities*
- *Dual manufacturing policies and methods for domestic vs. export products by some companies, particularly non MNC's.*
- *No control over their products in the logistics environment once they leave the factory/warehouse*

Singh (2012) has remarked that Indian agriculture has faced constraints on account of low yields, poor technology and improper distribution channels. Singh, also stresses that along with an improved Public distribution system, there is a need increase the efficiency of the supply chain. Minten, et.al. (2009) suggest that the current system is incapable of dealing with food safety and traceability. Narrod et. al. (2009) have discussed issues surrounding food safety standards, and suggest that with adequate institutional support SMES will be able to comply with the standards. They suggest the need for collective action by farmers and supply chain linkages along with the help of government in meeting safety standards. Singh, et. al. (2009) have studied the Indian fresh produce supply chain and suggest that there is a need for public- private collaboration through contract farming along with the formation of specialised market infrastructure.

4. ***Lack of education and skills***

The lack of education in producing, processing and value creation is a challenge that permeates at the producer- processor interface. The respondents felt that it is not just the logistics and supply chain industry facing an acute shortage of skilled manpower but the food industry at large. The sector requires personnel that are not only trained and skilled in safety standards, technology for processing and advanced IT systems for traceability but are in general more aware of the requirements of the regulations in the food industry, for e.g. safety standards, temperature control for cold chains, etc. An investment in skills across the wider industry will help with raising farm productivity and manufacturing benefiting the entire chain from farm to fork.

Many of the 10 interviewed said they work very closely with vendors to help raise their standards towards global ones and find that many SME's whilst very innovative are reluctant for full automation and rely on semi automation. This is due to the low operational costs in India and abundance of unskilled labour. There are specific Indian laws applicable towards skilled and unskilled employees that can have a profound effect on the manufacturing processes.

5. ***Sustainability challenges***

Most respondents felt that sustainability/food security in terms of volumes of food within the Indian supply chain was not a concern. The country is self sufficient with most staple produce and allows imports of items like edible oils and pulses. Many felt that much more can be done to improve farm and processing practices resulting in higher yields since in the long run the population growth will out run farm productivity. The lack of good infrastructure and a poorly managed, long supply chain lead to food wastage and loss that has much room for improvement. With an influx of technology at all levels, it is broadly felt that wastage will be controlled increasing productivity of the supply chain and could also help with economic security by allowing the export of some items.

The respondents remarked that 'economic' sustainability is more of a concern for particularly for small farmers since most land holdings in India are very small (less than half an acre) and SMEs (they constitute nearly 70% of the Indian food processing industry) than 'environmental' or 'social' sustainability.

One respondent clearly spelt out that *'It is unfair to compare the food industry with other industries like IT or Aviation. The food industry has to follow strict waste management systems whereas the other industries do not. All food factories must have ETP's (Effluent Treatment Plants) and stringent rules of recycling waste but the other industries do not. Revenues and incomes for the other industries are much higher and they can off-set these costs whereas the food industry works on much smaller margins and very easily disrupted by the fluctuation of commodity costs that they rely on.'*

Some respondents felt that 'social stability' is ensured with the government setting minimum purchasing rates for most commodities at the farm level but most felt that the pds (public distribution system) needs to revamped as, "food security in India means people having access to nutritious, healthy foods that meet their daily calorific needs" with the biggest challenge being malnutrition.

Many remarked on the need to think about energy security particularly clean sustainable energy as increased consumer demand and a growing population place increasingly higher stress on manufacturers.

Most respondents felt that there is work in progress with regards to good farming techniques and the reduction of pesticide levels in food. There are no laws at the farm level and most farmers don't have knowledge on internationally acceptable levels/norms unless told otherwise. However there are laws under the FSSAI (Food Safety and Standards Act of India) that dictate acceptable levels for raw materials causing a fundamental disconnect as food manufacturers sometimes struggle to source the right quality of ingredients. Additionally there are low incentives from the government and a lack of funding for SMEs to implement sustainable practices.

8. Conclusions

Most challenges as represented above in the five categories are sources of risk for food supply chains and are a source for unsustainable practices. Hence, within the India specific domain it can be inferred that sustainable practices can permeate easily through the food supply chain if steps are taken to overcome the risks (challenges) as identified above. The findings reported in this paper have sought to seek a sectoral view of the challenges facing Indian food supply chains. India as a country provides many unique challenges for both domestic and international food companies. The analysis revealed some challenges that are common across the world with regards to food supply chains but also revealed some unique points pertaining only to India. These unique perspectives need an additional mention so that further work can be done in understanding these challenges better and finding the appropriate solutions for them. In some cases the challenges are borne out of the lack of governmental support and this needs intervention from a political process to overcome.

The challenges from the perspectives of respondents in the study are:

- The need for modifications to the 'Agriculture Produce Market Committee' Act to empower the farmer to select the best buyer for the produce.
- The need to make supply chains shorter and less complicated
- The need for governmental intervention in the issues of contract farming, so as to enable greater trust and resource sharing between producer- processor.
- The need for a national framework of taxes as against individual state tax regimes.
- The need for more education and skilled manpower in the supply chain and logistics industry.
- The need for advanced processing technology and the infrastructure to support it.
- The need for clean energy sustainability to keep pace with greater demand.
- The need for a national culture of food safety and traceability with the provision for building the appropriate skills base. The standards are no good if there is no one to implement
- The need for private-public partnership in examining and setting certain acceptable ingredients/products in conformity with global norms
- The need for increased food security not from the aspect of volume of food but from the aspect of calorific value of the food (nourishment).

The study has thus provided valuable insights from a producer- processor perspective. In the future a multi-stakeholder study will be conducted to gain the perspectives of the other stakeholders involved in the operation of the Indian food supply chain. The points highlighted above also require a further study respectively to gain a better understanding of the challenges and possible solutions.

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Managing operations in the perishable food products industry: literature review and future research directions

Atanu Chaudhuri, Rajiv K. Srivastava and Samir Srivastava

Operations Management Area, Indian Institute of Management, Lucknow

Prabandh Nagar, off Sitapur Road, Lucknow, Pin-226013

atchaudhuri@iiml.ac.in,rks@iiml.ac.in,samir@iiml.ac.in

Abstract

Perishability of food products poses multiple challenges for producers, processing units and other stakeholders in the supply chain. Perishability increases the need for responsiveness and flexibility but has negative impact on efficiency. The Indian perishable food products industry also has its unique challenges. Supply uncertainty, multiple intermediaries, variable product quality, lack of safety and traceability and lack of adequate cold chain infrastructure create inefficiencies across the Indian perishable food products supply chain. It also impacts the price at which the product reaches the consumer. Literature on perishable food products has addressed specific challenges in operations planning, quality management, inventory management, traceability and cold-chain logistics an on multi-echelon optimization across the supply chain. An initial literature review coupled with understanding of the Indian perishable food products help us in identifying a few areas in the perishable food products supply chains where we would like to focus our future research.
Keywords: perishable food products, supply chain, literature review

1. Introduction

The perishable food products can be broadly classified into two categories- the fresh produce which requires no or minimal processing and the others which process perishable raw materials to produce finished products that typically have an expiry period. The first category includes fresh fruits and vegetables, liquid milk and fresh fish and meat while the second category includes packaged or pickled vegetables, dairy products like curd, yoghurt, soft varieties of cheese, processed fish and meat products and ready-to-eat meals.

Supply chain design in the fresh food sector is determined to a large extent by the characteristics of its manufacturing system (van Donk et al., 2008; Verdouw and Wolfert, 2010; Romsdal et al., 2011). Perishability increases the need for responsiveness and flexibility but has negative impact of efficiency. While, manufacturing lead time increases the ability to exploit economies of scale it has a negative impact on responsiveness and flexibility (Romsdal et al., 2011).

The primary reasons for inefficiencies in food supply chains are presence of multiple intermediaries and wastages which escalate prices at which the products reach the consumer. There are multiple decisions which the producers or farmers, the food processing manufacturing units and the retailers have to take in managing the operations of perishable food products to minimize wastages and hence reduced prices while ensuring profitability across the supply chain. We focus on the decisions which the manufacturers and retailers have to take in the perishable food products supply chain.

The decisions which the food retailers have to take for fresh produce involve sourcing, managing the logistics from the farms or intermediaries and inventory management in the stores. The retailers have to select the suitable suppliers or agents to ensure high quality and design appropriate sourcing contracts with them. The retailers also have to design their own logistics network or contract with logistics service providers for transporting the fresh produce from the supplier to the stores with minimal deterioration of quality while minimizing costs at the same time. The retailers may also decide to process the fresh vegetables as 'fresh-cuts'and pack them on their own or use another third party to perform the above activities so that they can be readily used by consumers. For fresh fish and meat products, the retailers will usually buy the products in cut form and get those packed for sale in stores. All of these additional processing and handling not only adds value to the product but also increases the chances of deterioration of quality.

The dairy manufacturers who produce packaged fresh milk and other value-added dairy products also have to design appropriate sourcing and collection model to maximize the quantity of milk so that the milk can be collected and sent to the processing centres in minimal time. They also need to decide the product mix and create the optimal production schedules so that wastage is minimized due to deterioration of quality and to meet customer orders. The dairy manufacturers also need to design an appropriate distribution network so that fresh products reach the consumers every day. The processed food manufacturers also face similar challenges in operations planning and scheduling.

In this paper, we report the findings from a preliminary literature review on managing the operations in perishable food product industry and identify areas for future research based on the literature review and our preliminary understanding of the challenges faced in the Indian perishable food products industry.

2. Literature Review

2.1 Focus of our literature review

We focus our literature review on the following decisions taken by various supply chain partners in the perishable food products industry:

Echelon 1 (Processed food manufacturers)

- Sourcing and collection of fresh produce/raw materials
- Product mix planning
- Production planning and scheduling

- Distribution planning
- Quality management including traceability

Echelons 2&3 (Distributors and Retailers)

- Sourcing and collection of fresh produce/raw materials
- Logistics
- Inventory management
- Pricing

Multi-echelon

- Optimization models across echelons eg. sourcing and production, production and distribution
- Supply chain redesign
- Co-ordination across echelon members

We also searched for papers which provide insights on managing the entire supply chain from farm to the stores or multiple links in the supply chain for example sourcing and production or production and distribution etc. as well as those which deal with managing collaborative relationships between supply chain partners in the perishable food products industry.

2.2 Findings from the literature review

2.2.1 Manufacturing of perishable food products

The decisions involved in the manufacturing of perishable products include product mix, determination of lot size, aggregated planning and scheduling. Quality degradation of the raw material over time, shelf-life considerations of the final product, traceability requirements, and constraints on intermediate storage pose challenges usually not encountered in other manufacturing environments except perhaps in pharmaceutical and in manufacturing of some chemical products. Research on perishable food product manufacturing has addressed some of the above challenges.

Tadei et al. (1995) develop a two-step heuristic procedure for aggregate planning and scheduling of perishable food products with the objective of minimizing inventory. Lutke-Entrup et al. (2005) develop mixed-integer linear programming models that integrate product shelf-life issues in production planning and scheduling of products with limited shelf-life. Using the principle of block planning, they develop three different MILP models for weekly production planning that apply a combination of a discrete and continuous representation of time and apply those in an industrial setting of yoghurt production. Darlington and Rahimifard (2007) develop a two-stage hybrid planning model, combining static and dynamic scheduling approaches to minimize overproduction waste for products that have a very short shelf-life and are subject to considerable volatility in demand, such as ready-meals. Akkerman and van Donk (2007) investigate the effects of product prioritization and dedicated storage when a food processer faces the constraint of limited intermediate storage and very short lead times. Cai et.al. (2008) address the problem of determining the product mix, machine allocation and scheduling for a seafood manufacturer which receives fresh fish everyday which can be converted to multiple finished products which need to be transported within a certain deadline. Food-processing companies can sometimes produce the same end products in different ways- either mix first and then process, or process first and mix later. Moreover, a final product can also be mixed from different raw materials or intermediates. Akkerman et al. (2010) address the problem of determining which intermediate to produce and in which quantity with the objective of balancing the material and mixing costs. The problem was modeled for a two-stage production in a flour mill.

Food processing companies have to deal with an increase in logistical demands from their customers (van Donk, 2001). These companies cater to a large number of products and SKUs with client-specific features, special packaging, etc. to increase or maintain the market share. Moreover, retailers and wholesalers expect small deliveries within short and dependable time window and do not accept two subsequent deliveries with the same 'best-before' date, even if they will sell the product well before that date. Thus, customers prefer a Make-To-Order (MTO) policy with short response time. As a consequence processed food manufacturers are forced to shift a part of their production system from Make-to-Stock (MTS) to MTO and are operating under a hybrid MTO–MTS strategy. Operating under pure MTO basis is not viable because of large number of set-ups that are required and pure MTS is also unviable because of unpredictable demand and the perishable nature of the products (Soman, et.al., 2004). Soman et.al. (2004) develop a hierarchical planning framework for combined MTO-MTS based production systems in food processing industry. The findings from the review on perishable food products manufacturing are summarized in Table 1 shown below.

Table 1: Summary of literature on manufacturing of perishable products, products with perishable raw materials and ingredients

Area of Research	**Authors**	**Demand-Product –Process characteristics**	**Objectives**	**Methodology/ Solution Approaches**
Manufacturing of perishable products, products with perishable raw materials and ingredients				
Production Planning and Scheduling	Nakhla (1995)	Multiple products with variability in demand, production lines with different levels of production rate, different impact of idle time on different stages of production and types of products in dairy product industry	Determining a schedule of batches on a production line by respecting the constraints of earliest and latest dates and understanding the impact of the constraints of variety, product and demand on workshop management	Conceptual framework for hierarchical scheduling
	Tadei et.al. (1995)	OR application to efficiently solve production scheduling problems	Derive a scheduling model from the factory specifications and presents a two-step heuristic procedure for its	Case Study

			solution.	
	Lutke-Entrup et al. (2005)	Fermentation and flavoring stages of yoghurt production considering shelf-life and sequence-dependent set-ups	Maximize contribution margin	Mixed-Integer Linear Programming
	Darlington and Rahimifard (2007)	Uncertain demand, short shelf-lives of ingredients, short order lead times and high production lead times for ready-to-eat meal manufacturing	Manufacture products with short reaction time as per demand while minimizing overproduction waste	TSP based heuristic combining static and dynamic scheduling
	Akkerman and van Donk (2007)	Two-stage continuous and discrete production process with different objectives and limited intermediate storage	Investigate the effect of prioritization and dedicated storage in a two-stage production system, for various product mixes	Deterministic analysis of sequencing rules and simulation
Planning for product and intermediate mix	Akkerman et al.(2010)	Manufacture of intermediate products and mixing them into a range of flour products for a bakery; need of product flexibility and minimal material and storage costs	Determine the number and composition of intermediate products, increasing operational efficiency, product quality, and flexibility while minimizing material and operational costs	Mixed-Integer Linear Programming
Multi-product Production and Inventory Control Systems	Soman et al. (2004)	Sequence-dependent set-ups and limited shelf life; Focus on high capacity utilization.	Discuss the issues and present a framework for managing a combined MTO–MTS system in food processing.	Literature survey and Framework approach.
Combined product mix planning and scheduling	Cai et al. (2008)	Manufacture multiple products with perishable raw material with fixed delivery lead time in sea-food processing	Decide the types and volumes of products to be manufactured and the schedule to process the products to maximize total profit given the constraints of the raw material and the delivery deadline	Analytical rules and an efficient algorithm for stochastic scheduling and stochastic knapsack

2.2.2 Distribution and Retailing of perishable food products

Perishable food products are susceptible to loss of quality during transportation. Time temperature indicators (TTI) can be used to individually monitor the temperature conditions of food products throughout distribution. Giannakourou and Taoukis (2003) used a TTI-based system for optimisation of frozen product distribution and stock management using Monte Carlo simulation techniques. TTI-responses are translated to the level of product deterioration, at any point in the distribution system, which helps classifying the products according to the remaining shelf life of the products. Their results indicated that the amount of rejected products in the market can be minimised using a TTI-based management system based on least-shelf-life-first-out (LSFO), in which products with the closest expiration date are advanced first.

A distributor usually buys perishable food products like fresh fruits and vegetables and transports it over long distances to retailers. A distributor has to determine his order quantity, level of freshness-keeping effort, and selling price, by considering the wholesale price of the producer, the cost of the freshness-keeping effort, the likely spoilage of the product during transportation, and the possible demand for the product in the market. The producer, on the other hand, has to determine the wholesale price based on its effect on the order quantity of the distributor. Cai et al. (2010) address the above problem and determine the optimal decision for both the distributor and producer in both decentralized and centralized scenarios. The authors also develop an incentive scheme to coordinate decisions of the two parties.

The management of perishable products in food retailers is far from satisfactory and perishable food loss in retailers can be as high as 15% due to damage and spoilage (Ferguson and Ketzenberg, 2006).In developed countries, shelf-life information is usually printed on product packaging for perishable products and may be even for fresh produce. But, as the products move through multiple stages with temperature and storage conditions, the remaining shelf-life can vary from what is printed on the package. Moreover, customers always choose the freshest products first leaving many products with limited shelf-life which also diminishes the chances of selling those products. Hence, retailers need to determine prices of the perishable products using dynamic evaluation of product quality using tracking and sensing technologies. Wang and Li (2012) develop a pricing model considering dynamic evaluation of product quality of perishable products which aims to minimize food spoilage waste and maximize the retailer’s profit.

Ferguson and Ketzenberg (2006) show that retailer benefits the most from information sharing when the variability of either demand or the remaining lifetime of the perishable replenished items is high, the product lifetimes are short, and the cost of the product is high. The authors also found that information sharing is generally more beneficial when demand is satisfied with a First-In-First-Out (FIFO) issuing policy than with a Last-In-First-Out (LIFO) issuing policy. Ferguson and Koenigsberg (2007) present a two-period model where the quality of the leftover inventory is often perceived to be lower by customers, and the firm can decide to carry all, some, or none of the leftover inventory to the next period. The authors investigate the competition between the fresh product and the leftover product and characterize optimal strategies regarding production, pricing, and inventory decisions. We summarize the literature on distribution and retailing in Table 2

Table 2: Summary of literature on distribution and retailing of perishable food products

Area of Research	**Authors**	**Demand-Product – Process characteristics**	**Objectives**	**Methodology/ Solution Approaches**
Distribution and Retailing of perishable food products				
Fresh Food Supply Chain Management and Coordination	Romsdal et al. (2011)	Mismatches between the product, market and manufacturing system characteristics and supply chain requirements.	Describe the key characteristics of fresh food supply chains' products, markets, and manufacturing system and investigate the impact these have on supply chain requirements.	Literature survey
Distribution of perishable products	Giannakourou and Taoukis (2003)		Minimize rejected products in the market	Monte Carlo Simulation
Order quantity and pricing for distributor	Cai et al. (2010)	Fresh products which have to travel long distance to reach the market and the distributor has to ensure its freshness while in transit	Determine optimal order quantity, level of freshness-keeping effort, and selling price, by taking into account the wholesale price of the producer, the cost of the freshness-keeping effort, the likely spoilage of the product during transportation, and the possible demand for the product in the market.	Game theory based analytical model
Retail inventory management for perishable products	Ferguson and Ketzenberg (2006)	The product lifetime is fixed and deterministic once received by the retailer, although the age of replenished items provided by the supplier varies stochastically over time. Any unsold inventory remaining after the lifetime elapses must be discarded	Explore the value of information in the context of a retailer that provides a perishable product to consumers and receives replenishment from a single supplier	Simulation

	Ferguson and Koenisberg (2007)	Products deteriorates over time, but does not reach a value of zero when a replenishment of new items arrive. The deterioration ensures that the customer values an older product lower than a newer one	Determine optimal quantities and price for fresh and deteriorating quality products over two periods	Two period analytical model
Retail Pricing	Wang and Li (2012)	Products with varying remaining shelf-life than what is printed on the package	Minimize food spoilage waste and maximize the retailer's profit	Pricing model considering dynamic evaluation of product quality of perishable products

2.2.3 Multi-stage optimization in perishable food products supply chain

Zuurbier (1999) noted that in a very few instances vertical coordination had been achieved in an integrated manner across production, distribution and retailing in the fresh produce industry. In most of the supply chains which the authors studied, the retailer-shipper demonstrated narrow levels of coordination. Production planning and scheduling decisions are usually taken by production department with the objective of meeting demand while meeting other production related objectives for eg. Minimizing costs, in-process inventories while the logistics department is responsible for managing finished product inventory and distribution of those finished products. Strong interaction between production and logistics is important for improving the overall supply chain performance (Kopanos et al., 2012). In the presence of multiple sites of production, such co-ordination assumes even more significance for perishable food products as storing of finished products in the manufacturing facility due to lack of synchronization with logistics schedules can lead to degradation of quality and hence loss of product value and may also require converting the raw materials to a different product to avoid wastage.

Amorim et.al. (2012) develop a multi-objective production and distribution planning problem for perishable products and show that such an integrated approach will be more suitable products with intermediate levels of perishability. The benefits of such an approach will diminish for products with low and very high perishability. Kopanos et al. (2012) develop an integrated production and logistics planning with the objective of minimizing production, inventory, changeover and transportation costs which was applied in a dairy product manufacturer. The authors study a real-life dairy industry, producing yoghurt and develop a novel Mixed-Integer programming model based on the definition of product families for combined production and logistics planning. In every planning period, the model helps in optimally assigning products and families to processing units, determines the quantity to be produced for each product, the inventory levels of the products, selects appropriate transportation mode, assign the transportation trucks to the product facilities and also the composition of load for every truck.

The objective is to fully satisfy customer demand while minimizing total cost including production, changeover, inventory and transportation.

Food safety problems often originate from contamination of a certain production batch due to errors in production processes and/or associated with the use of contaminated raw materials or production equipment. Thus, implementation of a traceability system alone cannot address the issue of product recall risks effectively. Further, it must be complemented with suitable production and distribution planning approaches. Reducing dispersion i.e. sharing of output from a particular batch among different retailers has the potential to reduce safety concerns. This would, however, lead to limiting batch sizes in the production stage and increase in production setups, cleaning efforts, etc., leading to increased production costs and decreased efficiency (Rong and Grunow, 2010). The authors develop efficient heuristics for the multi-period production and distribution planning model that aims to improve food safety and traceability based on the concept of chain dispersion. Zhao and Wu (2011) address the two stage agri-food chain coordination problem with the consideration of stochastic output and uncertain demand applying revenue sharing contract model.

There are limited studies on multi-stage optimization in perishable food supply chains in Indian context. We could find one such study by Subbiah et al. (2010). The authors develop a model which creates a purchase plan of raw milk, production plan of product mix and transportation plan of the products for a dairy located in southern part of India.

The design of food supply chains is complicated by an intrinsic focus on product quality (Van der Vorst and Beulens 2002; Luning and Marcelis 2006) and demand for environmental sustainability (Srivastava, 2007). Food supply chain performance depends to a large extent on how food quality is controlled and guaranteed in the network. van der Vorst et al. (2009) include food quality models and sustainability issues along with logistics processes in discrete event simulation models to develop an integrated approach towards logistic, sustainability and product quality analysis of food supply chains.

Using the product's marginal value of time (MVT), the rate at which the product loses value over time in the supply chain, Blackburn and Scudder (2009) show that a hybrid of responsive model from post-harvest to cooling, followed by an efficient model in the remainder of the chain minimizes lost value in the supply chain. The results show that the two segments of the supply chain are only loosely linked, implying that little coordination is required to achieve value maximization. Literature on Multi-stage analysis of perishable food products supply chain is summarized in Table 3 below

Table 3: Summary of literature on Multi-stage analysis of perishable food products supply chain

Area of Research	Authors	Demand-Product – Process characteristics	Objectives	Methodology/ Solution Approaches
Multi-stage analysis of perishable food products supply chain				
Simultaneous Multi-product Production and Distribution Planning	Kopanos et al. (2012)	Deliver value beyond plan feasibility and schedule optimization	An integrated framework for the simultaneous detailed production and distribution planning problem of multi-site multi product semi-continuous FPIs.	Case Study through Modeling approach
	Amorim et al. (2012)	Products with intermediate levels of perishability	Explore through a multi-objective framework and formulate models for the given cases.	Multi-objective mixed integer modeling
	Rong and Grunow (2010)	Effective Traceability and the management of food safety through coordinating production and distribution	Develop a production and distribution planning model for food supply chains to address food safety risks	Multi-period modeling approach
	Subbaiah et al. (2010)	Dairy industry with multiple suppliers, multiple production facilities and warehouses and customers in different locations	Minimize the total cost associated with the supply chain which includes material, production, transportation and inventory costs	Modeling with application in a case study firm
Supply Chain redesign	Van der Vorst et al. (2009)	Seasonality in production, variable process yields, need to keep quality constraints for raw materials, intermediates and finished products, and quality decay while products pass through the supply chain, requirement of conditioned transportation and lot traceability	Facilitate an integrated approach towards logistic, sustainability and product quality analysis of food supply chains	Simulation
	Blackburn and	Fresh produce which reach their peak value at	Minimize loss of value for perishable	Analytical modeling

	Scudder (2009)	the time of harvest; with value deteriorating exponentially post-harvest until the product is cooled to dampen the deterioration	fresh produce in the supply chain	
Supply Chain Coordination	Zhao and Wu (2011)	Coordination and revenue sharing	Address the two stage agri-food chain coordination problem with the consideration of stochastic output and uncertain demand.	Revenue Sharing Contract Model

2.3 Summary of the literature review

Literature on manufacturing of perishable products have considered decisions like lot sizing, product mix planning, machine allocation and scheduling, sequencing of mixing and processing steps. While developing models to take the above decisions, as demanded by the problem context, researchers have captured specific characteristics of products and processes shelf-life, traceability, limited storage, changeover time and strict delivery requirements. Such models have been applied in variety of industries like dairy products, bakery, marine products, ready-to-eat meals etc. Many food manufacturers are forced to work in a hybrid MTO-MTS mode and hierarchical planning approach for the same has been developed.

There is a nascent literature on transportation and distribution of perishable products considering time-temperature indicators. Similarly, there is an emerging literature on optimal ordering quantity, pricing decisions for the distributor considering the freshness keeping effort. Perishable inventory management literature is matured and recent developments focus on combined pricing and inventory decisions for the retailer considering deterioration of product quality. Literature has recognized the importance of multi-echelon planning for perishable food products. Authors have focused on combined production and distribution planning problems. There have been increasing instances of food recalls and authors have noted that developing a traceability system alone will not be able to address the risks associated with product recalls. Production and distribution systems have to be developed in conjunction while limiting the dispersion of the affected batch of production across retailers and end-users. Though food recalls are on the rise globally, there are limited studies on developing comprehensive sourcing risk assessment model for processed food manufacturers and retailers. Similarly, we could not come across studies which study the aspect of integration of food industries across countries.

3. Overview of the Indian perishable food products industry

The processed food industry in India is at an early stage with low penetration and high potential. The level of processing is currently low across the product categories. For example, only 2.2% of the total production of food and vegetables is processed, as compared to 65% in the US or 23% in China (Srinivas, 2009). The current low penetration levels in the processing activities across categories is due to the presence of unorganized and unintegrated players who lack scale and adopt low technology, which affects the production efficiency and the price at which the product is manufactured. Ernst and Young analysis shows that for fruits and vegetables, 47 percent of the price escalation occurs before the fresh produce reaches the processor and 8 percent between the processor and the wholesale market. Due to the higher transit losses and the low shelf life of these products, the price built up before the produce reaches the processor is disproportionate to the value addition in the process (Ernst and Young, 2009).

Poultry, meat and marine products

India is the 6th largest poultry populated nation, the cheapest country in the world in terms of cost of eggs sold, and amongst the cheapest Countries for day old chicks (Sri Lanka is the cheapest). The growth potential of this industry is high as per capita consumption is of 53 eggs vis-a-vis NIN's recommended 180 eggs. Similarly, per capita meat consumption is of 3.5 kgs as compared to NIN's recommendation of 11kgs (Sewhani, 2011).

In India, poultry meat is a commodity product, and only about 2-3% of the total poultry meat produced is sold in the processed and branded form. Two main reasons for this are consumers' preference for live chicken and scepticism about processed chicken, and inadequate infrastructure like lack of cold chains. To Indian consumers, chicken is fresh if it is live and cut before their eyes, even in a very unhygienic manner. Since live birds are available in plenty in the markets, consumers prefer live birds over processed chicken, which they perceive to be "not as fresh". Further, as processed chicken is costlier than live chicken, buying of processed chicken has so far been confined to the upper income group (Mitra and Bose, 2009).

Milk and Dairy Products

India is the largest producer of milk in the world accounting to 20 percent of global milk production but per capita consumption is still low compared to the BRIC's average of 184 kgs (Ernst and Young, 2009). Milk production is likely to reach about 190 million tonnes in 2015 from current level of about 123 million tonnes. In India, about 60 per cent of milk is consumed in liquid form, while the remaining 40 per cent is used in the form of butter, clarified butter (desi ghee), cheese, curd, paneer, ice cream, dairy whiteners and traditional sweets. The Indian dairy industry is predominantly controlled by the unorganised sector, which accounts for nearly 85 per cent. About eight crore rural families across India are engaged in dairy production and the rural market consumes over half of the total milk produced. Lack of proper infrastructure like cold storages and absence of a transparent milk pricing system are affecting retail consumption of milk and leading to escalating milk prices in the domestic market (Assocham, 2011). One of the key players in the Indian milk and dairy product industry is Amul.

Chandra and Tirupati (2003) outline the unique co-operative model of AMUL, the leading milk co-operative in India. The authors explain of how practices like using the surplus to promote the growth of milk supply and improve yields, the role played by GCMMF as the network integrator which ensures that all milk that the farmers produce gets sold in the market either as milk or as value added products and to ensure that milk is made available to an increasingly large sections of the society at affordable prices. The authors describe how GCMMF, in consultation with all the Unions, decides on the product mix at each Union location with the objective of maximizing the network surplus, and maintaining equity among unions for the surplus realized. Some considerations that govern this choice are the strengths of each Union, the demand for various products in its region as well as the country, long term strategy of each Union, procurement volumes at different Unions, distribution costs from various locations etc. AMUL also exceled in developing process technology for creating powder form of buffalo milk, the first time in the global dairy industry.

Food distribution and retail

Modern food retailers in India are increasingly shifting toward the use of modern logistics and wholesale companies and away from sourcing from traditional stockists and general wholesalers. Retailers are either backward integrating or creating their own logistics subsidiaries (eg. Future Logistics Solutions Ltd. of Pantaloon/Future Group and Advanced Logistics Asia of Metro Group) or are using the services of independent modern logistics companies (eg. Concor (the Container Corporation of India) provides logistics for Bharti-Walmart, Pantaloon, and Mother Dairy) (Reardon and Minten, 2011). Despite, this emphasis on food retail and logistics, cold chain infrastructure is still not adequate in India. Joshi et al. (2009) use semi-structured interviews and Fuzzy Interpretive Structure Modeling (FISM) approach including hierarchy-based model to identify and inter-relate the inhibitors that significantly influence the efficiency of a cold chain in developing economies like India.

3.1 Key trends in Indian perishable food products industry

Due to the paucity of published academic literature on perishable food products industry in India, we also searched for corporate practices in this industry from business reports and business press. This secondary research helped us to identify a few key trends in this industry.

Sourcing partnerships between processed food manufacturers, retailers and farmers' cooperatives

Multi-national processed food manufacturers like Hindustan Unilever Limited (HUL), Pepsico and domestic players like Mother Dairy Fruit and Vegetables have collaborated with farmer groups across the country to ensure supply of quality fresh produce. For example, HUL has put in place an integrated agriculture practice wherein it guarantees purchase of the crop from the farmer and in return expects that the farmer implements its bundle of services which includes buying from verified seed agencies, allowing audits and ensuring that HUL's recommended practices for cultivating a sustainable crop are implemented. Similarly, PepsiCo took up collaborative farming in 2004-05 to grow potatoes. It sources close to 50%, or 250,000 tonnes, of its total potato requirements through such initiatives (Agarwal, 2012). Local players like Mother Dairy Fruit and Vegetables Ltd (MDFV) has developed over 200 farmers associations with a membership of 8,000 farmers straddling 14 states. But, since there is no written contract, farmers are not bound to sell their crop to MDFV. Big names in domestic retail, such as Reliance Fresh, Spencer's and More were able to buy out stocks of popular vegetables from farmers at higher rates while still keeping the prices low for consumers (Jishnu and Sood, 2012). Retailers pay lot of transaction costs due to the current channel structure and are still not assured of quality of fresh produce. The producers also do not have access to retailers and have to sacrifice margins to wholesalers as well as pay taxes. Recognizing that both producers and retailers are disadvantaged, retailers are increasingly making efforts to connect with the producers to reduce the time, the fresh produce spends on the road, thereby improving quality while at the same time, reducing costs.

Forward integration of poultry firms into quick-service restaurants

Venky's, the leading player in Indian poultry industry has entered the hospitality industry with the launch of 'VENKYS XPRS' to serve their customers with a range of healthy, hygienically cooked, and yet reasonably priced chicken delicacies. The company plans to invest Rs. 2.5 bn for its research and development and set up over 100 Venky's XPRS outlets (including London) over the next three years. The company also has a technical agreement with Campden BRI of the United Kingdom to get food technologies. Venky's XPRS is set up with the intention to cater to the niche health conscious consumers who want quick food but do not want to compromise on quality. Moreover, the concept of healthy food is gaining momentum in Tier I cities in India and can lead to a stronger growth in the years to come. Even as the current menu is limited, Venky's XPRS serves their frozen products fried n hot right in front of the customer. This ensures that the products are fresh and healthy (Sewhani, 2011).

4. Conclusion and scope for future research

Consultants with the experience of working in Indian processed food industry report that there is a poor accuracy of shop-floor data, leaving it non-usable for critical decision-making, there are negligible checks for contaminants & post-expiry raw material, instances of pilferage of raw materials within the production facilities, prevalence of non-standardized products due to frequent recipe deviations, implementation of Food Safety & Hygiene Audits and GMP Practices considered resource consuming and non-essential activities Key challenges for the Indian perishable manufacturers are yield improvement, avoid losses due to overproduction and materials pilferage and meeting the demand on hand. Literature review along with our industry of the trends in the Indian food product industry has helped us in identifying some areas of future research.

Currently, there are no formal contracts between producers and retailers for procuring fresh produce. Inefficiencies in the supply chain allow these stakeholders to join hands but there are possibilities of defection if a competing retailer provides high price. There is a need to quantify the benefits of the potential collaboration between producers and retailers which retailers can use to design formal contracts to minimize possibilities of defection. Similarly, processed food manufacturers are increasingly going to use 'contract farming' to ensure supply of high quality fresh produce not only for local sales but also for export. There are opportunities to design optimal coordinating contracts which will ensure that the farmers follow the best agricultural practices and also follow international norms. But, India faces significant uncertainties in weather conditions and hence potential risks due to such adversities can also be factored in or appropriate risk mitigating measures taken while designing the contracts. But, one point to be noted here is that such formalized contracts can be developed only with a few thousands of farmers by the organized retailers and food processors. Price reduction due to retail competition may marginalize individual farmers. Hence, forming large co-operatives in the lines of what is followed by Amul and the dairy industry may be the way forward for fresh fruits and vegetables retailing in India. It will be interesting to analyze the implications of replicating such a model in large scale in India.

Poultry and meat product firms also pose interesting problems for research. Such firms which are planning to expand their ready-to-eat retail business will have to determine the optimal product mix in terms of fresh cuts which will be sold in raw form by their own outlets as well as others as well as number and variety of ready-to-eat or cooked products sold in their fast food outlets. It will also require co-ordination of production and distribution decisions. Research can be done to study the product mix and integrated production and distribution planning for this industry.

In India, most bakeries are local or regional. But local competition is forcing many of them to invest in technology and to develop innovative products like breads with multi-grain or multiple ingredients as well as flour based snack products suitable for the local tastes and preferences. These bakeries also need to estimate demand, co-ordinate production of multiple products, decide on appropriate processing sequences, use hybrid MTO-MTS systems and at the same time meet strict delivery time window requirements while replenishing the stores. They also need to manage inventory in the stores and price products appropriately. In-depth case studies can be conducted to understand these operations of these firms following which opportunities to develop appropriate decision support systems can be identified.

As identified from the literature, other potential avenues of research can be sourcing risk assessment for food industry and to study the possibilities of integrating the value chains of specific sectors of food industry like packaged foods between India and UK.

This study can atmost be considered as a scoping study. We will continue with an exhaustive literature review followed by field visits to companies which will help us in finalizing the direction of our future research in this area.

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A Transaction Cost approach to Cooperatives Companies' Supply Chain: case study in a Brazilian Dairy Cooperative

Fernanda Pacheco Dohms
Pontifícia Universidade Católica do Rio Grande do Sul, MBA at Faculty of Business, Economics and Accounting (FACE),
Av. Ipiranga, 6681 Prédio 50 - Partenon Porto Alegre/RS – Brazil 90619-900,
+55 51 93266716
dohms.fernanda@gmail.com
Sergio Luiz Lessa de Gusmão
Pontifícia Universidade Católica do Rio Grande do Sul, Director of Faculty of Business, Economics and Accounting (FACE),
Av. Ipiranga, 6681 Prédio 50 - Partenon Porto Alegre/RS – Brazil 90619-900
+55 51 33203547
slgusmao@pucrs.br

Abstract
This article aims to analyze the supply chain (SC) of a Brazilian cooperative company, focusing on cooperative members based on the transaction cost approach (TC). Thus was developed a case study in the cooperative company: Cooperativa Agropecuária Petrópolis Ltda. (COAPEL), collecting data about relationships and transactions of its critical cooperative members. In this research was considered, mainly, the cooperative's principles and business structure and, the segment in which the company operates: agribusiness. The main findings of this analyze concludes that is preferential a vertical integration of the SC's members because of a combination of some observed TC attributes. Also was demonstrated a degree of inefficiency in the cooperative business model for the control of its SC's members, as well as the model itself. And lastly, was suggested that the model should have a better governance structure in pursuit of lower costs and better control of its transactions.
Keywords: Supply Chain, Cooperative, Transaction Cost

1. Introduction

Supply chain (SC) studies are important because of a good management system and governance between its members can generate systematic earnings and competitive advantages for an entire SC. Therefore, understand the way that a supply chain is structured and witch are the main relations and transactions between its members are essential to make a critical analyze for systemic optimizations.

This article presents a research about a supply chain of a Brazilian cooperative company: *Cooperativa Agropecuária Petrópolis Ltda.* (COAPEL) that operates in the dairy industry. The analyses were based in notions of supply chain, cooperative and transactions cost approach, focusing mainly in the cooperative members relations, transactions and economics efforts to play the main activity of COAPEL's SC. So, was mapped the company's supply chain, identified its main cooperatives members and the way that this chain is structured. The findings were based in the transactions costs approach (TC) attributes and in how the management and the cooperative business model can influence it.

2. Literature Review
2.1 Supply Chain

Supply chain (SC) involves all stages, either direct or indirect; to ultimate provide a product or a service for a final client (Chopra and Meidl, 2003). In this process is not only considered manufactures and suppliers, but all external members that can influence or are involved in the process to generate a specific output (products or services) to a final client.

A SC is dynamic, where products, information and capital flow between different members that do different tasks to deliver an output, occurring for these interactions among these members (Chopra and Meidl, 2003). These interactions are important and necessary for the function of the SC, since it is indispensable raw materials and information to tasks subsequence that are needed in an output production process.

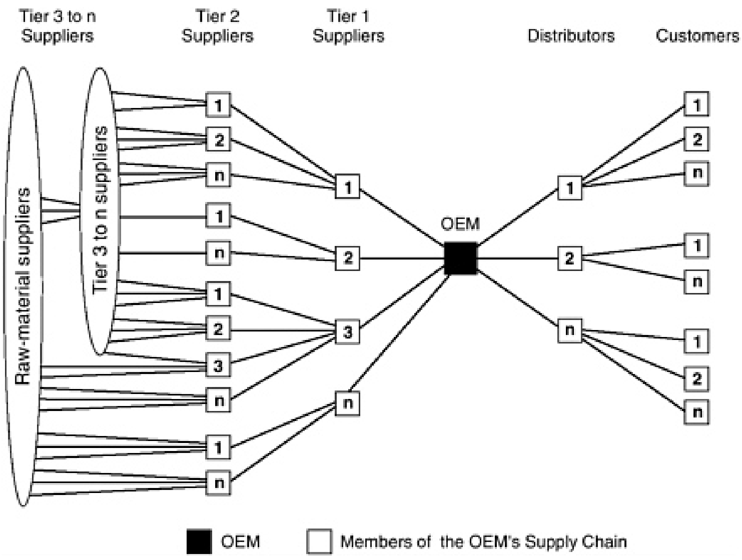

Figure 1. Typical structure of a SC
Source: Lambert and Cooper, 2000

A typical SC revolves around a major player; seeking support in other companies to obtain its process outputs, consequently not all members share same benefits. Thereby a SC must be measured in terms of final results for the whole SC, not in isolated tiers, thus assessing its degree of success. This major player is important for the process guidelines and to facilitated junctions between SC members, supporting exchanges among them and allowing the SC to operate under better conditions, not only financial, but also economic and technological through these interactions and exchanges.

Once the SC coordination is established it needs to be managed in a way to address issues such as opportunities to expand market share, adopt new marketing strategies, create new distribution channels or new ways to configure the chain, considering participation of new members, product differentiation and degree of SC's vertical integration (Farina, 2000). One of these forms that can be undertaken is the cooperative business model.

2.2 Cooperative

Cooperative can be defined as:

> A co-operative is an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise (International Cooperative Alliance, 2010).

This business model has its own values and principles based on the cooperatives understanding. Cooperative is also defined as a voluntary association of people, joying their production force, expenditures and, savings capacity for develop an economic and social business, generating to all members systematic gains (OCERGS, 2010). ICA had set the seven cooperative's principles that are: voluntary and open membership; democratic member control; members economic participation; autonomy and independence, education, training and information; co-operation among different co-operatives; and, concern for community.

Cooperative relationships are based on cooperative's principles, giving emphasis on long-term in a philosophy where everybody wins (Chistopherson and Coath, 2002). As a final point, some cooperative's doctrines are important to understand the relationships between its members, such as democracy, related to the manner in which a cooperative should be structured (administrative and management); the free membership adhesion as well as free leaving; and return of surplus capital, after deductions.

2.3 Transaction Costs Approach

The transaction cost approach (TC), first studied by Ronald Coase in 1937 and further developed by Oliver Williamson in 1985, is the study of economics organizations focusing on transactions and economic efforts to accomplish their activities. These transactions, according to Williamson (1985), occurs when goods or services are transferred between different interfaces, having inherent characteristics of this processes that determinates the way that outputs are generated and how it is delivered to a customer. From this process incurs costs for involved members to effect transaction and also internal costs for each member. These relations and transactions are influenced by several factors, categorized by Williamson (1985) as behavioral and dimensional assumptions.

The behavioral assumption focused on understanding the way that human nature works and also how the institutions work, such as laws and society, that shaped these behaviors. Transaction costs related to behavioral factors are: bounded rationality and opportunism of agents. The first is related to cognitive limits of competence to formulate and solve complex problems where the knowledge of all variables is limited in a decision process making difficult to an agent to choose between different alternatives presented to him. Organizations try to avoid it with governance structures predicting and anticipating transactions in-house and also is suggested as a way to increase rationality interactions between different agents as guidelines based on groups that can generate more efficient results than individual actions (Simon, 1971, *apud* Gusmão, 2004). While the second is related to pursuit self-interest in detriment of others interests seeking own benefits.

The dimensional assumptions are related to the way in which transactions are realized, with peculiarities of each organization. The main dimensions that describe a transaction are asset specificity that are characteristics of an asset that express its specific value and usefulness; uncertainty that are the future risks of a transaction related to its flows, difficult to be predicted and covered by contracts; and, frequency which a transaction recurs between two agents.

3. Methodology, Procedure and Model

This research deploys a single case study in order to try to deeply comprehend the main factors in the study context, chosen for this a qualitative research that is a way to examine events where behaviors cannot be manipulated (Yin, 2011). Hence, was made in-person interviews with employees and cooperative members, observations through visits to the factory and farms, collected others data and then made analyzes. These analyzes were limited only to transactions between cooperative agents in the SC.

4. Case Study

COAPEL was established on October 29th of 1967 in the city of Nova Petrópolis in Rio Grande do Sul, Brazil. Currently the company operates in over 80 counties and, has about one thousand employees and fifteen thousand associates. The company operates in dairy industry, also in retail (consumer and agriculture/inputs) and, in production of animal feed. COAPEL's market attendance for its products distribution is concentrated in the three states of southern region of Brazil.

From the research was designed COAPEL's SC structure, as shown in the figure below:

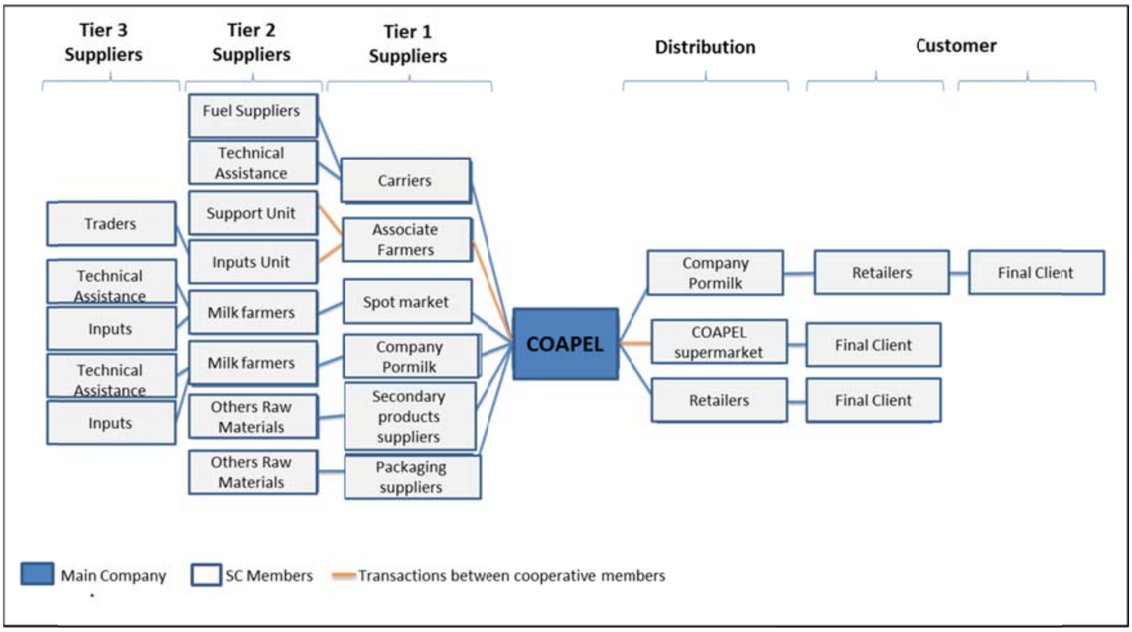

Figure 2. COAPEL Supply Chain
Source: The Authors (2011)

After a restructuring process at COAPEL over the past few years its activities were subdivided into two units to a better development of activities: main unit and support unit. The main unit is composed by the dairy industry, inputs factory and distribution centers/agriculture retail; and consumer retail/supermarkets. The support unit includes technical assistance; controllership, marketing, human resources, etc.

The company management is professional, but with permanent interactions of cooperative's members, through cooperative's councils. In addition, COAPEL has a strategic guideline to management, related to matters such as transparency, promotion of cooperatives actions and cooperatives principles, maximization of members' benefits, self-sufficiency, among some others, based on the company's bylaws. Also, the company is mainly run according to the cooperative's principles, discussed in the literature review, exposed in some COAPEL's practices, such as programs and benefits offered to its members.

In this SC the main transaction are the frequent interactions between COAPEL and its cooperative associates, since they are key members of the SC. In these transactions there are exchanges for both sides, farmers provide raw materials - fresh fruit and milk - and the company buys their production and supports them with some benefits for this production and development of theirs lands. To better manage the range of associates COAPEL had mapped them and subdivided into five areas. However, this management has some limits, since there is no strict control of production receipt. Besides, there is no association or supply contract with the company and its associates. However, to join the cooperative the associates accept norms and rules of the organization that includes some liabilities.

In conclusion, the company is social efficient with strong performance by members in management, especially the farmers. In this SC process flows are controlled by the main company, COAPEL, but the SC management is shared among professionals and cooperative members through councils, with big farmers associates acting more actively.

These farmers are also consumers of the company's retail (supermarkets and inputs). In the retail business the company also has urban members, and these associates are managed according to their purchases, obtaining at the end of a year profits shares of this business.

4.1 Focal Supply Chain Analyze

In this research analyzes were limited to a focal SC where the main company is the dairy industry of COAPEL and transactions are done between cooperative members. Below is presented the focal SC:

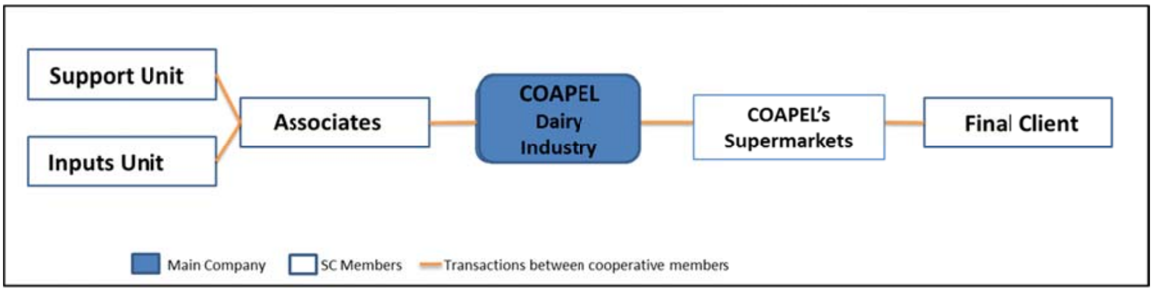

Figure 3. Focal supply chain
Source: The Authors (2011)

Some requirements to join COAPEL are to be a person dedicated to agricultural activity in self land, selling all production to the company, the limitations are related to practices that can harm or conflict with cooperative's activities. Also, can join the company individuals and entities not dedicate to agricultural activities, interested in the retail consumption.

COAPEL do not have a maximum number of members, but this number cannot be less than 20. The association process is done by filling a membership proposal, having no contracts in this relation. The entrance of a new member must be approved by COAPEL Board of Directors and, if there are no restrictions the candidate will subscribe shares turning a cooperative associate. Everybody is free to join and leave the association, and COAPEL also have the right to dismiss a member that is violating some company's bylaws. Associates shares are transferable to heirs, aiming maintenance of farmers as company suppliers, but in some cases is more financial attractive disassociation due the appreciation of shares. It was noted that the company has little control of associates leave, and that some of them become inactive or no longer company's suppliers, but still being associates.

Members participation is done through the General Assembly, the main company council, where big decisions are made and Board of Directors and Audit Committee members are elected. All members, except the ones with employment relation can be elected and voted in COAPEL councils. Council representatives are elected every three years and allowed reelection of ⅓ of them. In the Board of Directors at least two thirds of members need to be engaged in agricultural activities, in order to keep focus on the cooperative's core business and generating more understanding of associates needs and feelings such as prices changes of raw materials. The main members of this SC are milk farmers, that is a prerequisite for the cooperative only buy raw materials direct from producers that are associates. COAPEL undertakes to buy all associates production and is not allowed them to sell this production to other companies, although the company has little control over this. The associates have a huge range of benefits given by the company and if they divert production the company can charge them the amount of investments made in their lands. Most of these farmers have small lands, producing less than 18 thousand liters of milk every day, as showed the distribution in the table below:

Table 1. Associates bulk production

Production Range (daily thousand liters)	**# of suppliers** (in %)	**Total Production** (in %)
0 – 18	55%	19%
18-100	36%	48%
<100	9%	33%
Total	100%	100%

Source: COAPEL (2010)

4.2 Supply Chain Analyze based on Transaction Cost Approach

After explained the relationships and management among COAPEL's SC, their transactions were analyzed based on TC, divided into two phases: behavioral assumptions and dimensional assumptions.

4.2.1 Behavioral assumptions

Table 2. COAPEL Behavioral Assumptions

Bounded Rationality	- Different cognitive capacity between big and small/medium farmers.
Opportunism	- Pursuit of self-interest and economic gains by farmers; - Use of the benefits provided by the company; - Free membership and leave principle; - Different treatment of members seeking economic gains for the company; - Lack of division between ownership and control; - Prices paid to raw material and paid by consumers in retail.

In bounded rationality were founded differences in cognitive abilities between different size farmers: large vs. small. Larger farmers have their rationality expended, due greater access to education and information, and better relationship with the company, community and other farmers. These factors generate more subsidies to them in decision making and, consequently results in further development of their properties. Small farmers tend to have less access to education and information and, restricted relation with other members and community, as well as range of cultural and social barriers.

These cognitive capacity differences were visible in members council participation, where small farmers are minority because of a lack of awareness and organizational capacity, due to a bigger bounded rationality to make strategic decisions. But also was noted bounded rationality of all members, big and small farmers, in performance of administrative functions.

Members opportunism were once more related with farmers size. Bigger farmers are less loyal and have weaker ties in relations with the company due a greater independence that they have from the company to development their activities and larger focus in self-interests. This factor was evidenced in dairy farming competition, when associates choose no longer provide for COAPEL seeking more profits offered by competitors companies.

This opportunism was also evidenced in the use of cooperative's benefits. Members can improve their lands and improve their production through subsidies and access to low-cost loans given by the company and are free to join and leave at any time the association, which is a cooperative principle, without COAPEL receiving returns on those investments.

Another opportunism factor was evidenced in the dependence of small farmers with COAPEL to turn their activities economically viable. In this relations were evidenced some dissatisfaction, as production bonuses are given, in general, to large farmers who have greater ability to modernize and invest in their lands, impacting directly in volumes and quality of milk. The cooperative tries to solve part of this problem through an actively approach to small producers, seeking growth and development of their productions. Besides, COAPEL face a dilemma in this issue: maintenance of small farmers, even being under an optical cost economically unviable vs. the need to retain large farmers, less representative in membership, but more economic profitable for the company.

Were also founded, as previously referenced by Batalha (2001), a lack of division between ownership and control of the company. Although the company is managed by professionals, trying to mitigate this risk, the associates have an actively manifestation on the COAPEL's councils, affecting directly the management. Thus, there are trends in pursuit of self-interest and seek greater benefits for farmers. To finish, is visible evidenced that there are huge differences between the price paid to producers and those paid by consumers.

4.2.2 Dimensional assumptions

Table 3. COAPEL Dimensional Assumptions

Frequency	- Milk is collect every two days in farmers lands; - Daily is produced and distributed final products; - Inputs are sold to farmers depending on their needs; - Technical visits are done sporadically and by associates ask.
Asset Specify	- Assets in the industrialized process are little adaptable to other production process;

	- Assets related to farmers care to the animals are highly specific to this activity.
Uncertainty	- No contractual relations between associates and cooperative; - Price volatility and seasonality of productions, influenced by external factors; - Investments vs. returns.

Mostly assets used in dairy industry to the industrialization process are high specific and have high monetary value. Also, equipment and machinery used to animals husbandry, as well as the animals themselves, have high value-added to production and are too specific. A dairy cow, for example, has no value or quality in its meat because their genetics is specific for milk production and meat is not noble.

Transactions frequency between members of the SC occurs on recurring basis: (1) every two days milk is collected in the farmers' lands, (2) daily are manufactured end products, (3) daily these products are distributed to final clients, (4) products sales also occurs depending on stocks and needs of consumers, and (5) technical visits occur more sporadic, depending on ask of farmers.

Uncertainties of transactions are also strongly related to lack of contracts for members milk supply. The only contract between COAPEL and its associates are related to financing, which guarantee payments and remain of an associated during the contract period. Thus, there is no certainty of permanence of associates or return on investments made by subsidies given.

Another uncertainty factor is related to the dairy sector that have high volatility of prices and other external factors such seasonality of production and clients demand, which directly affects the SC activities. The cooperative seeks to mitigate these risks through products reserves, maintaining stability of prices paid to its members.

4.2.3 Findings

After analyze COAPEL's SC based on TC was evidenced a preference for a SC's vertical integration of its main activities, controlling the main process and activities for the development of the company's core business, from the production of raw materials till the commercialization and distribution of end products. Because of the cooperative business model, some of these controls are uncertain, like the ones related to the principle of free membership and leave. Even if the company has control of raw material production is not guaranteed retention of farmers as suppliers.

Vertical integration is also desirable because of the high asset specificity, frequency of transactions between SC members, seeking to mitigate risks and uncertainties related to dairy segment and members relationship. COAPEL also seeks to reduce other costs related to behavioral assumptions, in compliance with cooperatives principles, such as information and education, developing several programs and giving a range of benefits to its members, seeking expansion of their rationality and less opportunism risks for the company through a closer relationship with the associates.

Due to some TC elements influences, addressed in this research, particularly related to high asset specificity, opportunism and bounded rationality of agents, is possible to determine the need of a governance structure model. This governance structure can generate greater efficiency to COAPEL's SC setting the importance of each member to the process, ensuring better organization, stability and, security for the SC transactions.

Also, the cooperative business model itself is not fully efficient based on TC analyzes, evidenced in findings about bounded rationality, such as the principle of education and information. Even with the company giving to its members access to programs and other benefits it does not guarantee a rationality expansion of SC members. This model also have some critical lakes to opportunism actions, particularly because the non-existence of contracts and no defining division between ownership and control.

5. Conclusion

This research had focused on efforts to increase knowledge of cooperative actions in a SC of an agribusiness company, analyzing those relations and transactions based on TC. Thus, it was evidenced in the analysis some particularities of the cooperative business model, based in cooperatives' principles and doctrines that have important impact in relations and transactions between the SC members.

The findings based on TC presented several critical factors, like high assets specificity of COAPEL business, and huge frequency of transactions among the company and its members. So, the company should monitor closely and in a more efficiently way the SC transactions, trying to minimize costs related to uncertainty relations. These uncertainties were related to the fact that the company does not have formal contracts to guarantee members raw materials supplies, intensified by lacks in associates' management. In addition, the company is affect by other factors inherent to its activity but influenced by external factors, such as seasonal production and consumers demand, price volatility of raw materials, etc. Thus, inferences were made to these results, since the combination of some factors can lead to a SC better structure and to optimizations in its process and transactions.

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Securing Food Supply through Efficiency in the Supply Chain

Zaragoza-Gasca, P.; Ridgman, T.
University of Cambridge, Department of Engineering
17 Charles Babbage Road, Cambridge, CB3 0FS
pedro.zaragozag@gmail.com, twr20@cam.ac.uk

Abstract

Feeding 9 billion people by 2050 without a dramatic increase in the demand for water, energy and land for food production is one of humankind's biggest challenges. The increase in the incomes is likely to drive the lead to a surge in the food demand.

Improvements in food efficiency could considerably decrease food and resource demand whilst decreasing hunger and obesity around the world. This scenario requires strong food policy leadership from the developed world to regulate consumer's food waste, strong investment in the developing world to develop the food supply chain and the redistribution of food by decreasing the food overconsumption of some regions of the world.

Keywords: Food 2050, food waste, food efficiency, food footprint, yield gap, waste roadmap.

1 Introduction

The economic and political systems that support present society seem to have been founded under the vision of endless resources (A. y Hall 2011). Since the start of the industrial revolution humans have adopted a resource intensive lifestyle (McDonough y Braungart 2009). Thus, meeting humankind's demand for resources without further degradation of the environment and while improving human welfare is one of the biggest challenges (Meadows, Randers y Meadows 2004). **However the sustainability debate has been largely centred on reducing carbon emissions** and few efforts from the sustainability bodies can be identified in the other sustainability dimensions, these being: meeting resource demand, improving human welfare and increasing levels of employment

Efficiency and effectiveness gains can reduce resource demand. Materials, energy and water have received most of the attention. According to McKinsey Global Institute humankind needs to address resource demand in its 4 major dimensions, these being: land & food, water, materials and energy (McKinsey 2012, McKinsey Global Institute 2009). Furthermore, according to McKinsey the efficiency and effectiveness gains in these systems can considerably reduce demand (McKinsey Global Institute 2009).

Food efficiency and effectiveness have received little attention. Some first attempts to tackle the food problem have been focused on isolated problems like malnutrition, yields, biofuels and crop-land demand (FAO 2011, FAO 2005, Henningsson, et al. 2001). The efficiency opportunity, by reducing food waste, has been barely explored.

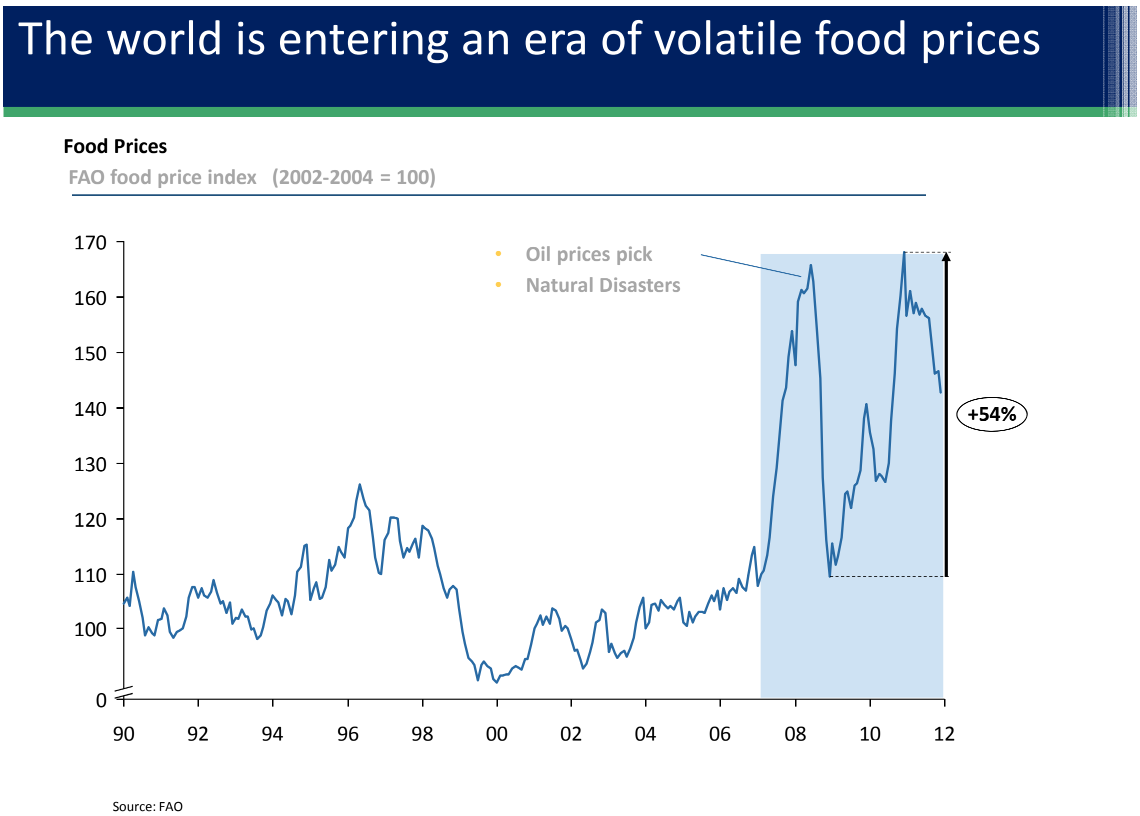
The objective of this research is to explore the feasibility of building a quantitative food-demand model, and how an efficient and effective food system can help humankind to address the food & land demand challenge towards 2050. Three dimensions are explored: Food waste, malnutrition* and yield improvement. The trade-offs between yields, waste, and diets are quantified in terms of resource demand using 5 illustrative scenarios towards 2050.

2 The Consumption Challenge

The 20th century was characterized by a decline in resource prices regardless of the huge increase in resource demand driven by population increase. (McKinsey 2012). According to the McKinsey Commodity Index, the price of all the major commodities felt by half (McKinsey Global Institute 2011); while the population, increased more than 400% (Maddison 2007). These two factors led to an increase in the demand for natural resources between 600% and 2000% (McKinsey Global Institute 2011); at the same time the GDP grew 700% (Maddison 2007). The food system has been through the same phenomena. The food prices felt by 11% between 1990 and 2000 (FAO 2012); at the same time, the demand for food grew 12% (FAO n.d.) and the world's population by 11% (United Nations 2010).

However, it seems that the era of cheap resources and price certainty has come to an end. The increase in the price of resources during the last decade has already overcome the price reduction achieved during the 20th century (McKinsey Global Institute 2011). The FAO Food Price Index (FPI) has increased 100% (FAO 2012). Additionally, as can be observed in Exhibit 1 the volatility is higher now than at any other point in the story.

Exhibit 1: Price variations

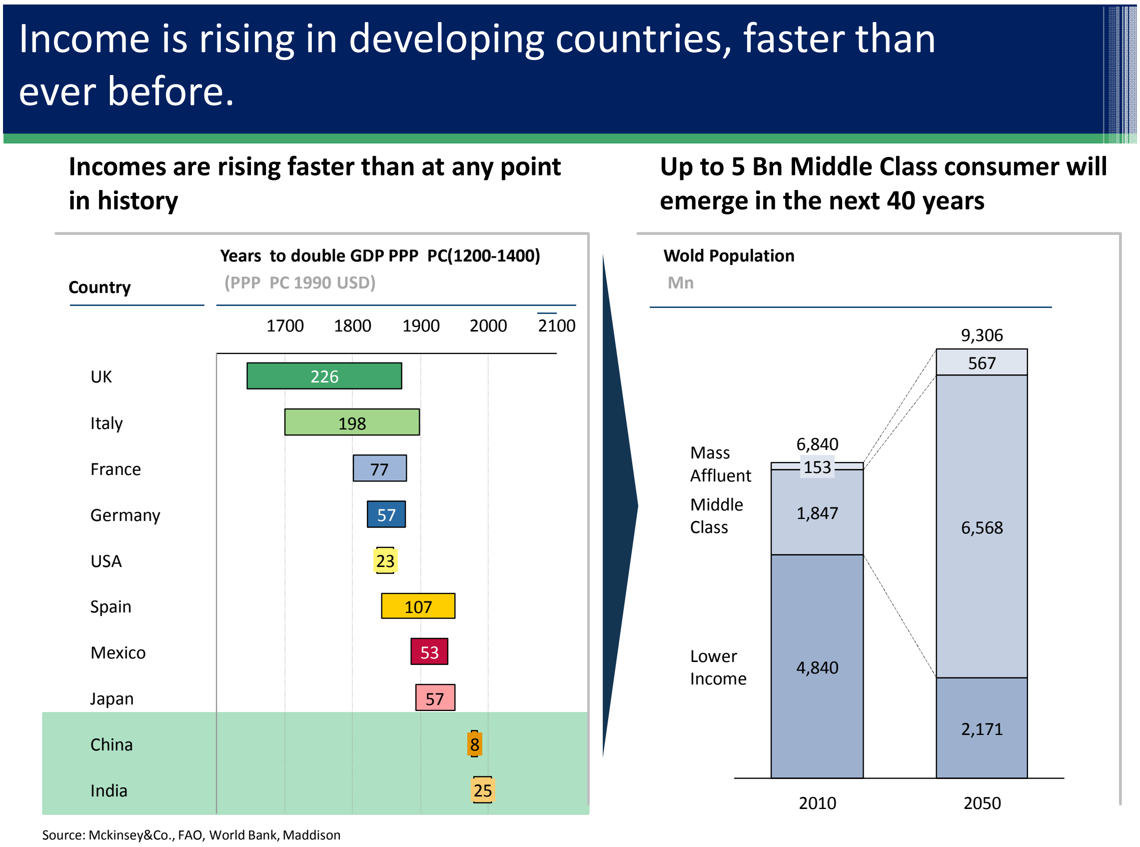


* The term refers to under-nourishment or overweigh due unbalance diets where some nutrients are lacking or are in excess.

2.1 Consumption Increase

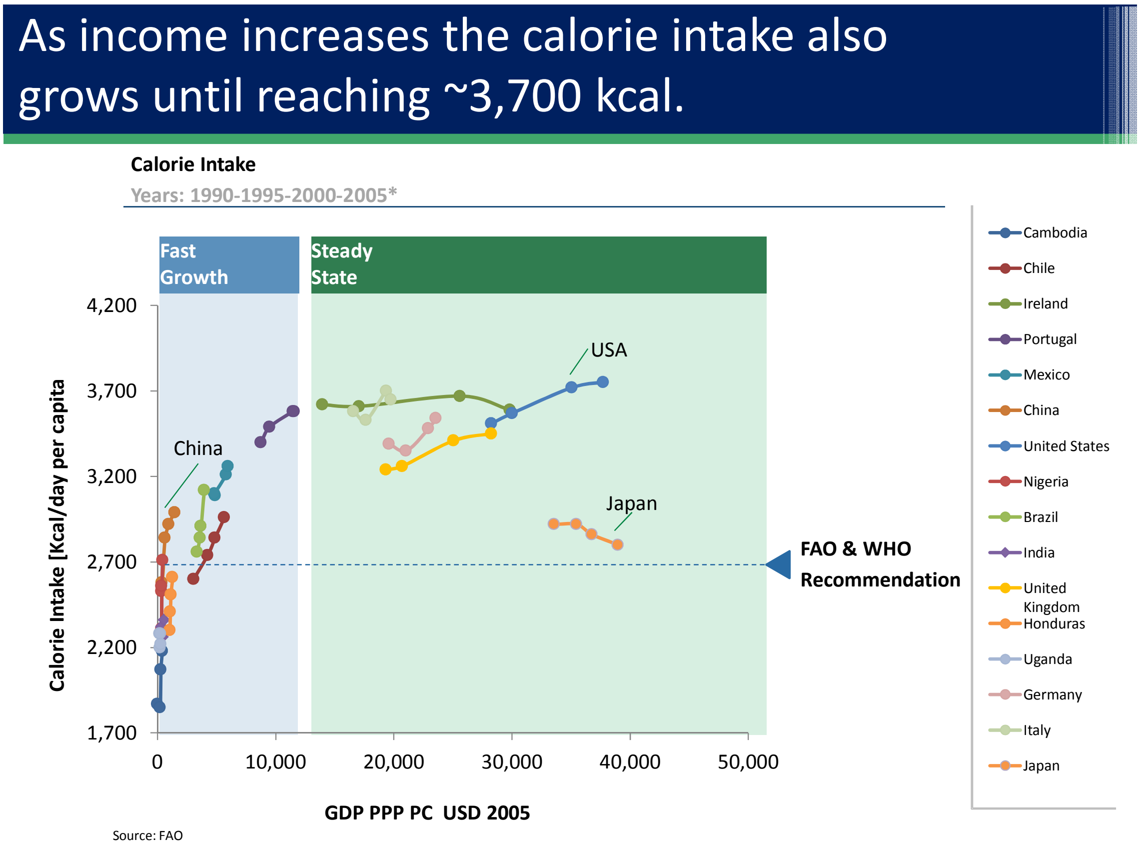
The income per capita is increasing faster and at a bigger scale than at any point in history (McKinsey Global Institute 2011). According to Maddison's estimation of the GDP per capita in comparable terms, the United Kingdom doubled its GDP PPP per capita from 1200 to 2400 USD in 226 years with a population of roughly 10 million people. Now China and India, with a population of 2.3 billion, doubled their GDP in 8 and 25 years respectively (Maddison 2007). This means that the acquisition power of these regions is growing 9 times faster with a population 230 larger when compared to the UK. As a result of this up to 3 billion middle class consumers might be added in the next 20 years (OECD Development Centre 2010) and up to 5 bn in the next 40 years. The demand will grow faster in the cities, 61% of the world's population is expected to live in urban areas by 2030 (International Food Policy Research Institute 2007)

Exhibit 2: The increase in the purchasing power



As the GDP per capita in comparable terms increases, the food demand also increases rapidly, overtaking the FAO calorie intake. Exhibit 3 shows food demand as function of purchasing power; it can be observed that the food demand, measured as calorie consumption (FAO 2011), increases as the GDP per capita (World Bank Indicators n.d.) rises. Exhibit 3 shows that the WHO's calorie intake recommended level of 2,600 Kcal/day (Smil 2010) (Griffin, Sobal and Lyson 2009) is reached at a GDP per capita of 3,500 USD. Furthermore, the calorie consumption continues to grow until reaching a steady of 3,800 Kcal/day. Exceptions to the economic trend can be found. For example, Japan with a GDP per capita at the same level than USA has a calorie consumption of ~2,800 kcal per capita/day.

Exhibit 3: Food consumption road map

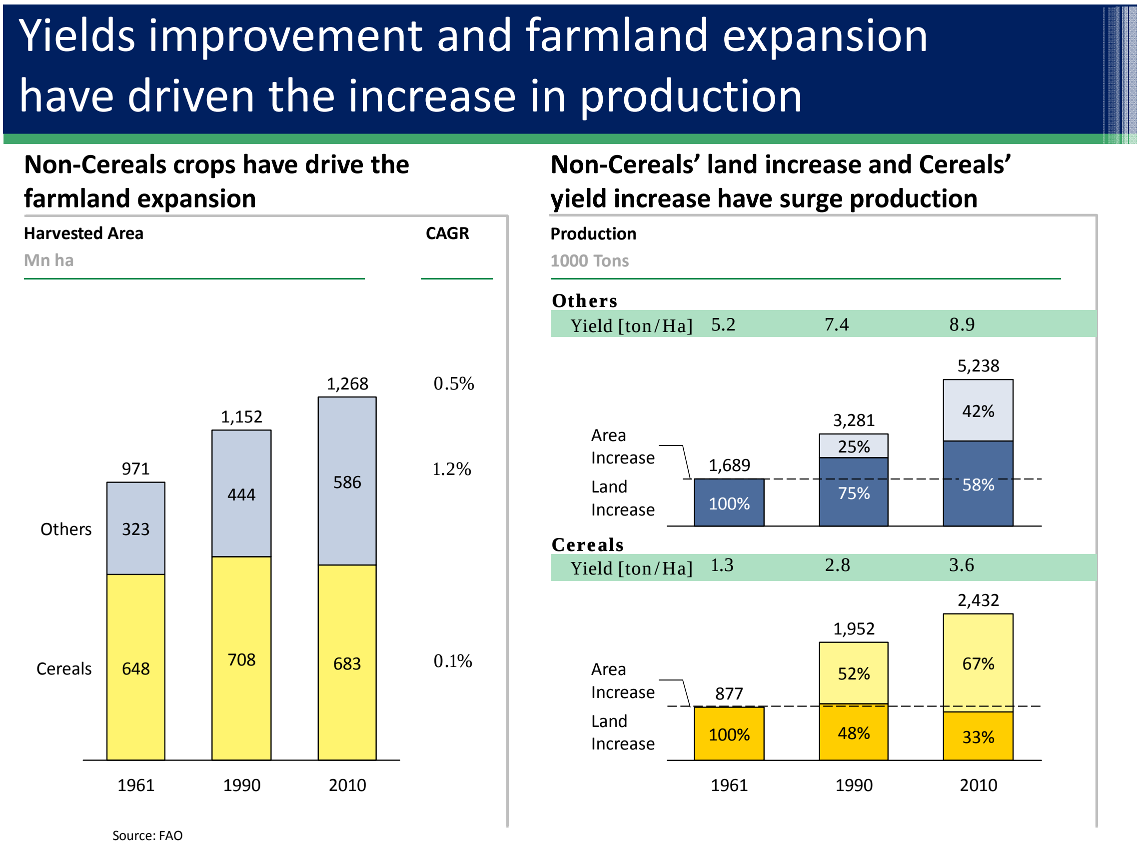


3 The Yield Challenge

Technology improvements have been the main mechanism to increase yields and meet demand. Over the last 50 years the crop production grew 300% reaching a total throughput of 7.6 G tons in 2010 (FAO n.d., David Tilman*, et al. 2002). The increase in agricultural throughput has had two drivers, these being: the increase in land and the increase in yields. The most common methods to increase yield have been the use of pesticides, water, fertilizers, new crop varieties and other technologies from the Green Revolution (Tilman, et al. 2001, WHO 1990). The yield and land increase have had different importance in the production of cereals and non-cereals.

Cereals' harvested land has remained steady during the last 50 years, while yields have increased 300%. According to FAO statistics (FAO n.d., FAO 2012) the increase in the production of cereals has been driven only by the increase in yields. While the land used for cereals remained steady in the last 50 years at 650 million of hectares, the cereal yield tripled, reaching and average of 3.6 tons/Ha (FAO n.d.). On the other hand, the **production of non-cereals increased through a combination of yield and land increase.** The non-cereal crops include Pulses, Roots, Fruit, Sugar crops, Vegetables and Oilcrops. The non-cereals harvested land increased 81% from 1960 to 2012; while their yield increased 71% within the same period of time.

Exhibit 4: Yield and area increase

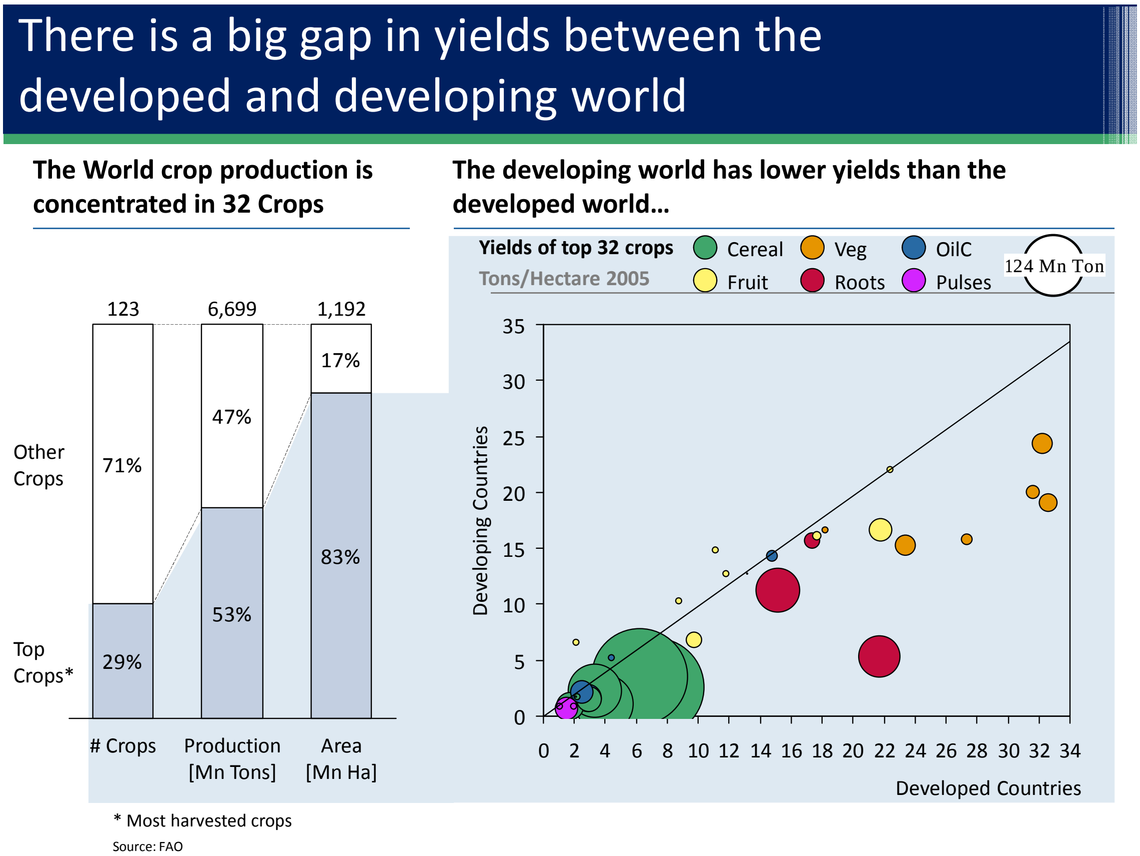


3.1 The Yield Gap Opportunity

Further increase in production should not be achieved by land expansion. Increasing production in ways that does not deteriorate the environment and does not compromise public health is the major challenge that humans will face in the coming years. Already more than 60% of the arable land is in use (Tilman, et al. 2001) and the remaining 40% does not have the same soil quality in terms of water and nutrients availability (FAO 2011), and therefore, its use for agriculture could be costly. Further quality land is available but its use implies the destruction of ecosystems. (Cassman, et al. 2003, K. G. Cassman 2001, DN and KG. 1999).

Although higher yields are needed, increasing them in some parts of the world is unlikely as they are almost reaching the maximum genetic yield. There is evidence worldwide that suggests that some agricultural systems in some parts of the word are reaching the maximum genetically possible yield (K. G. Cassman 2001, Lobell, Cassman and Field 2009, DN and KG. 1999)**.** For example, Rice yields have remained steady for the last 10 years in some regions of China, Korea and Japan (David Tilman*, et al. 2002). It has been estimated that this region have reached yields equivalent to 80% of the genetically possible yield (K. G. Cassman 2001). The evidence suggests that increasing yields in some parts of the world is economically unviable, due the high investment required to reach 100% of the genetically possible yield (David Tilman*, et al. 2002, Page 2009).

Exhibit 5: Developed and developing world yields



On the other hand there are many regions, mainly in the developing world that still have a considerable improvement potential. A significant yield differences among countries, for the same crop, can be observed in Exhibit 5 (using FAO Production statistics data (FAO 2012)). The 45 degrees line represents an ideal scenario, where the yields are the same in every part of the world.

Narrowing the yield gap is one of the major opportunities to increase production. The FAO and many authors have recognized that increasing production by reducing the yield gap is a strategy that is likely to have a small environmental impact (FAO 1989, K. G. Cassman 2001). This strategy could increase agricultural throughput without further land increase. In addition, it can also reduce the water intensity of high yield agriculture by deploying water efficient irrigation technologies (McKinsey Global Institute 2011).

Although most authors recognize the importance of the yield gap few efforts have been made to generate a worldwide view of the opportunity. The current efforts to understand the yield gap seem to have been focused on understanding the required technologies and practises that need to be adopted to narrow the yield gap. However, little effort has been put in building a consolidated global quantitative view of the yield gap opportunity across all geographies and crops.

4 The Waste Opportunity

4.1 Food Supply Chain and Waste Definition

The food supply chain encompasses 5 main stages. For the purpose of this work an approach “farm-to-fork” is used; and the definition from Scott and Westbrook is adopted: “The chain linking each element of the production and supply process from raw materials through to the end consumer” (Scott and Westbrook 1991). According to FAO the supply chain of vegetable and animal commodities can be separated into 5 mains activities as shown in Exhibit 6.

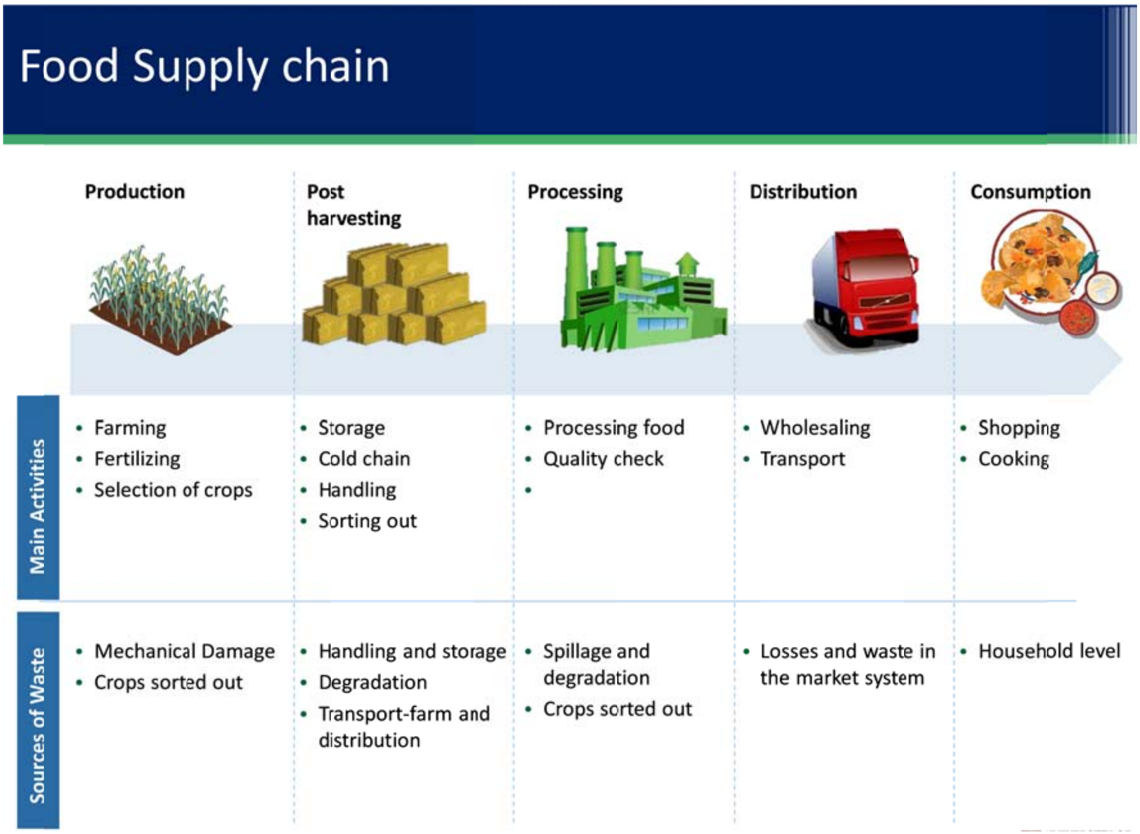
Food waste is the material produced for human intake that is not consumed or consumed above the recommended calorie intake. It has been widely recognised that food waste occurs at the different stages of the supply chain (Parfitt, Barthel and Macnaughton 2010, FAO 2011, Vorst, A.J. M. Beulens and Beek 1998). In the literature the term “food losses” is used to refer to the food wasted before consumption; and waste is used to describe the food that is not eaten by consumers (FAO 2011, Kader 2005). In this his report the term food waste refers to both food losses and food waste alike. Furthermore, the consumption of food above the recommended calorie intake can also be considered as waste (Smil 2010), this report refers to it as overconsumption.

Exhibit 7 shows the food waste drivers for each stage of the supply chain.

Exhibit 6: Waste Drivers

Stage	Food waste causes
1. Agricultural Production	Mechanical damage, spillage, crops sorted out, crops left in the field or eaten by birds, harvest timing
2. Post-harvesting Handling and Storage	Degradation, damage during transportation and storage, spillage, pest, diseases,
3. Processing	Degradation, industrial losses, crops sorted out or damaged during operations.
4. Distribution	Damage, spoilage, pest and crops sorted out in the market system (E.g. market, retailers, supermarkets)
5. Consumption	Poor storage, overbuying, confusion of “best before date” and “use by”.

Exhibit 7: The food supply chain



4.2 Driver of Waste

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4.2.1 Developing World Waste Drivers

In the developing world the distribution of perishable goods in suboptimal conditions and large farm-to-fork times are the main causes of waste. In these regions, farmers, and especially small farmers, appear not to have dependable and fast means to get their products to the local, national or international markets (Kader 2005). This lack of transport infrastructure, like roads and refrigerated trucks, is increasing farm-to-fork times and therefore is leading to waste generation (Kader 2005).

4.2.2 Developed World Waste Drivers

In these regions, overbuying, and therefore food waste, is driven by food low prices and marketing strategies, such as 2-4-1 offers (Dam 1996). Furthermore, cultural aspects such as the low use of leftovers and oversized portions can also significantly increase food waste generation (Hodges, Buzby and Bennett 2010). Additionally, **the low level of process standardization and certifications is one of the main drivers in the developed world**. Although the cost of raw materials in the food industry can represent up to 80% of the production cost (Somsen and Capelle 2002); companies have put little effort in the waste reduction of raw materials. In the UK, from the 722 companies certified by ISO in 1999 only 16, less than 2%, belonged to the food industry sector (Henningsson, et al. 2001). This low level of process standardization has led to a high level of waste. It has been estimated that in some food companies up to 50% of the perishable materials can be wasted. (Henningsson, et al. 2001).

4.2.3 Worldwide Waste Drivers

The lack of communication between the supply and demand of food is one of the main drivers of food waste across the world (Parfitt, Barthel and Macnaughton 2010). Historically the food industry has coped with the variations in demand and quality by creating large stocks and proving excess capacity of perishable goods (Kader 2005). In the particular case of the perishable good, the excess capacity is likely to lead to the generation of waste. In order to reduce waste, the supply and demand should be aligned throughout all the supply chain (Parfitt, Barthel and Macnaughton 2010).

4.3 Past Efforts to Understand the Food Waste Opportunity

Although the high awareness of the food-waste opportunity few qualitative attempts can be found in the literature. In 2010 FAO published a first attempt to quantify the food losses worldwide along the food supply chain. Although this is a first good effort to breakdown food waste to manageable parts, it does not show the evolution of food waste and its relationship with economic development.

5 Methodology

5.1 Data Sources

The production volumes for all the commodities were collected from the FAO's Food Balance Sheets (FAO n.d.). The yields for all the crops in every country in the world were collected from the FAO Production statistics (FAO 2012). Population forecast at country level was obtained from the United Nations Population Forecast (United Nations 2010). The waste factors reported by the FAO in Food Losses and Waste (FAO 2011) are used to estimated waste.

Global calories Intakes per group of food, according to the FAO classification, during the period 1961 to 2000 were obtained from the FAO report on agriculture (FAO 2006). Calorie intakes at country level for the years 1990, 1995, 2000 and 2005 were obtained from the FAO Dietary Portal (FAO 2011). The FAO estimates of diets per geography area for 2000 were used (FAO 2006). The global diet forecast, in a business as usual scenario, was obtained from the Global Harvest Initiative (Kruse 2010).

5.2 The Data Mining and Model-building Approach

A data mining approach was selected as the main research tool. Using FAO's databases for production and yields requires handling a large collection of data; it has been widely recognized that a data mining approach can help to create valuable insights from big datasets (Han, Kamber and Pei 2012). **A quantitative model can be used to understand the implication of resource demand due changes in yields, diets and waste levels towards 2050.** According to several authors (Rivett 1980, Ragsdale 1998) modelling is a useful tool to establish and understand, from a quantitative approach, the relation and trade-offs among different variables.

Scenario planning, a widely used tool in strategic thinking, was used to understand future trade-offs. Business as usual thinking is an extrapolation of the past; this is a very limited technique to predict the future, and does not acknowledge the dynamics of the world we live in (Wright and Cairns 2011). On the other hand, scenario planning challenges "conventional thoughts" by making possible the construction of future scenarios outside the business as usual trend (Lindgren and Bandhold 2009).

5 illustrative scenarios were designed. The scenarios were chosen to show a range of illustrative futures. The scenarios “Super consumption” and “effective consumption” illustrate what could happen, and not what is likely to happen, if considerable changes in the social and economic level occurred. The scenarios “Biofuels Boom” and “Super Crop” show a possible future if certain technologies were developed and widely adopted. Finally the “Business as Usual Scenario” shows what is likely to happen if no action is taken, the projection of this scenario is in line with the FAO forecasts.

Exhibit 10 shows the level of effort across waste, malnutrition and yields improvement for each scenario. These scenarios do not reflect policy decisions and apart from the "Business as Usual" scenario, are not projections

5.3 Modelling the Food System towards 2050

A model was constructed to forecast food and crop-land demand by 2050 and it was tested using 5 food scenarios towards 2050. 3 main dimensions where taken into account: Change in diets, yields improvement and waste reduction. The reference year was 2000, and the initial conditions where the food demand reported by FAO (FAO 2012), the GDP per capita (World Bank Indicators n.d.) , the current global diet mix (Kruse 2010). 5 illustrative scenarios towards 2050 were used to test the model. The results were validated with fellow students, other experts in the field. The model methodology is described next; Exhibit 8 shows the variables used.

Exhibit 8: Model variables

Variables					
CI	Total calorie intake per food-group or crop	A	Harvested land	r	Water improvement factor
Φ	World population	**f**	Yield improvement factor	**q**	Waste improvement factor
CI	Total calorie intake	π	Production potential		
d	Share of the food-group in the diet	LF	Land footprint	Sub and super indexes	
P	Production	WF	Water footprint	l	Crops evaluated (132)
CC	Cereal for consumption	EF	Energy fooprint	**h**	Countries evaluated (172)
Pn	Production corrected by waste	wf	Water footprint factor	j	Supply chain stages (5)
G	Yield gap	ef	Energy footprint factor	k	Geographies (7)
ξ	Yield Potential	**F**	Food flow	i	Food groups (8)
y	yield	wl	Waste level	a	year
GDPp	GDP per capita	W	Waste		

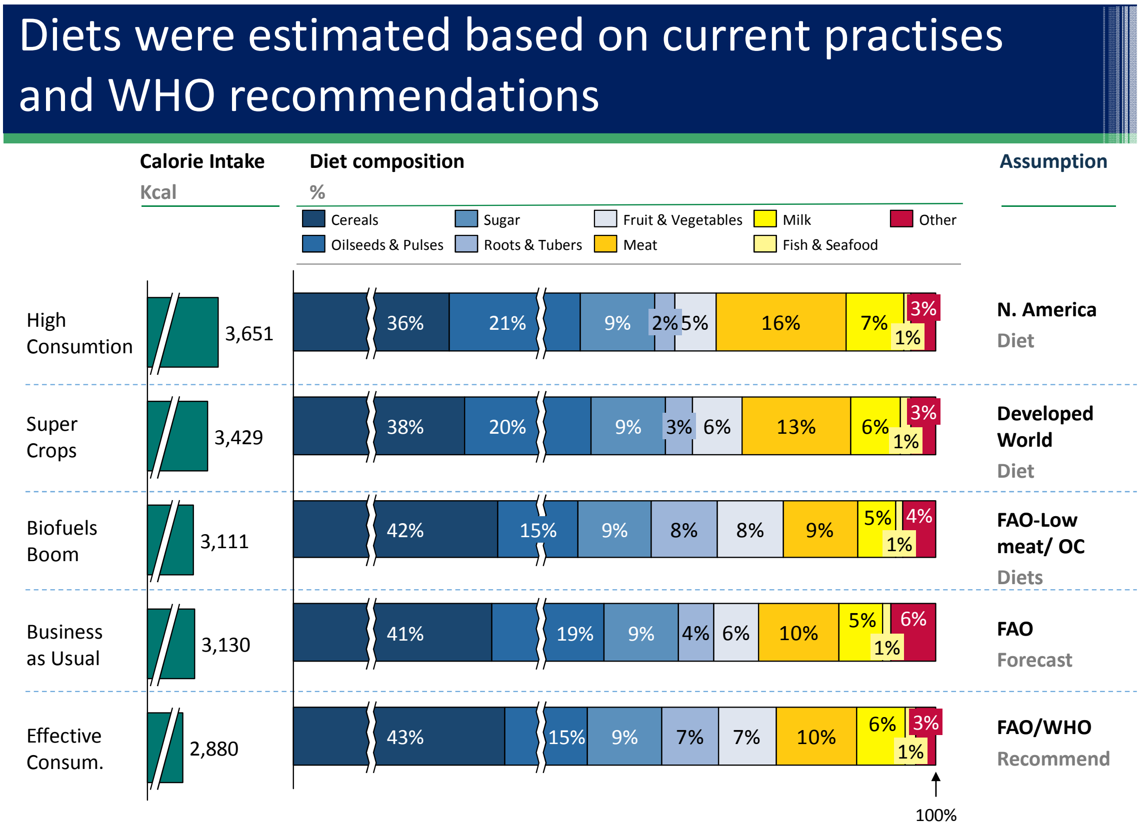
5.3.1 Estimating Consumption

Diets for the 5 scenarios were defined based on current practices and trends. For the "Super Crops" scenario the current diets of the developed world were used (FAO 2006). A developed world diet low in oilseeds, meat and dairy was created to represent the "Biofuels Boom" scenario (FAO 2006). The FAO forecast was used to calculate the "Business as Usual" scenario (Kruse 2010). The "Efficient Consumption" diet was created based on FAO's calorie intake and WHO's diet mix (Nishida, et al. 2004). Finally the "High Consumption" calorie intake was modelled used the calorie pathway of the United States of America (FAO 2011, FAO 2012). Exhibit 10 shows the diets used for the model.

The calorie intake for the High Consumption scenario was projected. The formula 1.1 represents the relation between GDP per capita and calorie intake and describes the USA Calorie Intake Pathway described in Exhibit 3. Formula 1.1 was used to forecast the calorie intake by 2050 in the "High Consumption" Scenario.

$$
(0.1) \qquad \begin{array}{ll} \text{If } CI < 3{,}700 & CI = 1.232\times10^{-10}GDPp^{3} - 8.539\times10^{-6}GDPp^{2} \\ & \quad + 0.186 * GDPp + 2331.4 \\ \text{If } CI \geq 3{,}700 & CI = 3{,}700 \end{array}
$$

Exhibit 9: World's diets, 2050 scenarios



The calorie intake was used to model the required food production to meet demand by 2050. The required production to meet demand was modelled at the FAO's food-group level (i). The changes in the world's calorie intake per food-group (CI), defined by formula 1.1, are used to estimate the changes in food production at the food-group level, formulas 1.2 to 1.3. For the particular case of cereals demand, the model takes into account the demand for cereals for livestock feed (CL) and human consumption (CC); according to FAO, 3kg of cereals are needed to produce 1kg of meat (FAO 2011). Formulas 1.4 to 1.6 represent this relationship. The demand was adjusted to account for changes in waste levels (formula 1.7).

$$
(0.2) \qquad CI_i\big|^{a} = \Phi^{a}\left(C \cdot d_i^{a}\right)
$$

$$
(0.3) \qquad \Delta P_i = \frac{CI_i\big|^{2050}}{CI_i\big|^{2000}}
$$

$$
(0.4) \qquad P_i\big|^{2050} = \Delta P_i \cdot P_i\big|^{2000}
$$

$$
(0.5) \qquad P_C = CC + CL
$$

(0.6) $$CL = 3P_M$$

(0.7) $$P_C\Big|^{2050} = 3P_M\Big|^{2050} + \Delta P_C □ P_C\Big|^{2050}$$

(0.8) $$Pn_i = P_i\left[1-\left(wl_i\big|^{2000} - wl_i\big|^{2050}\right)\right]$$

5.3.2 Estimating the Yield Gap

The yield potential is the yield of a variety that grows without nutrients, water limitations in the absence of pest and diseases (Lobell, Cassman and Field 2009). It has been proved that the yield potential of a crop depends on solar radiation, temperature and crop variety (Cassman, et al. 2003) and therefore is geographic-specific. While the comparison of yields among similar climate areas is the best approach, databases with this level of granularity are still under development (Cassman, et al. 2003, David Tilman*, et al. 2002). On the other hand, it has been proved that regional average yields are always below the potential yield (Lobell, Cassman and Field 2009). In this study, the highest average yield observed among the top 30 producer countries for each crop is used as an approximation of the yield potential. This assumption implies that the regional variability of yield potentials can be decreased by land management and the adoption of best practises (Cassman, et al. 2003) by 2050; for example the large deployment of water efficient technologies and organic fertilizers.

The possible increase in production without further increase in cropland was estimated. The yield statistics for year 2007 at country and crop level were used. For each crop the top 30 producers were identified and ranked from the highest yields to the lowest yield. Then the production increase potential was calculated per country (*n)* and per crop (*l)* as the difference between the best practises (highest yield among the top 30 producer countries (ξ_l) and the county's average yield (y_{ln}) multiplied by the harvested land (A). Formula 1.9 represents the yield gap, formula 1.10 the production potential (π) per country/crop and formula 1.11 the total production potential.

(0.9) $$G_{ln} = \left(\xi_l - y_{ln}\right)$$

(0.10) $$\pi_{ij} = G_{ij} A_{ij}$$

(0.11) $$\pi = \sum_{i=1}^{n}\sum_{j=1}^{n}\pi_{ij}$$

Yields towards 2050 were estimated at the scenario/crop-group level. The crops were grouped in the 5 crop-groups listed in Exhibit 9 (Cereals, Oilseeds & Pulses, Roots, Fruits & Vegetables and Sugar) the crop-group yields and potential yields were calculated using formula 1.12. The yields 2050 were calculated using formula 1.13, where f is an assumed factor than represents the level of effort to improve the yield of the crop-group in each scenario.

(0.12) $$y_i = \frac{P_i}{A_i} \qquad \xi_i = \frac{\pi_i}{A_i} \qquad G_i = \xi_i - y_i$$

(0.13) $$Y_i\Big|^{2050} = f \cdot G_i \cdot Y_i\Big|^{2000}$$

Energy, land and water footprints for each food group were estimated. The yields calculated with formula 1.13 were used to calculate the land footprint (formula 1.14), for crops, the other food-groups land footprint is not calculated due the lack of reliable data. The water footprint was calculated for the 8 food-groups using the values reported by Meknonnen in 2011 (M. and Y. 2011) and an improvement factor that reflects the level of adoption of water efficient irrigation technologies (formula 1.15). To estimate the energy footprint the values reported by Cuellar (CUellar and Webber 2010) for USA were used as an approximation due the absence in the literature of global values; no improvement towards 2050 was assumed (formula 1.16)

(0.14) $$LF_i = \frac{P_i}{Y_i}$$

(0.15) $$WF_i = P_i \cdot r \cdot wf_i$$

(0.16) $$EF_i = P_i \cdot ef_i$$

The share of resources used for the production of food waste was estimated as the share of food waste, at food group level, multiplied by the resources needed to produce it (formula 1.15).

(0.17) $$Y_i\Big|^{2050} = f \cdot G_i \cdot Y_i\Big|^{2000}$$

(0.18) $$\mathrm{Re}\,sources\;wasted = wl \cdot resource\;for\,production$$

The values used for r and f are included in the appendix

5.3.3 Estimating Waste

The food production was classified in the 8 FAO categories, these being: Cereals, Oilseeds & Pulses, Roots, Fruits & Vegetables, Meat, Fish & Seafood, Milk and Sugar. The analysis was performed across 7 geographies according to the FAO classification, these being: North America & Oceania, Europe, Industrialized Asia, Sub-Sahara Africa, North Africa & Central-West Asia, South & Southeast Asia and Latin America. The waste in the 5 stages of the supply chain were analysed, these being: Agricultural Production, Post harvesting, Processing, Distribution and Consumption (FAO 2011).

The methodology and the waste factors used by FAO are used to estimate waste in the period 2000-2010, this methodology is shown in formulas 1.4 to 1.5. However, the numbers in this report refer to total food waste and are not comparable to the numbers in the FAO report that refers only to the edible part of the food.

(0.19) $$W_{ijk} = F_{i-1,jk} \cdot w_{ijk}$$

(0.20) $$wl_i = \frac{\sum_j \sum_k W_{ijk}}{\sum_k F_{2ik}}$$

The values of for F can be obtained from the Food Balance sheets (FAO 1981, FAO n.d.).

Waste levels towards 2050 were estimated based on current trends. To estimate waste in 2050 the current waste factor at the level of Food Group/ Geography/Supply Chain Stage were adjusted to mimic current practices according to the nature of the scenario according to formula 1.20, values for q can be found in section 13.6.

(0.21) $$w_{ijk}\Big|^{2050} = q \cdot w_{ijk}\Big|^{2000}$$

6 Results

6.1 Scenario Description

The 5 illustrative scenarios that were simulated are described below:

The "High Consumption" scenario illustrates an increase in consumption to the current level of the United States of America. This scenario is characterized by a high economic growth driven by a resource intensive economy. Investment in agriculture continues to decline while the efforts are focused on the development of the manufacturing and service sectors. As a result of this, there is a reduction in the waste levels at the production and processing stages and the world reaches the current North America & Oceania levels. Yields increase slightly and demand for food is met by land increase. The growth in food prices is overcome by the surge of incomes. The North America levels of calorie intake and consumption waste are reached. The obesity numbers rocket as well as the resource demand for food production (Land, Water and Energy).

An equitable distribution of food is achieved in the "Effective Consumption" scenario tackling malnutrition worldwide. In this scenario education and policy work together to tackle malnutrition, the number of undernourishment and overweight people descend reaching levels below 1% of the population. As a result, the average calorie intake of the population decreases to the FAO and WHO recommendation of 2,800 Kcal/day per capita. On the other hand, food waste is tackled along all the supply chain. At the same time, the investment is focused on the diffusion of sustainable agricultural practices; therefore an increase in yields while decreasing the resource intensively of agriculture is reached. Technologies like drip irrigation and practices like agroforestry, multi-crops and fertilizer efficiency are widely deployed.

The surge of yield narrows the yield gap in the "Super Crops" scenario, increasing the calorie intake worldwide. The surge of investment in agriculture leads to the development and wide adoption of genetically modified (GM) crops and land management practises, at the same time, water efficient technologies, like drip irrigation, are widely adopted. Consequently, the yield gap is narrowed as a result of the increase in yields in many parts of the world. The surge in production brings food prices down and diets continue to evolve following the current trends, by 2050 the world has adopted the developed world diets. The calorie intake reaches 3,429 Kcal/day per capita. There are no considerable efforts to reduce the waste in the supply chain; therefore the food waste in the consumption endpoint increases reaching the developed world levels.

The "Biofuels Boom" scenario supposes a wide adoption of biofuels leading to a surge in food prices. Governments foster the adoption of biofuels by the implementation of national adoption targets. By 2050, biofuels represent 40% of the primary energy. The biofuels crops (oilseeds, sugar and fuel cane) use 10% of the cropland. The high investment in the biofuel industry helps to reduce the yield gap in the oilseed and sugar cane crops, but no considerable yield improvement is observed in other crops. However, the increase in the food prices drives the reduction of waste in all the food supply chain stages. Furthermore the high prices of oilseeds and sugar help to shape a less resource intensive diet, rich in roots, fruits, vegetables, cereals and low in meat and dairy.

No considerable changes in the food system occur in the "Business as Usual" Scenario. No high efforts to reduce waste, increase yields and improve malnutrition are observed. The world's food system continues as it is today. Waste per capita stays close to the current level but total waste continues to growth as result of the population increase. The calorie intake reaches 3,130 Kcal/day per capita while the overweight continues to grow and the undernourishment decreases slowly, measured as a percentage of the population.

Exhibit 10: Scenario description

			Healthy World	BAU	Super production	Biofuels Increase	High Consumption
Supply: Yields Improvement	Water	Drip and pivot irrigation	◕	◔	◑	◑	◑
		Addition of Hydroscopic su. (manure)	◕	◔	◔	◔	◑
		Drought resistant crops	◑	◑	◑	◑	◕
	Techniques	Landscape-scale	◕	◑	○	○	○
		Agroforestry	◕	◔	○	◔	○
		Fertilizers efficiency	◔	◔	◕	◕	◔
		Multi-crops deployment	◕	◑	◔	◔	◔
		Deployment of Greenhouses	◔	◔	◕	◔	●
	Land	Land reactivation	◕	◑	◔	◔	○
		Biodiversity conservation	●	◑	◔	◑	◔
	GM	Investment in new GM crops	◔	◔	●	◔	◑
		Deployment of current/new GM	◑	◑	●	◔	◑
Waste Reduction	Production Practises	Efficient use of food (food cycle)	●	◔	○	◑	○
		R&D in industrial process	●	◕	◔	◑	◔
		Commercialization in local markets	●	◔	◔	◑	○
		Creation of industrial agreements	●	◑	○	◕	◔
		Marketing cooperatives	●	◔	◔	◑	○
		Lean manufacturing	●	◕	◔	◕	○
	Supply chain	Supply chain concentration	●	◑	◑	◑	◕
		Improved communication	●	◔	○	◔	◕
		Wide deployment of cold chains	●	◑	◔	◑	●
Demand/Diets	Policy	Adequate food fiscal incentives	●	◔	◔	◔	○
		Adequate landfill taxes	●	◔	◔	◔	○
		Major tolerance to product variations	●	○	○	◕	○
		Major tolerance to best before dates	●	○	○	◕	○
	Various	Education on eating habits	●	◑	◔	◑	○
		Adoption of healthy-sustainable meals	●	◔	○	◕	○
		Discourage food over-buying	●	◔	○	◑	○
		Adoption of low resource intensive diets	●	◔	○	◕	○

Level of Effort ● High ○ Low

6.2 Model Output

As shown in Exhibit 11 the way in how humankind addresses the food challenge will shape the demand for food and resources. The 5 modelled scenarios show that demand for food could increase from 61% in and "Effective Consumption" to 83% and 141% in a "super crops" and "High Consumption" scenario respectively. The land needed for the production in a "high consumption scenario" would be 2.4 Bn Ha, 55% more than the current available arable land.

Exhibit 11: Food supply and resource demand

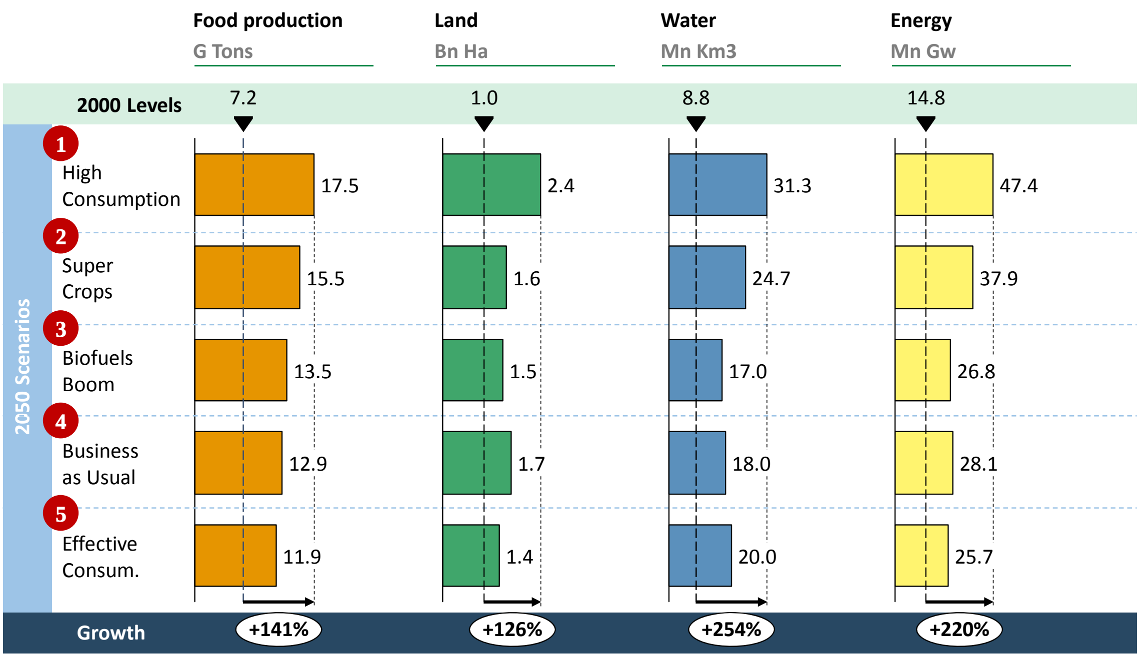


Exhibit 12 **and Exhibit 13 show the evolution of yields and waste respectively.** An increase in yields is likely in all scenarios. The “Super Crops” has the biggest increase reaching 5.0 tons of cereal/ha capturing half of the cereal yield gap. The increase in yields will depend on the effort dedicated to each crop. Likewise, food waste is likely to grow in all scenarios; the food waste in the consumption stage is likely to grow faster and in the “High Consumption” scenario it could represent up to 38% of the food waste.

Exhibit 12: Yields

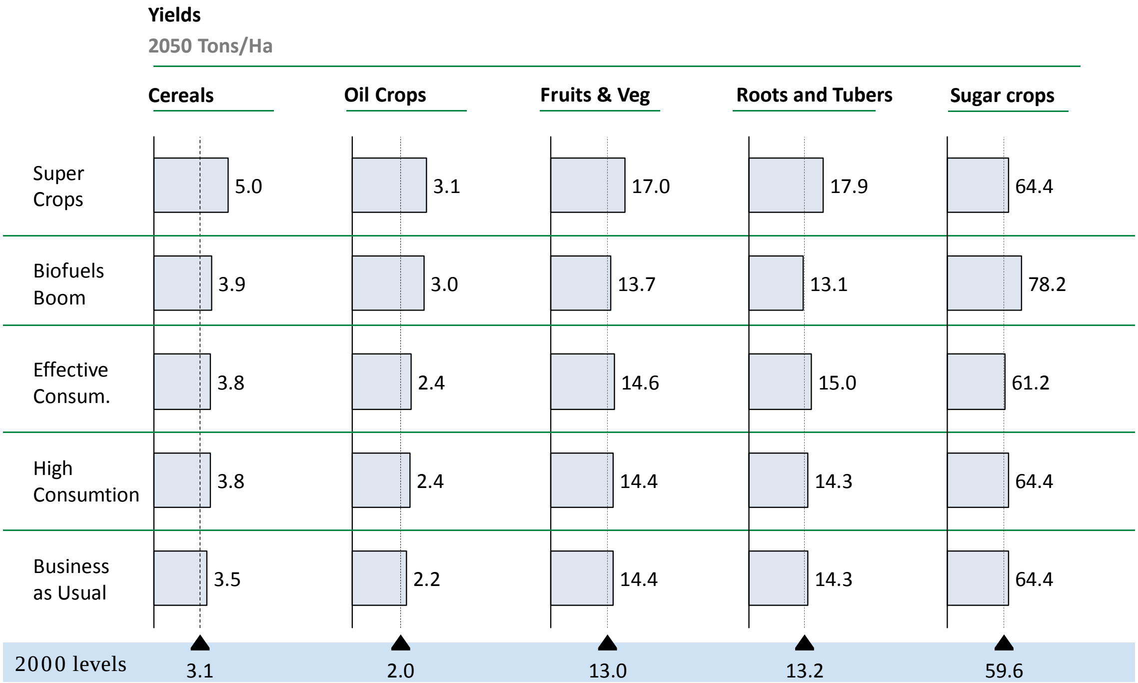
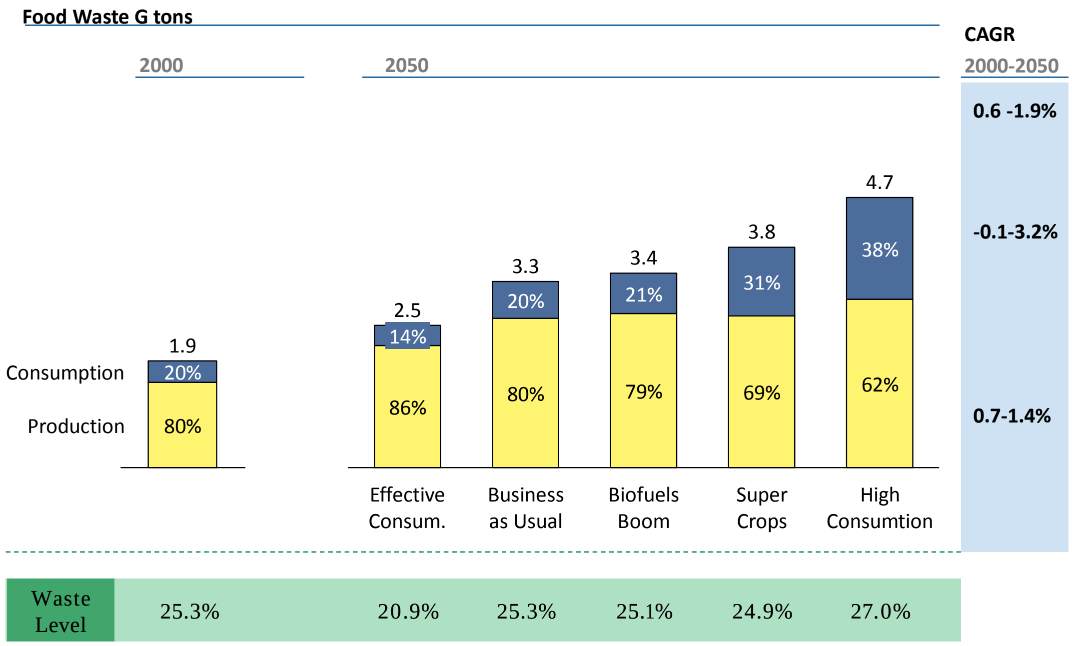


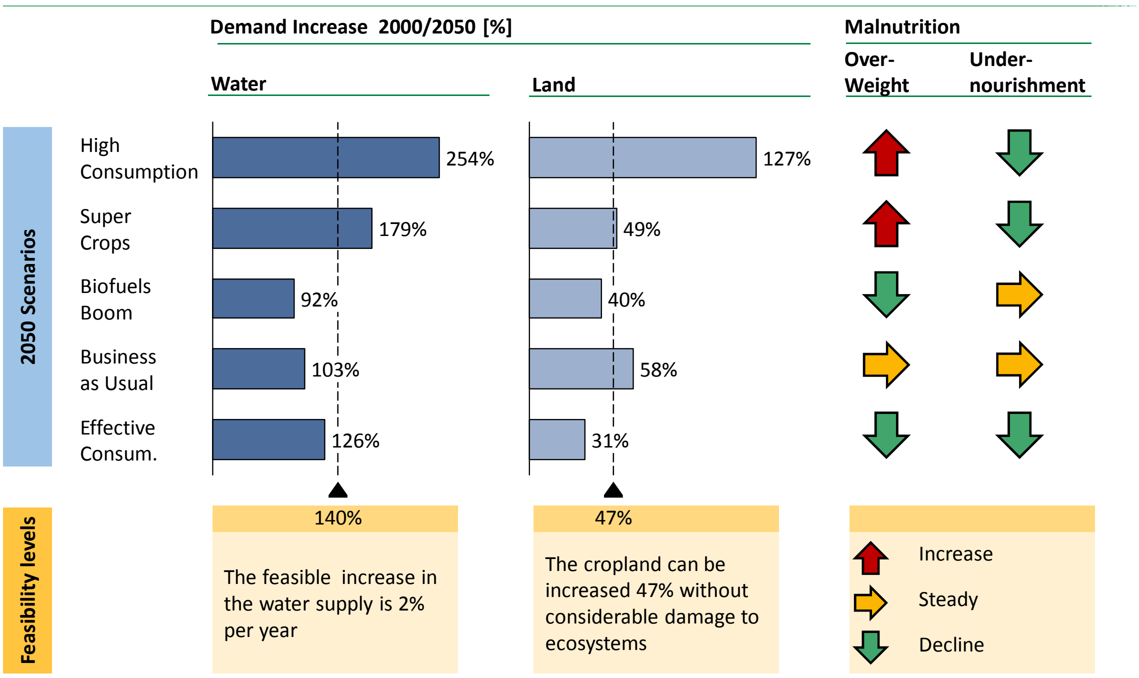
Exhibit 13: Waste per scenario



6.3 Analysis of the Scenarios

Food production can compromise the integrity of the ecosystems and decrease human welfare. There is only 1.5 Mn Ha of arable land, enough to increase the crop-land by 47% (FAO 2012). On the other hand, according to McKinsey, a sustainable increase in the water supply of 140% is possible (McKinsey Global Institute 2011). Any level above this would imply a significant increase in water withdrawals that could considerably damage the ecosystems. According to Exhibit 14, the "High Consumption", "Super Crops" and "Business as Usual" are above these limits. Furthermore, the over-supply of the first two is likely to considerably decrease human welfare by increasing the levels of overweight. Next section analyses the opportunities and trade-offs to decrease the food footprint

Exhibit ***14: Scenario analysis***



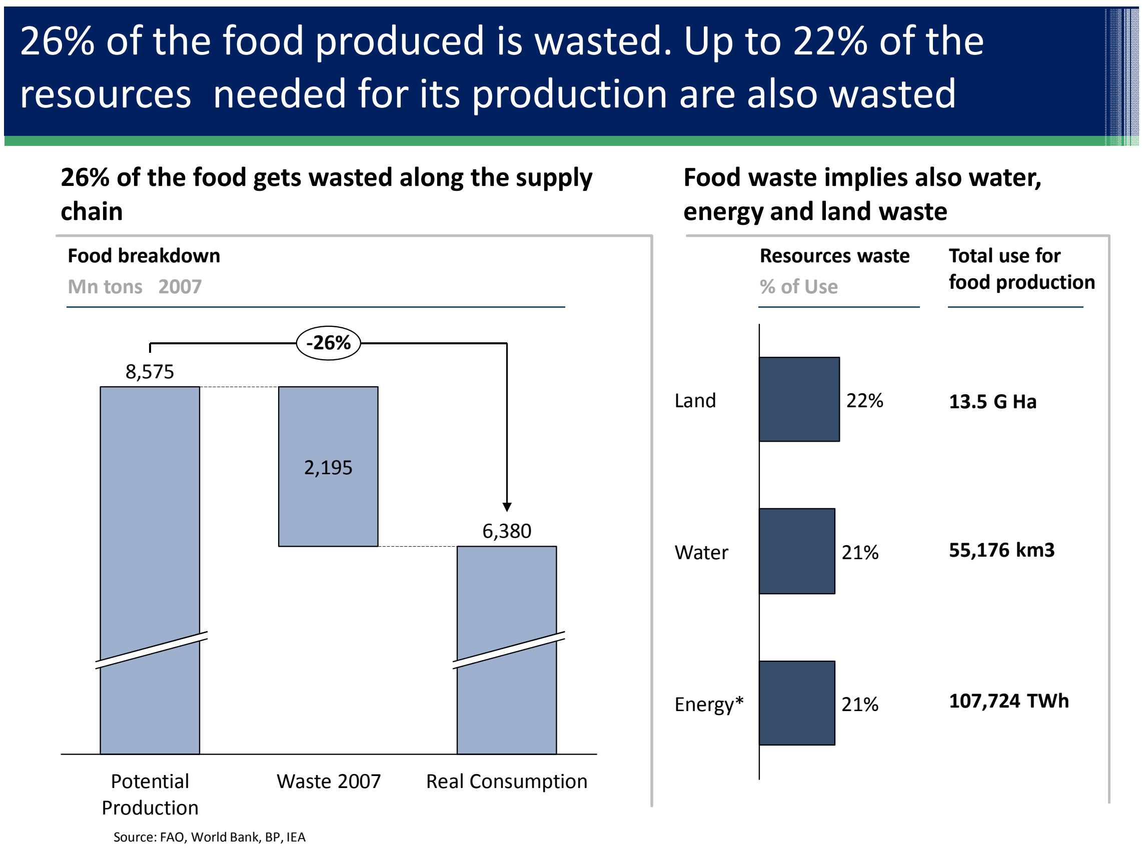
7 Analysis

The strategic decision in agriculture, infrastructure, nutrition and Crops R&D will shape the food demand. The 5 models analysed showed that the food system is shaped by diets, yields improvements and waste generation. It was also concluded that there are many trade-offs among these variables. For example, while the increase in yields has the potential to reduce land demand, it also has the potential to foster overconsumption if the right policies are not put in place at the right time. The identified opportunities and trade-offs are described in detail below.

7.1 Food Waste, Waste of Resources

Reducing food waste represents a big opportunity for reducing the demand for resources; up to one quarter of the water, land and energy used for food production is wasted. In 2007 from the 8.5 G tons of food produced, 27% was wasted, equivalent to 2.5 G tons. Enough to feed 1 Bn people with a 2000 Kcal/diet. Furthermore the food waste represents 22% of the land, 21% of the water and 21% of the energy used for the food production. According to these figures, the reduction of waste is not only key to reducing food demand and undernourishment but also to cutting humankind's demand for resources (Ridoutt, et al. 2010). Agriculture uses 70% of the water consumed every year (United Nations 2003) and the water footprint of food in 2007 was 8,800 km^3, 16% of the total water resources available worldwide (55 000 Km3 (Pacific Institute 2010)). Thus the water used to produce the food wasted represents 4% of the fresh water available worldwide. The land picture is similar; from the 1.1 M Ha used for crop production, 21% is used to produce food that will be wasted; this represents 15% of the arable land (1,533 MHa).

Exhibit 15: Food waste and resource waste

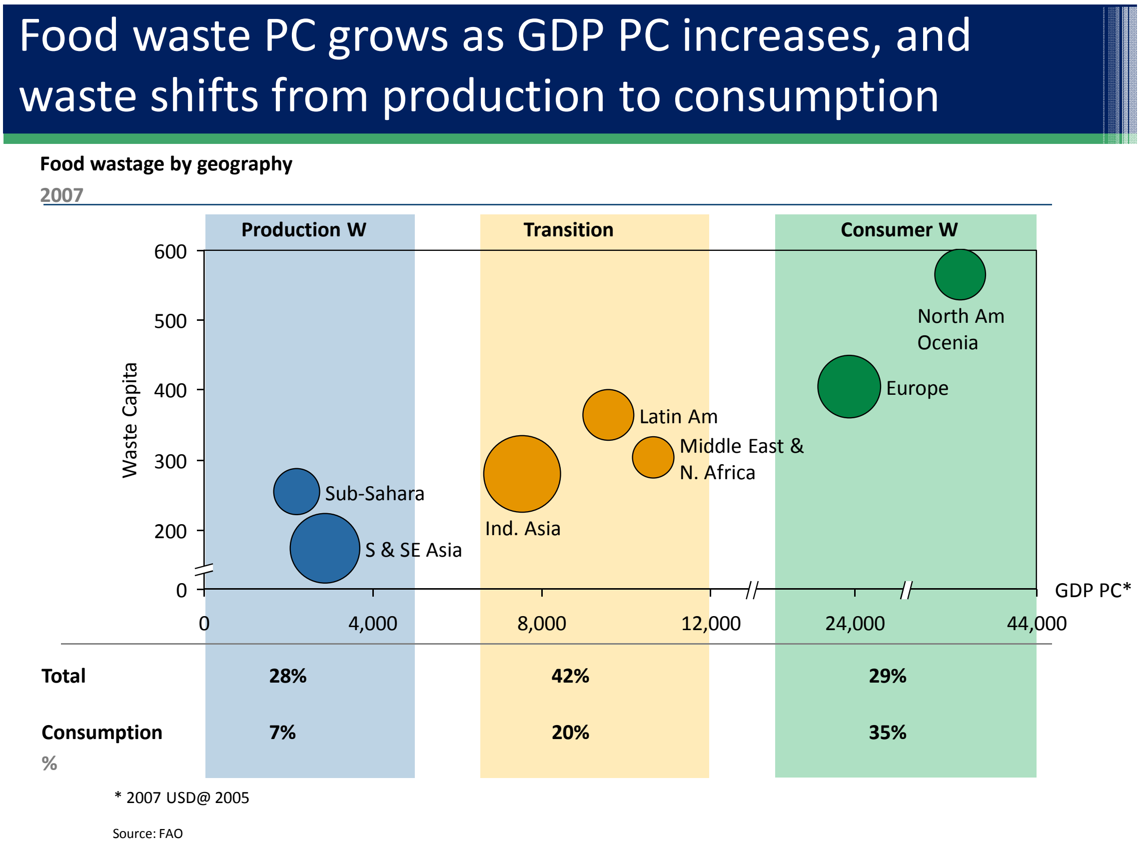


7.2 The Waste Road Map

The geographical regions can be classified in 3 groups according to their level of waste: As shown in the Exhibit 16 the 7 geographies in the analysis can be grouped in 3 these being: I) The "Production Waste" region including Sub-Sahara Africa and South and Southeast Asia; this zone is characterised by a high efficiency in the consumption endpoint, only 7% of the waste is generated at this stage of the supply chain. II) The "Consumption Waste" group embraces North America & Oceania and Europe, in this region a high relative efficiency in the production and processing can be observed; however, a high level of waste occurs at the consumption point, where more than one third of the waste is generated. III) Latin America, Industrialised Asia and Middle East & North Africa are the regions in the "transition zone"; these geographies have levels of waste in the consumption and production stages that are between the "Production Waste" and "Consumption Waste" zone.

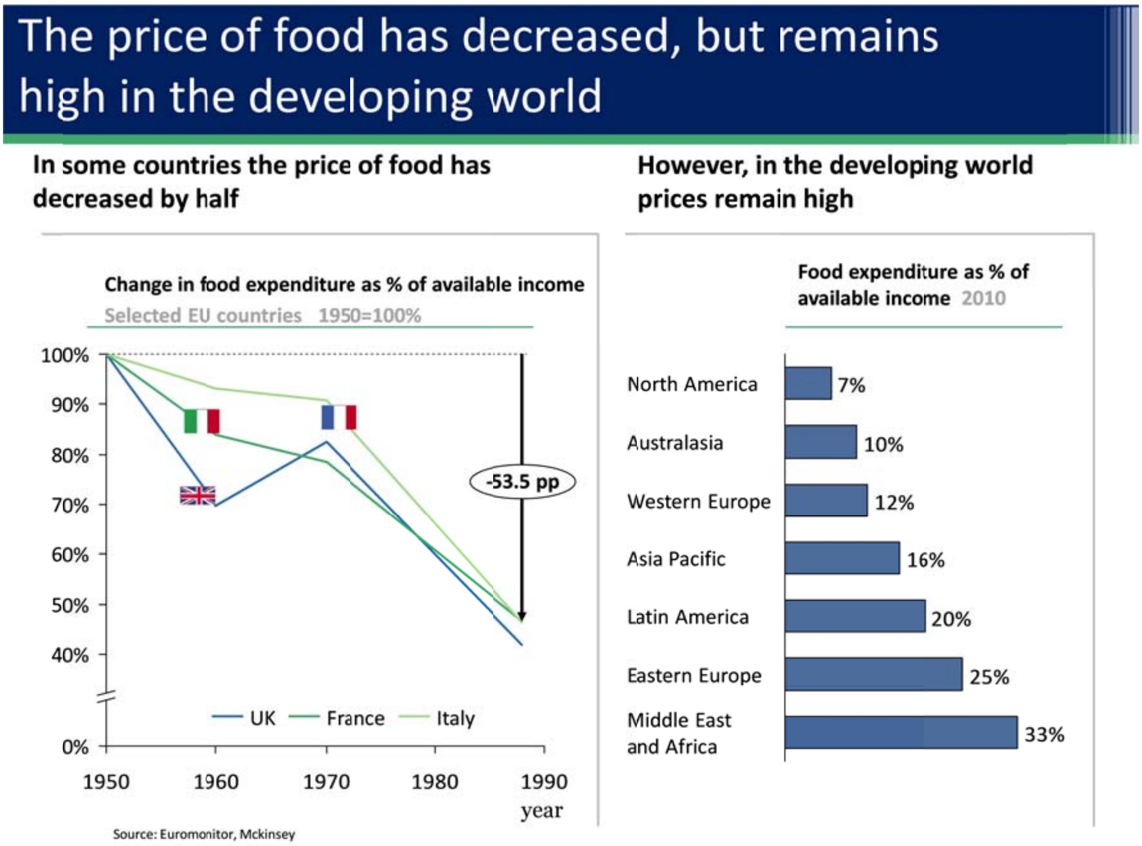
A food waste route map can be established from Exhibit 16. It can be argued that the waste is dynamic, it changes as the supply chains and consumer behaviours evolve. It can be observed from Exhibit 16 that there is a strong relationship between the GDP per capita and the level of waste. Furthermore it seems that higher calorie intakes correspond to high levels of food waste. The lowest level of GDP per capita in comparable terms corresponds to the lowest level of waste. Sub-Sahara Africa has and average GDP of 2,200 USD/capita year with a waste level of 253 kg/year.

Exhibit 16: The waste route map



Food waste shifts from production to consumption as a country develops. It has been shown that the GDP per capita can be used as indicator of the level of infrastructure of a country. Countries with a high GDP per capita are likely to have better infrastructure at the farm, factory and transport level and therefore, a more efficient supply chains. This allows them to reduce waste in the harvesting, post harvesting, processing and transport stages. However these efficiencies are likely to reduce price and therefore foster waste in the consumption end point.

Exhibit 17: The decrease in the food relative price per geography



It seems that the reduction of prices has increased the level of food waste at the consumption point. It seems that the fast rise in income in the developed world has decreased significantly the relative price of food as shown in

Exhibit 17. However, it seems that although the price of food has decreased in many parts of the world, it still remains high in the developing world. In the Middle East and Africa the food expenditure as percentage of the available income was 33% in 2010; 5 times the cost of food in North America. The regions with the highest food prices have the lowest levels of food waste at the consumption stages.

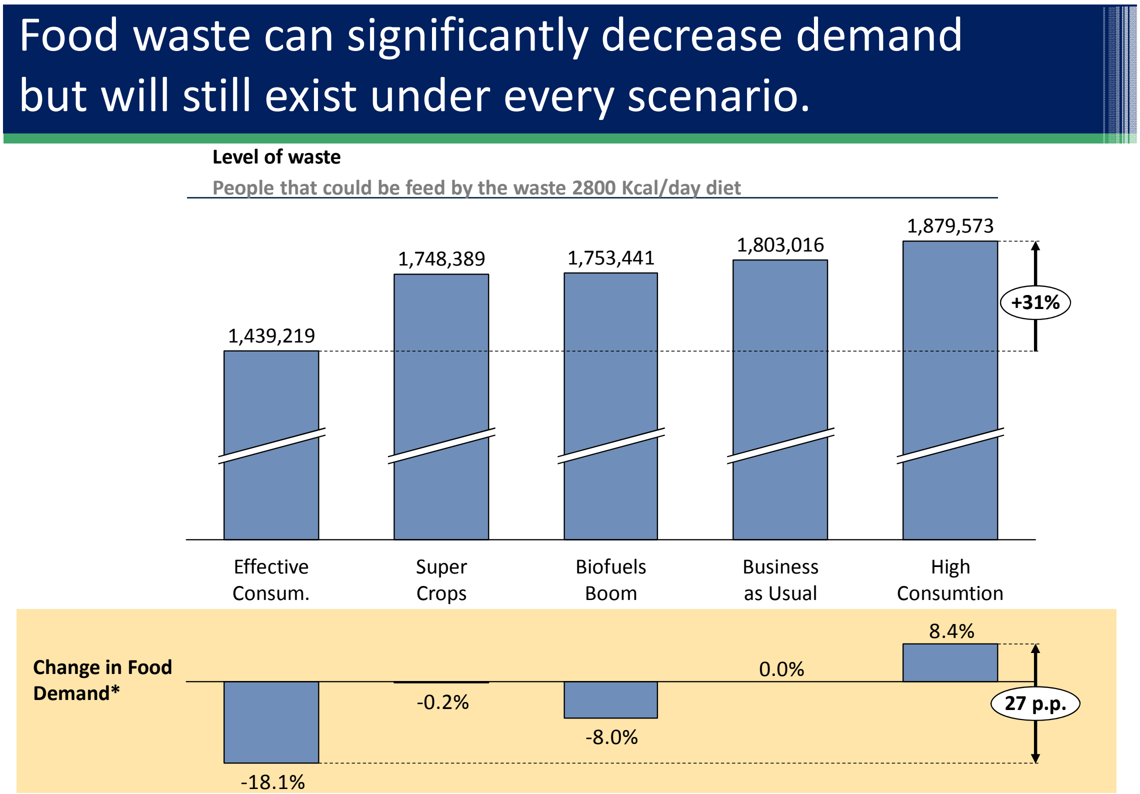
The concept of efficiency and effectiveness used for energy should also be applied to the food system. Energy is essential for the development of a country as food is necessary for the wellbeing of the population. The efficient use of energy has been tackled in many parts of the world during the last 10 years under the argument that resources should be used efficiently and effectively. According to this research, food is also resource intensive and therefore efforts should be done to encourage an efficient and effective food system.

7.3 The Waste Opportunity

The way in how humankind addresses the food challenge will shape the waste generation. The actions taken to meet food demand will considerably affect food waste generation. On one hand, the strategies based on rapid economic growth (High Consumption) and on a considerable increase of the food supply ("Super Crops") are likely to increase the waste per capita. On the other hand, the strategies that foster the adoption of resource efficient diets, either by education (Effective consumption) or price (Biofuels Boom) are likely to reach levels of waste that are close or below the current levels.

Efforts to reduce waste are likely to be outperformed; however tackling the waste can reduce food demand. The total food waste is likely to increase by 2050. The waste reduction efforts are likely to be overcome by the increase in the population and the growth in the food consumption per capita. The scenarios show that even if waste per capita is cut by 6 percentage points ("Effective Consumption" scenario) the average per capita waste will be reduced only 13%, reaching a level of 267 kg/year. At the same time, the population will increase 55% and therefore the world's waste generation will grow 33%. However, if no action is taken, the per capita food waste is likely to grow affecting the demand for food. In a "High Consumption" scenario, the increase in food waste is responsible for 8% of the increase in food demand. On the other hand, the reduction of food waste in the "Effective Consumption" scenario is responsible for a decrease in demand of 18%.

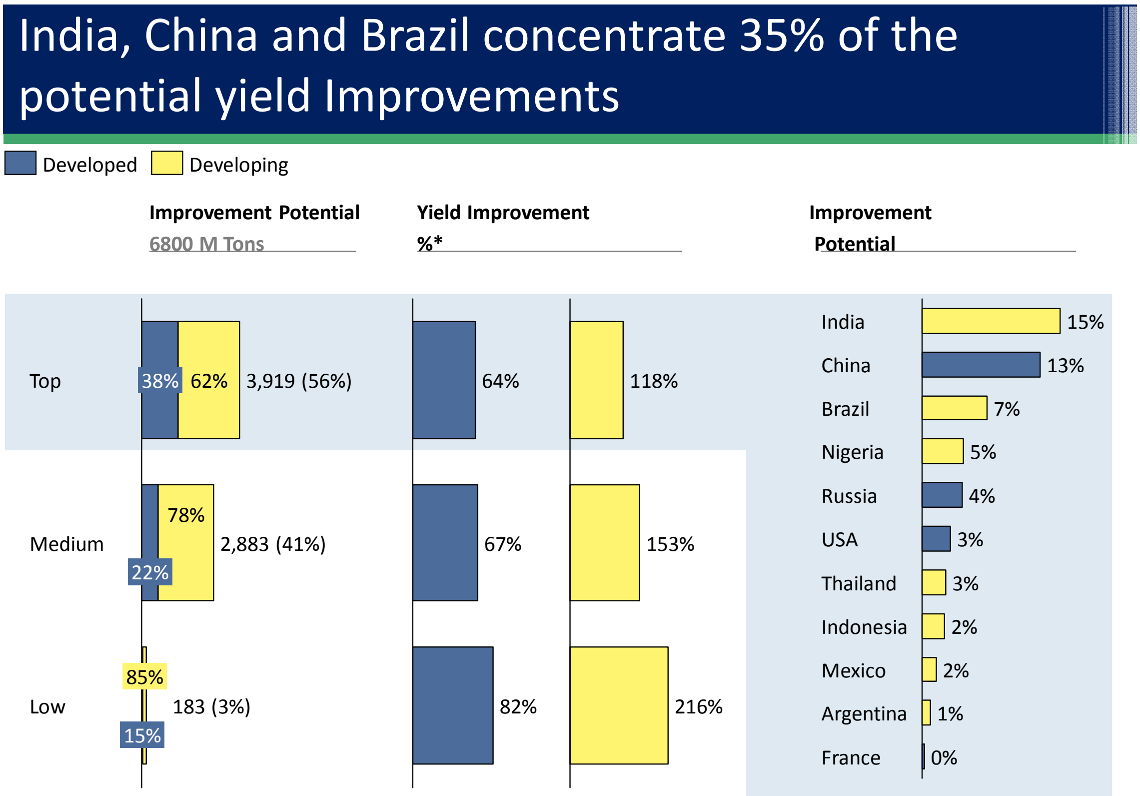
Exhibit 18: The food waste in 2050



7.4 Identifying the Yield Gap

The yield gap was estimated in 6.8 G tons. Increasing yields to narrow the yield gap by the adoption of current best practices can increase agricultural throughput by 79% to reach a production of 16 G tons. The analysis indicates that the opportunity is bigger in the developed world, which represents 71% of the possible increase in production. However, tackling the gap yield across every country can be a complex task, and therefore, from a strategic point of view the identification of the biggest pools of production increase should be identified (Johnson, Scholes and Whittington 2011). The study also revealed that the top 11 agricultural producer countries, that represent 57% of the world's crop production, represent 56% of this opportunity. Furthermore, India, Brazil and China, the world's top emerging economies, represent 35% of the opportunity (2.4 G tons). Moreover, the effort to close the yield gap across these 11 countries is different. While the developed ones require a yield increase of 64%, the developing ones need a yields increase of 118%.

Exhibit 19: The yield gap per country



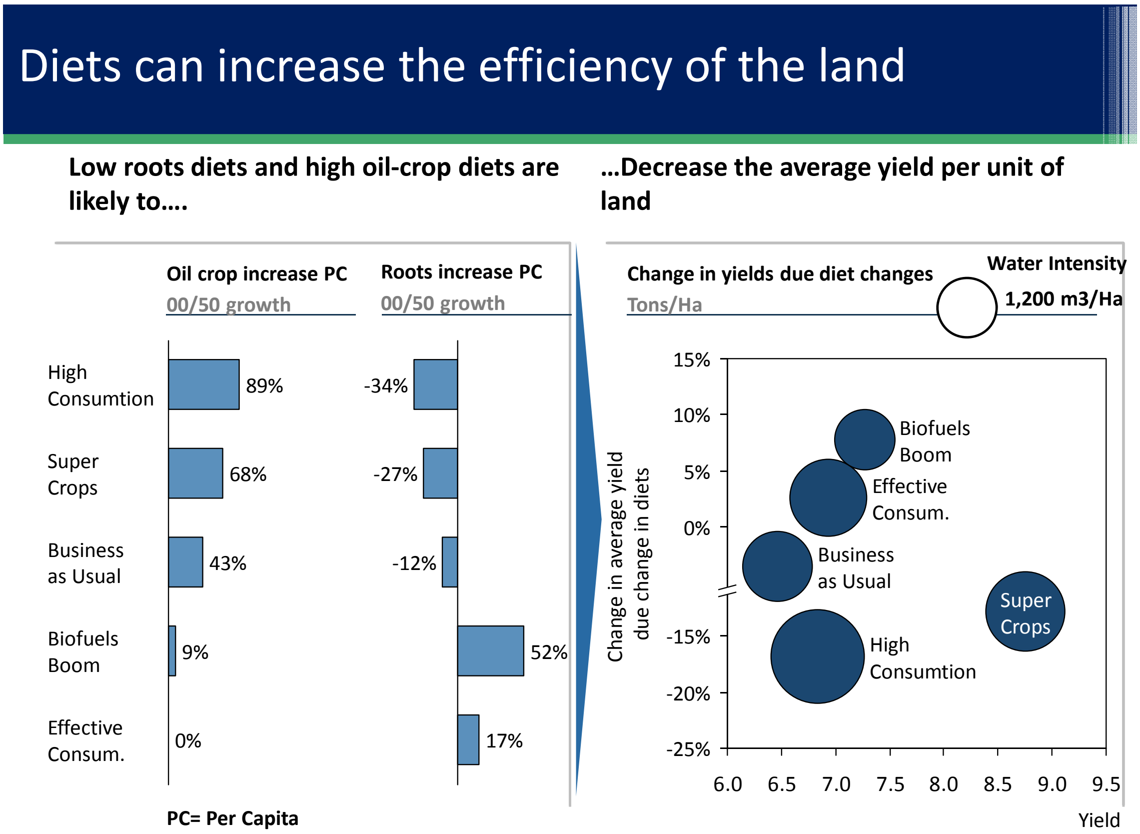
7.5 The Diet Effect

Changes in diets have the power to increase land productivity and therefore reduce resource demand. Each crop has different yields and water footprints; therefore, the evolution of diets has a considerable impact on land efficiency, measured as the average agricultural throughput per unit of land. According to

Exhibit 20, an increase in the yields is likely in all scenarios; however the diets can improve the land efficiency up to 10% or decrease it by 20%.

Exhibit 20 shows that diets can also considerably increase the average water footprint of food.

Exhibit 20: Diet effect on land efficiency

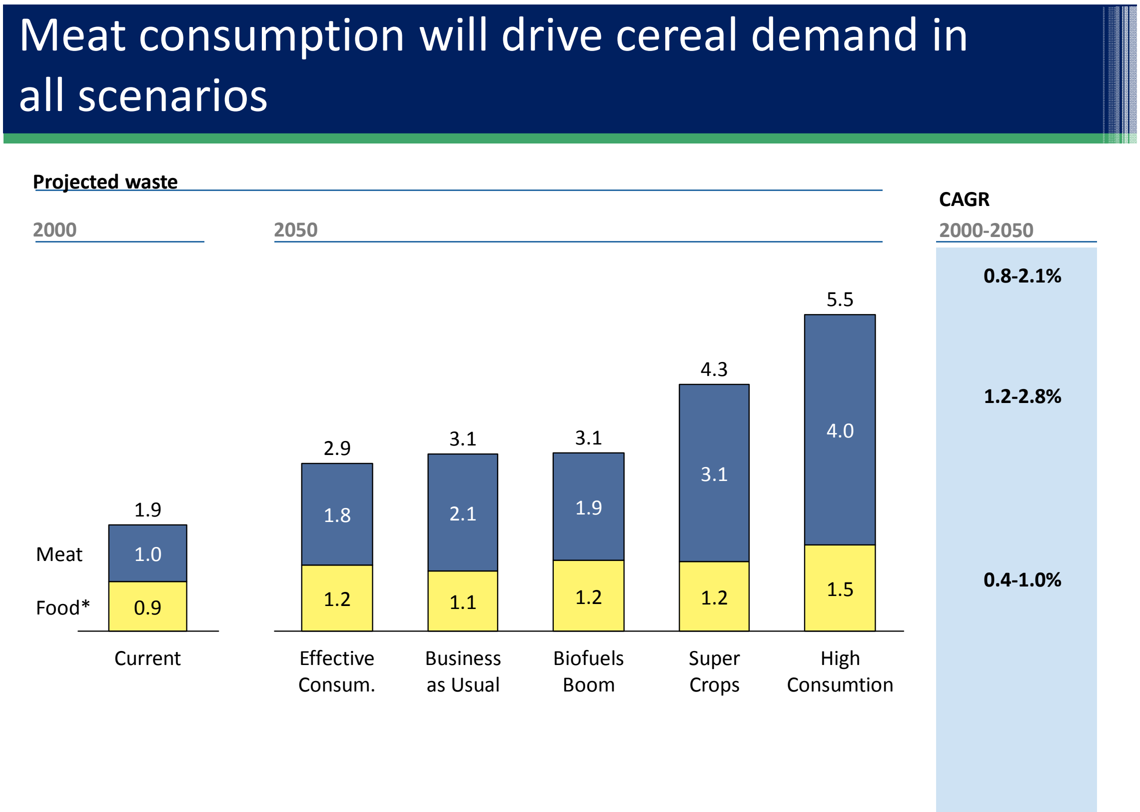


Diets rich in roots and low in oil crops are more land efficient. It can be observed that the "Biofuel Boom" diet shows the biggest improvement in average yield, while the "High Consumption" and "Super Crops" diets have a negative impact on the land efficiency. The main reason for this is that the last two diets are rich in oil crops and pulses and poor in roots; while the average yield of the roots group is 13 tons/ha, the yield of the oil crops is 2 tons/ha. Furthermore, the oil crops are 6.5 times more water intensive than the roots which have an average water footprint of 387 m^3/ton. Therefore, it can be concluded that diets reach in roots, vegetables, and fruit are more land efficiency than diets rich in oil crops and pulses (

Exhibit 20).

Meat is going to drive cereal demand towards 2050. cereals are widely used to produce other types of food, mainly meat. The model showed that from the 1.9 G tons of cereals produced in 2000, almost half of it was used as feedstock for the production of meat. Moreover, meat is the food group that is likely to have the biggest demand growth under every scenario. Furthermore the model showed that meat production is likely to be the main driver of cereal demand in all the scenarios. In the effective consumption scenario more than 60% of the produced cereals are used for meat production. On the other hand the high adoption of meat in a High Consumption scenario will require more than 72% of the produced cereals.

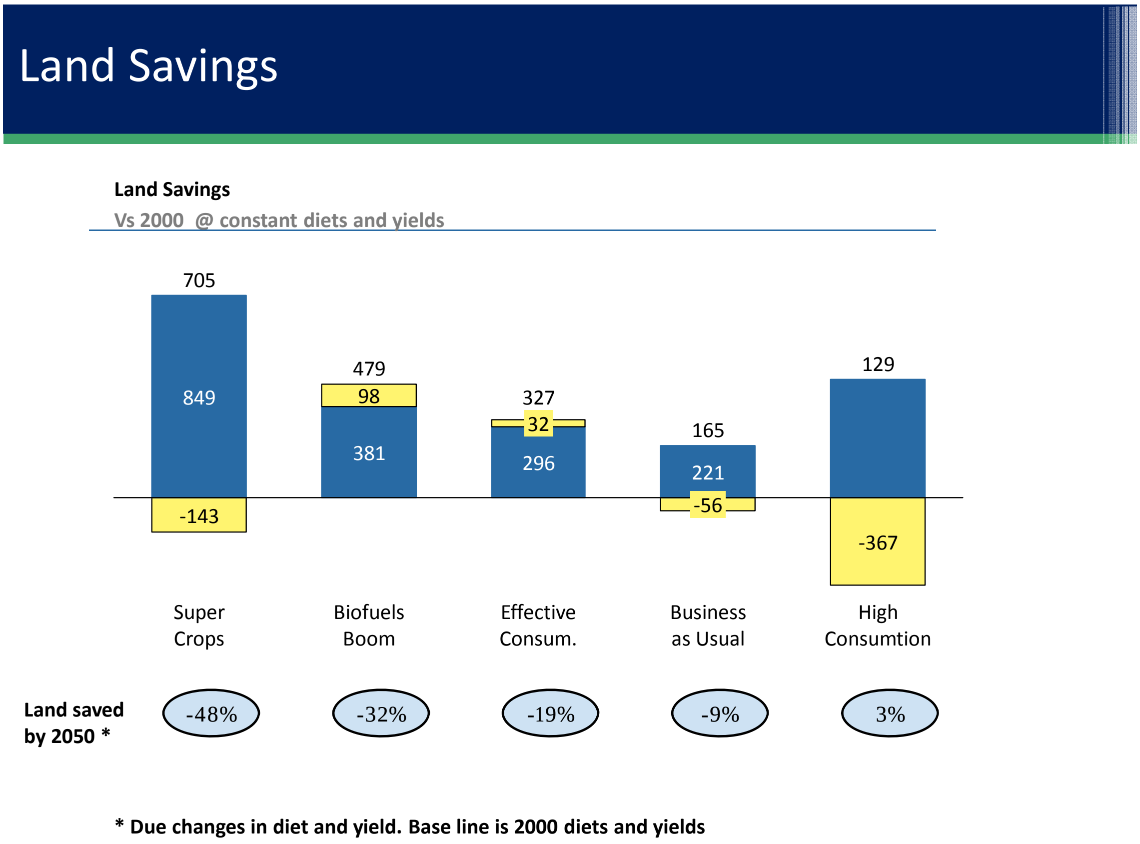
Exhibit 21: Cereal demand towards 2050



The increase in yields has the potential of reduce the land demand, however, diets could offset this benefit.

Exhibit 22 shows the potential land saving due the increase in yields and changes in diets. It can be observed that a high increase in yields, as shown in the “Super Crops” scenario can reduce significantly the demand for land. Moreover, the adoption of more sustainable diets, like the ones of the “Biofuels Boom” and “Effective Consumption” scenarios can also help to reduce land demand. On the other hand, the adoption of land intensive diets and a low increase of yields due to patchy investment in the sector are likely to increase land demand as show in the “High Consumption” scenario.

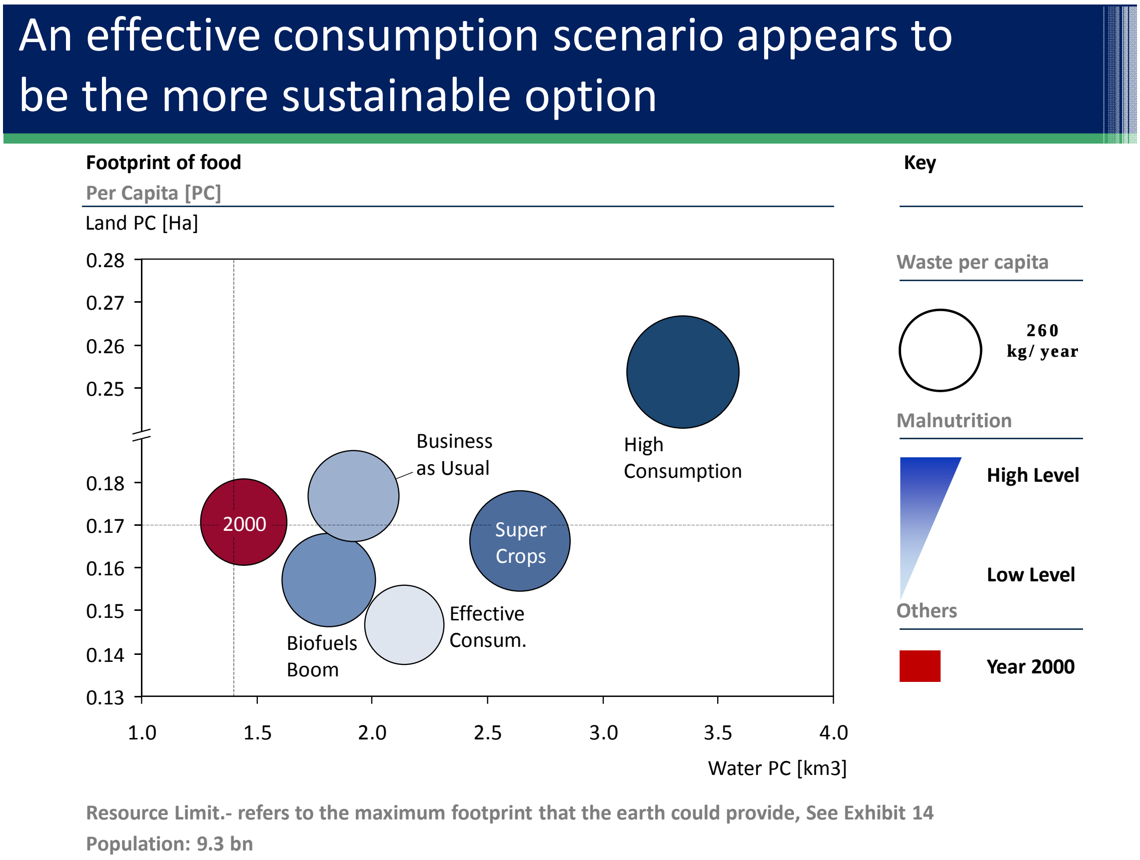
Exhibit 22: Land savings



8 Choosing a Sustainable Scenario

A sustainable food scenario needs to reduce the food environmental impact while improving human health by providing affordable food. From the 5 modelled scenarios, the “Effective Consumption” is the more resource efficient and therefore has a low water and land footprint. Moreover, is the only one that tackles malnutrition in its two dimensions.

Exhibit 23: Identifying the sustainable scenario



8.1 Model Limitations

The main limitations of the model are:

Global factors are used for most of the estimates. For the water footprint, energy footprint and diets, global values were used during the modelling. While this is likely to be good first estimation, it ignores that these factors are geographically specific.

The carbon footprint of the transport is not taken into account. The model ignores the emissions due the transport of food; and therefore it doesn’t take into account the effects of the redistribution of food in the “Effective Consumption” scenario.

Lack of reliable data. As identified by many papers, there is a considerable lack of reliable data for the yield potential and waste factors. The publication of more works in this field will allow a more detailed modelling.

9 Conclusions

The construction of a model to understand the interactions and trade-offs amongst changes in yields, diets, malnutrition and waste levels towards 2050 is possible. In addition, the model can be used, with a good confidence level, to build scenarios towards 2050.

The study also revealed that an effective and efficient food system is central for reducing environmental impact and increasing human welfare. The main findings are:

Food waste reduction: Food waste is dynamic, it evolves as a country develops, and its reduction needs to be approached across all stages. The food waste levels are highly correlated with the level of infrastructure and the relative food prices of a region. The efficiency improvement of only one stage of the supply chain is likely to increase waste in other stages. Therefore, technological and policy strategies across all the supply chain, from farm to fork, need to be implemented to reduce food waste successfully. The reduction of food waste has the potential to reduce food demand by up to 18%. However, failure in tackling it can increase it by 8% if the waste levels of USA are reached.

Yield improvement: Narrowing the yield gap is a major opportunity to reduce land demand. Closing the yield gap can increase production by 79% without increase in cropland. The wide adoption of sustainable and appropriate land techniques has the potential to narrow the yield gap without significant increases in the demand for energy and water. If the yields are not improved, the needed increase in cropland is likely to be bigger than 47% (available cropland) leading to the depletion of ecosystems.

Diets and malnutrition: The change in the consumption behaviour has the power to reduce demand and improve human welfare. The wide adoption of an adequate calorie intake and resource efficient diets (rich in roots and low in meat and oil crops) has the potential to increase land productivity by 10% while improving human welfare. On the other hand, the adoption of today's North America diets will decrease land productivity by 20%.

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MANAGING SOCIAL FOOD SUPPLY CHAIN

Dr. Gyan Prakash
Assistant Professor
Indian Institute of Management Indore, Faculty Block C, First Floor,
Prabandh Shikhar, Rau - Pithampur Road, Indore 453 331 (Madhya Pradesh)
Tel: 919406581635
gyanprakasha@yahoo.com

Mukesh Kumar,
Institute for Manufacturing, University of Cambridge

Abstract
The objectives of this study are to understand the design, implementation and monitoring of social food supply chain. As a case in point Indian public distribution system (PDS) have been investigated. In India a public distribution system (PDS) and its improved version targeted public distribution system (TPDS) was carved out as a novel system of safety net operations for the distribution of scheduled commodities to the targeted citizens through a network of institutions comprising Food Corporation of India (FCI) warehouses and fair price shops (FPS). The methodology adopted is a mix of literature review, document analysis, interview with policy makers, officials responsible for distribution of food grains, fair price shop owners and survey of end users. It is inferred that this system is fraught with inefficiency at all stages of the supply chain and service delivery is poor. A hybrid approach is proposed to retain the current PDS supply chain while making suitable process redesigns, introducing ICT based interventions and involvement of private actors in service delivery.

Key Words: Food Supply Chain, Public Distribution Systems, ICT Intervention, Service Delivery

INTRODUCTION

In India a public distribution system (PDS) and its improved version targeted public distribution system (TPDS) was carved out as a novel system of safety net operations for the distribution of scheduled commodities to the citizens especially the below poverty line (BPL), above poverty line (APL) and those coming under *Antyodaya Anna Yojana* (AAY)[1] through a network of institutions comprising Food Corporation of India (FCI) and fair price shops (FPS). Poverty line is multidimensional in nature. At one level it represents deprivation from physical needs such as food, clothing, and shelter. At other level it represents deprivation from education, health, lack of voice and information. Therefore, poverty alleviation involves providing basic food and other essential commodities at subsidized rates, providing relevant information and developing human capabilities so that they can acquire, assimilate and make decisions. For a developing county like India which is positioning itself as a pragmatic and progressive State, it is an opportune moment to serve its underprivileged citizens by crafting its TPDS supply chain through ICT based interventions. Hence forth the term PDS is used to mean TPDS.

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[1] APL is a sub-category of BPL and represent poorest of the poor.

PDS provides rationed amount of basic food items such as rice, wheat, sugar, and non food items such as kerosene at below market prices to specified group of citizens. The issues dealing with PDS comes under concurrent list of the constitution of India. Therefore, Central as well as States governments are responsible for planning and running the PDS supply chain. The supply chain of PDS involves various actors such as producers, warehouse, FPS and end customers. The Central ministry of civil supplies lays down policy to cover what commodities are sold in different areas, their prices, legislation, coordinating the work of several agencies and monitoring their performance. Central government agencies are responsible for procuring the food grains, storing them, and transporting them to convenient locations in the States. The FCI handles food grains. Within each State, the State ministry of civil supplies administers the PDS.

However, this system is fraught with many challenges such as inefficiency, deterioration of food grains, unsatisfactory quality of commodities (representing food grains and items such as *kerosene*), malpractices in weights and measures, mismatch of demand and supply, long waiting times, exorbitant corruption, rude behaviour of shopkeepers and poor service delivery. The PDS had been criticized for its urban biased (Dev and Suryanarayana, 1991) and for its failure to serve effectively the poorer sections of the population. Preliminary assessment of PDS reveals that PDS suffers from heavy losses of food grains, mismanagement of inventory, high carrying cost, lack of accountability and poor quality of service. The underlying reasons include lack of visibility of movement of food grains and embedded information. Information needed for planning and control of PDS fails to deliver desired results. Information and communication technology (ICT) enabled interventions in the PDS are very weak. The central argument of this paper is that streamlining of PDS processes will result in increased operational efficiency, thereby reducing transit losses and pilferages. This can be achieved by real time flow of information across all the stages of PDS. This visibility will ensure availability of correct quantities of scheduled commodities to FPS owners and to the end customers thus, improving the service delivery. Improvement in service delivery will also improve quality of service across various stages of the PDS. To meet the expectations of policy makers and demands of the citizens, the PDS should be agile enough to identify the needs of the targeted citizen groups and adapt and align itself with dynamic market conditions and policy frameworks.

This paper is the outcome of an exploratory study on PDS in the district of Gwalior in the state of Madhya Pradesh in India. The objectives of this study are to understand the design, implementation and monitoring of PDS supply chain activities. Understanding of which will help in proposing redesigning of PDS processes, introducing ICT based interventions and making some policy recommendation. The remainder of the paper is structured as follows. Next couple of sections present review of the literature, the research gap and the research method. Penultimate sections present results and discussion and possible solutions for PDS supply chain. Paper concludes with a discussion on the limitations and scope for future work.

LITERATURE REVIEW

Supply chain

Supply chain management (SCM) refer to integration of actors involved in activities of procurement, processing and distribution of products and services. It also involves coordination and collaboration among all the actors. Food grain supply chain consists of various autonomous actors involved in production, procurement, transportation, distribution and other support activities. This supply chain involves dyadic relationships between various actors such as buyer and seller, seller and distributor and distributor and end customers. These relationships can be based on trust, norms, dyadic symmetry, mutuality and bargaining power. Collaboration and coordination among these actors improves overall performance of the supply chain (Petersen et al, 2005). Performance of supply chain might be expressed in terms of on time delivery, enhanced level of responsiveness, enhanced level of service and lower cost. Quality of relationship (Christopher, 1998) and partner orientation (Duffy and Fearne, 2004) improves the overall performance of a supply chain. Sharing of information among these supply chain actors culminate not only in enhanced level of coordination but also facilities the flow of the underlying product (Coughlan et al, 2001). Supply chain perspective has been extensively used in the analysis of manufacturing and service systems. However, supply chain perspective is not much used in the context of food sector (Higgins et al, 2008; Kottila and Ronni, 2008; Sage 2003; Smith and Mansden, 2004; Wycherley, 2002).

Indian public distribution system

Indian PDS is a safety net operation to deal with the problems of poverty (Mooij, 1994) and is one of the important forms of government intervention in the food grain market. The original objective of the PDS was universal access, stabilisation of food grain prices and management of its supply. The primary responsibility of the Central government was to intervene in the food grain market by announcing minimum support prices (MSP) as well as procuring surplus food grains. This was offered to the States for distribution through the PDS at a subsidized price. The government of India however, changed this policy as part of its economic reform programme and introduced in 1997, a targeted PDS (TPDS) under which food grains are being allocated to states on the basis of the estimates of population below the poverty line (Kannan et al, 2000). PDS is the joint responsibility of the Central government, State governments, and the Union territory administrations to ensure the smooth functioning of the system. While the responsibility of the Central government is to procure, store, and transport grains from purchase points to central warehouses, the responsibility of State governments and the union territory administrations is to transport these commodities from the Central warehouses and distribute them to targeted citizens through the network of FPS. PDS supports approximately 400 million citizens and involves a network of 478,000 FPSs which distributes more than 200 million tones of commodities having worth of more than INR[1] 15,0000 million. PDS also provides subsidy which depends on the level of procurement of food grains and off take under PDS and other welfare schemes. The budgetary estimate for food subsidy (Vyas, 2005) during 2008-2009 was about INR 370 billion. Rural India spends about 64% of its budget on food. Food share is an inverse indicator of welfare (Deaton, 1997). Several empirical studies based on PDS purchases have shown that the poor were not benefiting much from the PDS (Gaiha, 2002). There is literally no public participation in the working of the PDS network, even in an advisory capacity. The government guidelines issued in 1997 serve the purpose of issue of ration card to the intended BPL segments[2]. The intended segment of citizens, for whom items such as food grains or *kerosene* are despatched, is not involved in planning of these items, their quantities, quality and price (Jain, 1989). The operational details of the PDS differ from State to State. Though the policy of setting up of FPSs

[1] One U.S. Dollar is equal to approximately 55 Indian Rupees.

[2] Those who have salaried regular job or possesses consumer durables such as television set, refrigerator, fans, fuel operated vehicles, tractors, threshers, tillers and assets such as five acres of land, and house made of backed bricks are excluded.

owes its initiation to national food policy, its implementation remains the direct responsibility of the State governments.

PDS operations

Pricing within the PDS involves assessment of current and the anticipated open market prices by the government. The building of buffer stocks serves the purpose of meeting unexpected exigencies, matching the demand with supply and stabilizing inter-seasonal demands. Cost incurred in managing this buffer stock is reimbursed by the government to the FCI. The Central government is responsible for inter-state movement of grains so as to balance the regional demand with supply. However, such grain movements incur operational costs. These costs plus the procurement price are often higher than the prices at which the grain is released through the PDS (Zhou, 1998). All the operations of PDS supply chain is performed by the public actors and excludes participation of private actors. As for relative food grain price stability, it is more sustainable and less costly to seek to achieve it through expansion of irrigation and technology, especially to the less developed regions (Thamarajakshi, 1997). The leakages in PDS operations take place at every stage of the supply chain and take place in various forms. One estimate shows that at country level, 67% of wheat is siphoned off (Khera, 2010). The leakages may take place right at the warehouse level and food grain may not reach to the targeted FPS, or FPS dealer may divert a part of allotted quota to open market. FPS owner may collude with district supply authorities in this operation or the leakage may also take place at household level where beneficiary may purchase the ration but sell it in open market at higher prices (Idrakanth, 1997). The leakage in PDS operations may also be attributed to the fact that the commission which a FPS operator earns on sale of PDS items is so small that he can not sustain.

PDS quality and service delivery

Public actors procure food grains at MSP which is fixed by government on the recommendation of Commission for Agricultural Costs and Prices (CACP) on yearly basis. The FCI procures food grains at the fixed MSP. Food grains are issued to States at Central Issue Prices (CIP). The difference between the total cost incurred in PDS supply chain and the CIP is reimbursed to FCI as food subsidy. Thus, government spends a handsome amount of subsidy so that intended citizens' gets good quality of basic food items at very low prices. A reduction in food subsidies increases food prices and hurts the poor even when they are not major recipients of the subsidy. On the positive side the wider reach of the PDS makes it more effective than other welfare schemes such as employment guarantee scheme (EGS). Further, proper targeting and improved delivery system in rural areas will make the PDS more efficient. Nevertheless, not PDS alone, but a mix of policies involving effective implementation of anti-poverty programmes, controlling inflation, improving health facilities, will be needed to solve the food security problem in India (Dev, 1996). While many people do benefit from the present set-up, there are also people within almost all categories of stakeholders who are dissatisfied with the large-scale misappropriation of food grains. The poor quality of food grain distributed through PDS marks the inefficiency of its operations. It is argued that there is scope for change, but change requires strategic political maneuvering and initially an evolutionary approach in order not to awaken and antagonizing strong vested interests (Mooij, 2001). The improvement in PDS operations is possible when all the activities of the system are analysed in an integrated manner from supply chain perspective. Procurement of food grains, their storage, their inter-state movement, their allocation to various states and distribution by FPS are not isolated problems and therefore, must be tacked in a holistic perspective. Table 1 depicts select list of studies examining various issues related to Indian PDS. From this table we see that majority of the studies have been done from economic perceptive. Analyzing PDS operations from supply chain perspective is missing link in the literature. It is this gap in the literature that this research seeks to address.

Table 1: Select list of studies on PDS in India

Researchers	**Key Finding of the Project**
George (1979)	Analysis of public distribution of food grains and their income distribution effects in Kerala
Subba Rao *et al.* (1980)	Estimation of food requirement for India under certain assumptions.
Krishna (1981)	Analysis found that the beneficiaries of the public distribution system could be arrived at by deducting from the total population.
Mahendra and Suryanarayana (1991)	Analysis found that urban people were getting more benefits through PDS than rural and tribal people.
Howes and Jha (1992)	Analysis found that PDS is urban biased.
George (1996)	Analysis of food subsidy and production incentives for public distribution system
Tata Economic Consultancy Service (2000)	Analysis of PDS items found that at the national level there was the diversion of 36 per cent of wheat supplies, 31 per cent of rice and 23 per cent of sugar. In the case of rice in Bihar and Assam the extent of diversion was as high as 65 per cent. In the case of wheat the diversion was estimated to 10 per cent in Nagaland and 69 per cent in Punjab. The report found no correlation between the frequencies of the use of Enforcement Acts and extent of diversion. In Northern Region U.P has more diversion of rice and sugar despite a higher number of raids and convictions.
Srivastava (2001)	Analysis of food security and targeted PDS in U.P. found that multiplicities of agencies, poor coordination and low administrative accountability have combined to cripple the delivery machinery.
NIRD (2003)	Analysis of leakages in PDS found that not drawing and partial drawing of quota was substantially contributed to leakages.
Planning Commission (2005)	Analysis of PDS found that at about 58 per cent of the subsidized food grains issued from the central Pool do not reach the BPL families because of identification errors, non-transparent operation and unethical practices in the implementation of TPDS.
Khera (2010)	Analysis of PDS in State of Rajasthan show that only about one-third households have access to PDS and utilization levels are also poor.

METHODOLOGY

This paper follows a case study method which is an inquiry of a real life phenomenon having blurred boundaries (Yin, 2003) and involves cycles of description, explanation and testing (Meredith, 1993). Case studies are used to serve the purpose of exploring, describing and explaining the empirical setting (Yin, 2003). The paper follows descriptive feature for the analysis of PDS in the State of Madhya Pradesh in India. Administrative machinery of PDS in 25 Indian States are almost similar. Madhya Pradesh as a case in point is unique in a sense that State of Madhya Pradesh is one of the poorest States in India as well as it is a representative case similar to other Indian States. Further, PDS in Madhya Pradesh is revelatory as researcher had accesses to various actors operating PDS in Madhya Pradesh.

The unit of analysis is PDS in the State of Madhya Pradesh. Operations of PDS are described along the structural elements of procurement, storage and distribution. This description is analysed in terms of complexity of the PDS supply chain, key performance indicators, needed information and ICT enablement and building operational excellence.

The research process followed is in line with Stuart *et al.* (2002) and followed linear approach. Literature on PDS in India was reviewed to understand the context and critical issues of the problem. This learning was supplemented with discussions with various stakeholders such as policy makers, fair price owners and end customers. The data collection involved document analysis such as government gazettes, and interview with policy makers in the government, officials of PDS, officials of FCI, FPS owners and survey of end users.

Data was gathered from Gwalior district in the State of Madhya Pradesh. District Magistrate, District Supply Officer, officials of Civil Suppliers, Block Development Officer and other supervisory staff of Gwalior district have provided information about current mechanisms of the PDS. A schedule has been used to gather data from 194 end users representing both urban and rural areas in the study district. Annexure 1 depicts the layout of the instrument used for data collection. Data was collected during July 2010 to June 2011. The sources of data are summarised in table 2.

Table 2: Sources of Data

Source of Data	Methods
Government at State-level - Officials at the State Planning Commission GoMP - Principal Secretary, Civil Supplies, GoMP	- Semi-structured interviews - Documents in the form of policy statements. - Website of Government of Madhya Pradesh.
Government at district-level - District Magistrate, Gwalior, District Supply Officer Gwalior, Officials of Civil Supplies Department, Block Development Officers	
- Fair price shop owners in Gwalior	- Interviews using structured schedule
- Citizens using food grains distributed through PDS	

Empirical context

PDS in the State of Madhya Pradesh consists of 39 base depots, 25 general depots, 14 subsidized depots, 185 distribution centers, approximately 15,000 FPS and 58 mobile trucks operating in tribal areas. In financial year 2002-03, the State of Madhya Pradesh had approximately 6.05 million beneficiaries whom 2.54 million ton commodities should have been distributed. However, total distribution made was just 0.88 million ton, thereby incurring a deficit of 1.66 million ton. In the State of Madhya Pradesh majority of the citizens complain about not getting desired information related to PDS such as information about availability and price (Right to Food Campaign Madhya Pradesh Support Group, 2004).

FINDINGS

Configuration of PDS supply chain in the study district

The objectives of PDS operations are to safeguard the interests of farmers by assuring them minimum price for their produce and concomitantly providing food grains to poor citizens at State controlled price. After purchase food grains are transported to nearby warehouses of FCI. The purpose is to meet the regular demand as well as tackle unforeseen exigencies. PDS supply chain is governed by various Central (*i.e.* Union) Acts such as Essential Commodities Act, 1955; Jute Packaging Materials Act; RBI Selective Credit Controls; Agricultural Produce Act, 1937; Rice Milling Industry Act, 1958; Essential Commodities Act, 1955; Forward Contracts, 1953 and Sate government Acts such as Agricultural Produce Market Acts; State Paddy/Rice Order; State Storage Control orders; State Levy Control orders; New Rice Mill Incentives; State

Licensing Acts. The underpinning of these acts is to balance demand of food grains with its supply. Figure 1 depicts the configuration of PDS supply chain.

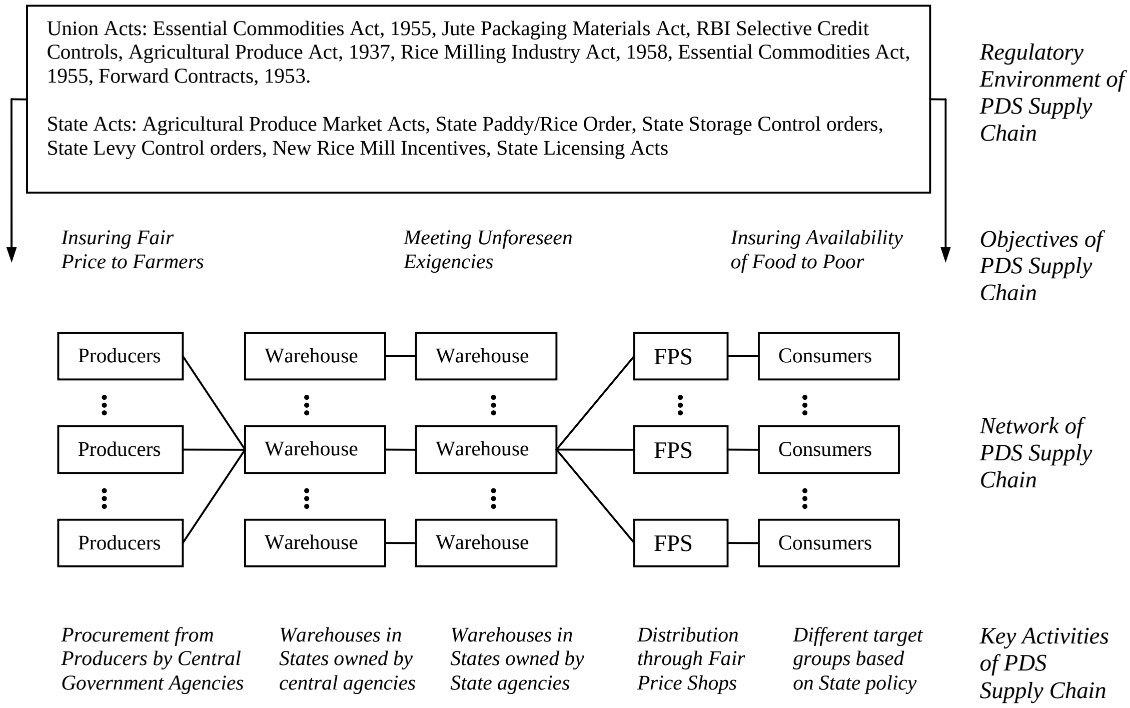

Figure 1: Configuration of PDS Supply Chain

Procurement of food grains in the study district

Central government has decentralised the procurement of food grains since 2010. Local purchase of food grains has improved the availability of food grains in FPS. As a State policy Government of Madhya Pradesh provide additional incentive over and above the MSP. The procurement process involves registration of farmers, collection of food grains and its transportation to the allotted warehouses. Registration of farmers enables government to capture data about farming related activities. The captured record consists of data about farmers land holding, type of land in terms of irrigated or non-irrigated and credit status of farmers. Farmers register themselves with a society. These societies are registered with Madhya Pradesh State Civil Supplies Corporation Limited. Each society acts as a procurement centre and schedules the purchase from member farmers. Food grain quota assigned to a farmer is based upon his land holding and the productivity of his land. Mobile numbers are used for identification of farmers as well as sending information to them in the form of short message services (SMS).

Farmers bring their produce in a tractor-trolley. Acceptance or rejection of food grains depends on the quality of the food grains and currently quality check is based on visual and touch based inspection. In the case of wheat quality is defined in terms of presence of maximum amount of moisture-12%, broken grains-7%, partially broken grains-6%, damaged grains-2%, presence of foreign food grains-2%, presence of external items-0.75%. District level officials provide jute bags which are used for packaging of food grains. The packaging of food grains in jute bags is manual. After bags are filled, the farmer is issued a receipt. These jute bags are stamped with the name of the associated society. Farmers are paid based on the weight of their produce. Money is transferred in farmer's bank account within seven days of purchase. The movement of food grains involves first unloading of food grains from a tractor-trolley on to the ground and then using manual labour to fill it into jute bags. These filled jute bags are measured on electronic weighing machines. The transportation of food grains to the allotted warehouse is the responsibility of district level officials for which they issue a *truck challan*. These warehouses are managed by Madhya Pradesh Warehouse and Logistics Corporation. Farmers complain that waiting time at the procurement centers is up to a day. Internet facility is not available at these collection centers therefore, pen drives are used to carry collection related data which is uploaded in procurement module of a software called *e-uparjan* from the nearest available internet facility. Person performing this task is called runner.

Distribution of food grains in the study district

Distribution of food grains and other related items to the intended segment of citizens is the responsibility of district level administration. The District Magistrate of Gwalior has started an innovative scheme (*Morena Model*)[1] for distribution of food grains through PDS. Under this scheme few days are stipulated which provide assured supply of commodities and other items. Purpose of this system is to overcome the effects of fluctuating supply and to close the FPS owners window of opportunity for opportunistic behaviour. Three levels of committees have been formed to monitor the working of the system. Under this system food grains are transported from warehouses to various FPS during first five days of each month. Stock received at each FPS is monitored by nodal officers on monthly basis. In urban areas food grains are distributed between 11th to 20th day of each month. First three days of this time window provides assured supply of all commodities. In rural areas time window for distribution of food grains is between 9th to 30th day of each month. In rural areas assured supply of commodities are guaranteed between 6th to 8th day of each month. Table 3 describes the working of the current scheme as followed in the study district. Seven commodities are currently covered by the PDS. For the purpose of distribution of food grains citizens are categorized in three segments.

Table 3: Mechanising of distribution and monitoring of PDS in study district

#	Items	Rural	Urban
Mechanism for distribution of food items			
1	Movement from warehouse to FPS	By 5th of each month	By 5th of each month
2	Stock Verification	By Nodal officers	By Nodal officers
3	Time Window for Distribution	11-20 of each month	6-30 of each month
	a. Assured supply of items	11, 13, 15 of each month	6,7,8 of each month (Stopped because of stay order from M.P. high court)
	b. General supply of items	Rest of the days of distribution	9-30 of each month
4	Achievement of Distribution	Up to 90% of allotted items	-
5	Complaints	Few	Lot of complaints
Monitoring and surveillance team			

[1] This scheme was started in Morena district when the current District Magistrate of Gwalior was District Magistrate of Morena district. This model has achieved up to 90% distribution of food items and complaints have decreased drastically. Morena Model was highly appreciated the Chief Minister of the State of Madhya Pradesh and prescribed its replication across other districts of the State. However, replication of the model was not much successful due to apathy of administrative officers in other districts.

1	Nodal Officer	People from various department chosen by roster system
2	Zonal Officers	People from district supply department
3	Supervisory Level	Tehsildar, Sub-district Magistrate, District Magistrate

These segments represent citizens covered under AAY, APL, and BPL categorization. Citizens covered under each categorization not only receive different volume of food grains but also charged differential prices. Though local purchase of food grains has improved the availability of food grains at the FPS however, sugar and *kerosene* still suffers from receipt of stock from central agencies. Except sugar and *kerosene* all the other commodities are available at the fair price shops. Targeted citizens complaint that FPS owners cheat by using faulty weights and measures and that quality of commodities received is poor. Each month around six to seven FPS owners are caught by district level officials. The punishment given to FPS owners varies from monetary penalty to cancellation of shop licence. In the context of PDS service delivery, targeted citizens value availability of food items most. This is followed by accurate weights and measures, quality of food received, waiting time at shop, behaviour of FPS owner, and flexibility in purchase of items. Overall eight to ten percent of targeted citizens are satisfied with the level of service provided by fair price shop owners. Low level of satisfaction of end users from PDS operations is in line with findings of Paul et al. (2004). Table 4 describes various items of service delivery in the study district. Recently, Government of Madhya Pradesh has decided to distribute PDS food gains to the intended citizens through food coupons. Various private actors such as HCL Infosystems, ITC, Aditya Birla Group have shown interest in issue and management of food coupons. Based on the competitive bidding HCL Infosystems has been chosen to introduce food coupons in the State of Madhya Pradesh.

Table 4: PDS Service delivery at a glance

Issues		Response		
About Products				
Average quantity of commodity distributed per card per month. APL card is of white colour, BPL card is of blue colour and AAY card is of yellow colour.	*Items served under PDS*	*Type of Card: Category, Quantity (Rate)*		
		White: APL	*Blue: BPL*	*Yellow: AAY*
	Wheat	15 (Rs. 3/Kg)	14 (Rs. 3/Kg)	34 (Rs. 2/Kg)
	Rice	5 (Rs. 4.5/Kg)	6 (Rs. 4.5/Kg)	1 (Rs. 3/Kg)
	Sugar	7 (Rs.27.5/Kg)	2 (Rs.13.5/Kg)	2 (Rs. 13.5/Kg)
	Kerosene	5 Litre	5 Litre	3.5 Litre
		12.48-13.00 per litre		
Number of days when FPS is out of stock in a month		Urban: Nil (except for sugar and kerosene)		
		Rural: Nil (except for sugar and kerosene)		
Number of times commodities are transferred from warehouse to a FPS in each month		Urban: 1		
		Rural:1 (through lead societies)		
Number of commodities handled by FPS		7 (3 types of wheat, 2 types of rice, sugar and kerosene)		
Is supply available at FPS sufficient to meet demand?		In general it is sufficient except for sugar		
Which items are most sought after?		Kerosene, food grains		
Which category of card owners has highest utilization?		AAY		
Items for which demand is low.		Wheat prescribed under AAY		
About Malpractices and Control Mechanism				
Number of FPS owners caught per year		6-8 per month, around 80 per year		
Which types of malpractices are more frequent?		Adulteration in kerosene, commodities out of stock, not opening of shop		
What action are taken against FPS?		Suspension of FPS, Penalty, Recovery		
- *Any other:*		Unable to specify	-	
About Information Flow				
Which mode is used for communication between warehouse, District administration and FPS		Paper based reports in prescribed format between different these entities.		
Which IT based tools are used at:				
- *FPS*		Almost nil		
- *Government Officers*		Mobile phone, e mail		
About Service Delivery				
Which element of PDS delivery is most valued?		*Response*	*Ranking of items*	
- *Availability of food items at FPS*		yes	1	
- *Waiting time at shop*		yes	4	
- *Behaviour of FPS Owner at FPS*		yes	5	
- *Flexibility in purchase of items at FPS*		yes	6	
- *Accurate weights and measure at FPS*		yes	2	
- *Quality of food received from FPS*		yes	3	
Overall Satisfaction with FPS providers. (On a scale of 1 to 5, where 1: Low and 5: Very satisfied)		Rural: Average score = 3.1, overall 12 % satisfied		
		Urban: Average score = 2.3, overall 8 % satisfied		
Overall Satisfaction with Government officers. (On a scale of 1 to 5, where, 1: Low and 5: Very satisfied)		Rural: Average score = 2.9, overall 11 % satisfied Urban: Average score = 1.7, overall 9 % satisfied		

AAY: Antyodaya Anna Yojana, APL: Above Poverty Line, BPL: Below Poverty Line

This will incur a cost of INR 10 billion. Under this system a targeted citizen will be identified through nine types of signs such as (palm, thumb, eye, signature, ration card number etc.). Food coupons will be bar coded and provided to intended citizens in envelops. At the shops these coupons will be collected in a sealed envelop. These sealed envelops will be send back to company for verification and reimbursement. However, this process has been stayed due to court order. Moreover, the district administration officers and other providers (on the condition of anonymity) believe that this kind of coupons will not solve the problems of PDS and may become a futile exercise.

Actors in PDS supply chain in the study district

In PDS supply chain, resources and information flow among various actors. The resources involves flow of food grains, funds etc. and information flow involves policy guidelines, distribution and utilisation reports. These actors operate at three hierarchical levels. Tier 1 involves Union and State government; tier II involves district administration and tier III represent block level administration. Union and State level actors provide policy direction and receive compliance report from tier II actors. The District administration headed by District Magistrate provides resources and direction to the tier III actors. Tier III actors such as Block Development Officers, Assistant Supply Officers, Junior Supply Officers implement the food distribution activities through network of urban fair price shops. In the rural areas representatives of villagers form a lead society which monitors the procurement and distribution activities of rural fair price shops. Along with this there are three hierarchical levels of voluntary groups which perform the task of community level monitoring. These three levels are *zila nigrani samiti* (distrct level surveillance committee), *block nigrani samiti* (area level surveillance committee) *and nigrani samiti* (local level surveillance committee). In rural areas lead societies procure PDS items from the State Civil Supplies Corporation and distribute through FPS and self help groups. While in urban areas FPS owners directly purchase PDS items from the State Civil Supplies Corporation. Figure 2 depicts resource and information flows among various actors of the PDS supply chain.

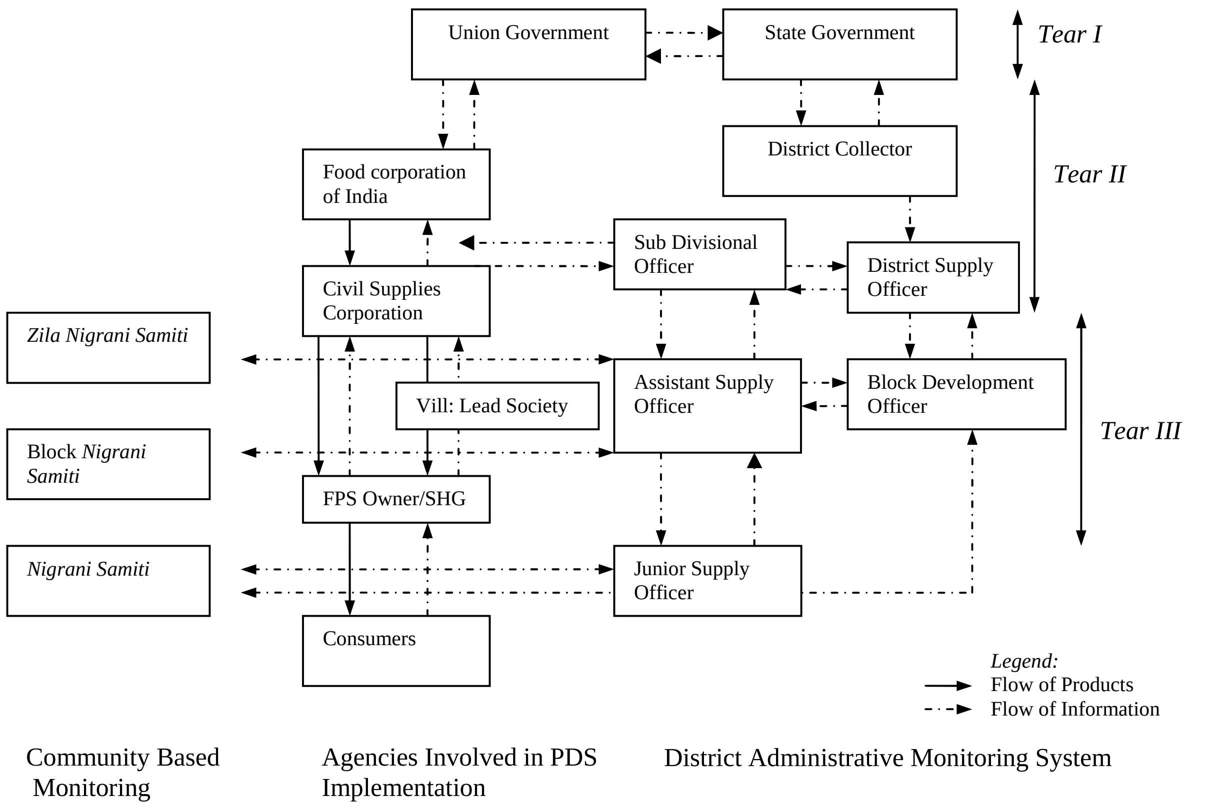

Figure 2: Resource and information flow across various actors in the PDS supply chain

Information flow is managed with the help of application softwares such as PDS Allotment, Transportation and Distribution Module, Warehouse Storage Module and Civil Supplies Movement Module. These modules are developed by National Informatics Center (NIC), New Delhi and maintained by Ministry of Communication and Information Technology, M.P. State. All these modules are available through web site of the Ministry of Civil Suppliers, Government of Madhya Pradesh. Each module captures elaborate set of data during intricate processes of the PDS supply chain. Each module also generates large number of summary reports which is used by Union, State, District, and FCI level administrative officials. Figure 3 depicts the set of data items which are captured in each module and the number of reports generated by the system.

Implementation challenges of PDS supply chain

The PDS supply chain is fraught with many challenges. Poor targeting, poor empowerment of citizens, inefficient operations, lack of benchmarks, poor institutional setup and too many laws are the key causes which lead to implementation challenges in the PDS supply chain. Poor targeting of PDS system is because of lack of availability of data about correct socio- economic conditions of citizens. Poor classification of citizens results in transfer of benefits to segment of citizens which are not targeted. Targeted citizens' level of awareness is not only poor but their empowerment is also meagre. Because of bureaucratic processes they show little interest in getting justice through available redressal mechanisms. PDS operations involve high carrying cost and overall cost incurred on PDS operations is huge. On one hand PDS supply chain suffers from lack of warehouse capacities and on the other hand overall warehouse capacity utilization is poor. Coordination among participating actors is poor and their accountability is also blurred. PDS operations also suffer from poor outreach of government sponsored programmes. PDS systems do not benchmark its operations professionally. Performance measurement system is absent and there is no protocol for service delivery. There are many institutional actors which take part in day-to-day affairs of the system. These actors otherwise do not trust each other. There is rampant level of corruption. There is mismatch between available capacities and demand. PDS system is regulated by too many laws which results in blurring of reporting and accountability. Further, regulatory bodies have poor resources and regulatory sanctions against malpractices are slack. Figure 4 depicts cause and effect (fishbone diagram) to demonstrate the challenges in the PDS supply chain.

DISCUSSION

Some observations on the PDS supply chain

From the supply chain perspective the PDS supply chain is highly de-motivating as it is highly fragmented and the associated flows of food grains, information, funds and service are blurred. Various actors involved operate in almost independent manner which results in cascading of effects resulting in overestimation of demand and supply levels thereby, culminating into poor resource management and supply-demand mismatch. During the year 2012 State has set a production target of 7.4 million tonnes of wheat which was later upgraded to 11 million tonnes. But it was later decided to keep a target of 8.5 million tonnes. However, the actual production is much more than 8.5 million tonnes and State is clueless about the offload of wheat. The PDS supply chain is predominantly a supply driven system conceptualized at a time when India was not self-sufficient in food grain production.

Procurement: (Procurement Module)
Commodity Rate: [Marketing season, Crop year, Commodity, MSP rate, Incidental, Bonus], Operations: Update
Purchase Center: {Name, Marketing season, Crop year, Category, nodal officer, Address, Block/Tehsil, Phone}, Operations: Insert, Update, Delete
Farmer Details: {Name, Father's name, Khasara No., Ration card no., Ration card type, District, Tehsil, RI, Halka, Village, Status}, Operations: Insert, Update, Delete
Procurement: {Marketing season, Crop year, Agency, Purchase center, Farmer name, Commodity, Quantity, Amount Payable}, Operation: Update, Cancel
Payment: {District, Marketing season, Agency, Transaction date, Amount paid, Purchase center, Bags issues, Bags returned, Bill amount}, Operation: Update
Food Grain Transfer: {District, Marketing season, Procurement amount till date, Quantity lifted till date, Transaction date, Purchase center, Destination, Quantity transferred, Quantity transferred, transaction id, Transfer date, Purchase center, Storage center, Quantity transferred, Quantity procured}

Types of Reports Generated: 9

Warehouse Storage: (Warehouse Storage Module)
Godown: {Serial number, Name, Capacity, Hired type, Storage type}, Operations: Update, Delete
Stack: {Serial number, Name, Commodity name, Category name, Status, Maximum capacity, Current stock, Storage type, Hired type}, Operations: Update, Delete
Transporter: {Serial number, Transporter name}, Operations: Update, Delete
Depositor: {Depositor name, Depositor type, Address, Contact number}, Operations: Update, Delete
Miller: {Miller name, License number, Remarks}, Operations: Update, Delete
Depot: {State, District, Depot belongs to, Region, Depot name, Block name, Capacity, Address, Nodal Officer, Address}, Operations: Update

Types of Reports Generated: 18

Supplies Movement: (Civil Supplies Movement Module)
District Manager of MPSCSC: {Entry of release order by FCI, Transport order for lifting from FCI to destination issue center, Truck *challan*, Release order to lead society}
Issue Center Login: {Opening stock, Receipt from different sources, Dispatch to other depot/lead society/FPS}

Types of Reports Generated: 23

Legend: - Record = File master: {various data items which are captured}

Figure 3: Description of data captured in various modules of the PDS supply chain

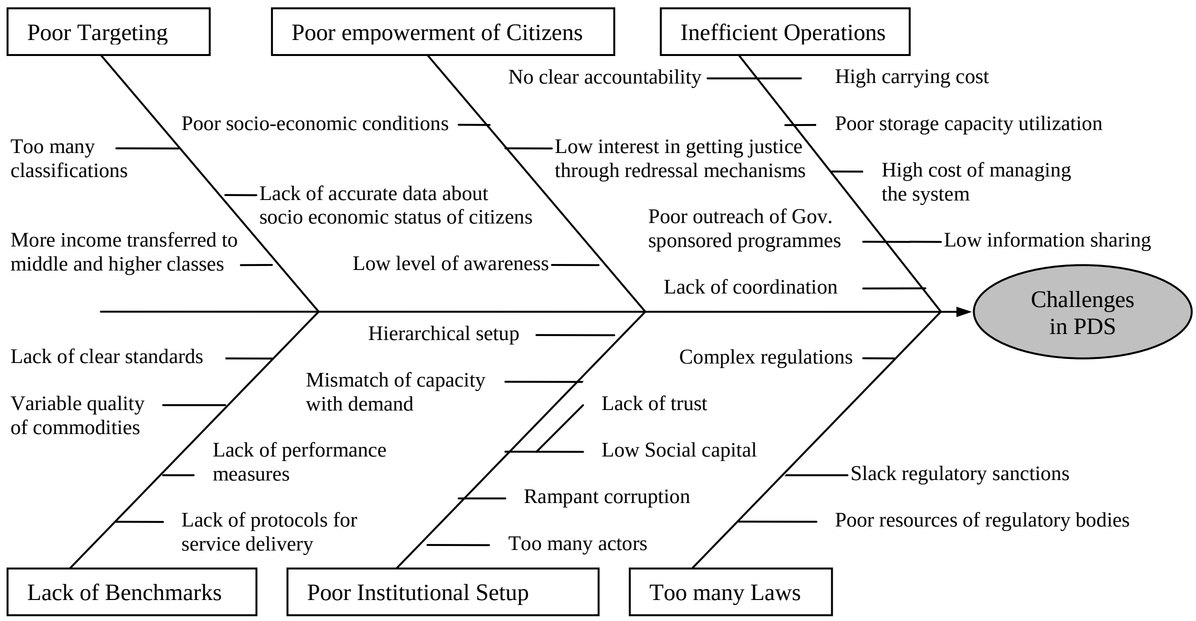

Figure 4: Cause and effect diagram representing implementation challenges in PDS

There is no connecting thread among various actors such as Union government, State government, FCI and FPS. These actors does not share common objective of overall value generation across the entire PDS supply chain.

Philosophically the underlying tenet of PDS supply chain is to improve the quality of life of underprivileged masses of India. The poor citizens for whom the entire PDS system is conceptualised remain voice less and at the mercy of the system. There is a wide gap between conceptualization of PDS supply chain and its implementation. Therefore, the role of poor becomes very important in conceptualization of supply chain design. Increased literacy, enhanced life expectancy, improved health status on the one hand and on the other hand reach of mobile phones, availability of fast transportation modes and people' increased mobility has redefined the meaning and perception of the quality. The meaning of quality in the context of PDS supply chain which is targeting underprivileged citizens of India is availability and desired quantity of food grains. Advances and enabling nature of information and communication technologies have potential to link all the actors of the PDS supply chain in a cost efficient manner. The ICT driven PDS supply chain have potential to operate in a seamless manner by providing real-time information about the flow of food grains and the status of service delivery to the targeted citizens.

PDS supply chain: possible solutions

Based on the ensuing analysis there are two alternative possible solutions for revamping the PDS supply chain in the study district. Improve and strengthen the present system or scrapping the present system and replacing it with a new system wherein e-coupons of appropriate value will facilitate the transaction between seller and intended citizens. In the new system private actors may also be roped in and together with them FPS actors would provide designated commodities to targeted citizens.

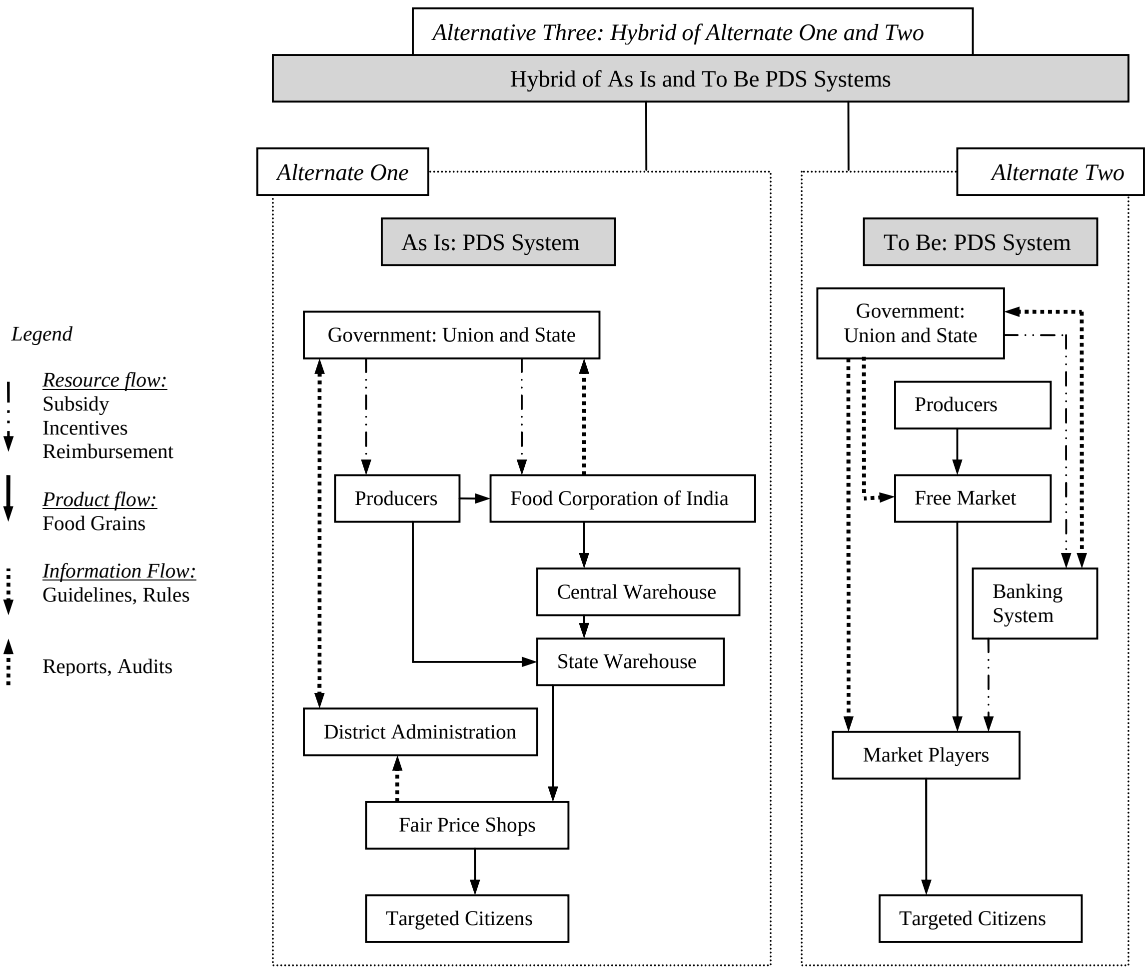

Figure 5: Schematic representation of the alternative solutions

Current supply chain of Indian PDS has a mammoth size and structure. Thus, it may not be feasible and stable policy alternative to dismantle the current PDS system and design a new one based on state-of-the-art processes and thinking. An evolutionary approach of identifying and fixing the pain points of the PDS system through interventions of process redesign and ICT based enablement may provide better opportunities for servicing the underprivileged citizens. A hybrid approach as depicted in figure 5 is to retain the current PDS supply chain while making suitable process redesigns, introducing ICT based interventions and involving private actors in service delivery. Following sections elaborate on key issues for implementation of above approach.

Achieving operational excellence in PDS supply chain

In the PDS context, operational excellence means conducting supply chain processes in an end-to-end manner. This achieves higher yields through effective agricultural practices, improves food grains quality, faster throughput, and provides citizens with designated commodities at competitive prices and delivery with minimal difficulty. A PDS supply chain that builds around operational excellence organises itself to provide market offerings that delight targeted set of citizens. Timely assessment of accurate demand level of food grains would trigger all the upstream activities in the PDS supply chain. This demand information needs to be visible across all the upstream actors of the PDS supply chain. In turn supply related visibility needs to be extended across downstream actors and nodes from procurement of food grains to its distribution to end consumers. Information Technology based tools such as bar codes, radio frequency identification (RFID) tags, geo-positioning systems (GPS) may be used for track and trace movement of food grains. Food grain processing system should encompass not only procurement and distribution of food grains but should also cover activities related with capacity development of farmers. All the activities involved in procurement and distribution processes should be based on the cycles of plan- developing processes to manage demand with supply and managing food grain surpluses, do-implementing processes for achieving high level of service delivery, check-monitoring elements of service delivery and finding a ways to improve processes and act-implementing the enhanced processes. Transportation of food grains should comply with trade, crop production, food grain processing, quality and environment related regulations, including license determination and quotas related norms as imposed by other State governments. The PDS supply chain needs to apply operational excellence through a continuous improvement of processes on a day-to-day basis to meet the challenges imposed by the perishable nature of food grains, dynamic demand, and low yield of food processing technologies.

Using key performance indicators of PDS supply chain

The PDS supply chain needs to define key performance indicators (KPIs) that measure performance of each actor across the supply chain. PDS supply chain is quite different from supply chains operating in sectors such a manufacturing, retail etc. Therefore, the KPI[1] used in these sectors may not be directly applicable in the PDS context. Supply chain of large scale and complex systems such as Indian PDS consists of multiplicity of objectives driven by the concept of a welfare State. Designing PDS supply chain around the needs of underprivileged citizens and then defining set of indicators which measures its performance is a Herculean task. Key performance issues which emerge are related to management of food grains from procurement to delivery to the end customer. Other performance issues are related to service delivery.

First measure of PDS supply chain is defining shelf life of perishable food grains. Transportation is measured in terms of unit cost of travel and the pilferage rate. Distribution of food grains to intended citizens is measured in terms of availability of right amount of food grains in a given time window and the percentage of citizens which are served. Collectively these indicators reflect the overall reliability of the PDS supply chain. Time taken in fulfilling a demand and the associated delay reflect overall responsiveness of PDS supply chain. Choice to choose between food grains reflects flexibility of the PDS supply chain. Adulteration in food items measured as percentage of volume represent the quality of food grains as supplied by the PDS supply chain. Quality of service (QoS) may be measured in terms of a QoS Index which is a composite index consisting of various service related factors. Losses in PDS supply chain is measured in term of wastage of food grains on monthly basis as well as losses incurred during the transportation. Losses also represent amount of blocked funds measured on monthly basis or yearly basis. Looses may also be due to poor packaging and may be measured in terms of per sack basis. Finally the overall cost incurred directly or indirectly by all the actors of the PDS supply chain should be mapped with the overall value generated to the targeted citizens. Table 5 depicts

[1] Return on investment, Inventory turns, Logistics cost ratio, Inventory carrying cost, Man power utilization etc.

various KPI as applicable to the PDS supply chain. These indicators are further grouped under logical constructs of reliability, responsiveness, flexibility, quality, asset, and cost.

Table 5: KPI in PDS supply chain

Underlying Constructs	KPI
Reliability	Shelf life of stock?, Time window for availability of stock (day basis or specified time frame) , Pilferage rate (each sack basis), Percentage of target group served, Availability of food grains (on any given day), Availability of right volume of food grains (on any given day),
Responsiveness	Delay in transportation (in days), Order fulfilment lead time (in days)
Flexibility	Choice to targeted citizens (selection from the applicable list of items)
Quality	Adulteration in food items (as percentage of volume), Quality of Service Index (a composite index consisting of various service related factors)
Asset	Wastage of food grains (monthly basis), Loss in transportation (each trip basis), Blocked funds (monthly basis), Loss due to poor packaging (each sack basis)
Cost	Cost of food grains sold, Total supply chain management cost to serve the targeted citizens

Challenges, information support and ICT enablement

In PDS supply chain implementation issues involve the challenges of supply, warehouse, transportation and distribution. These challenges may be addressed through information support and developing ICT based support systems. Production of food grains are geography specific and heavily depend on the rainy season. Currently the movement of food grains between States is regulated as per the State policy. These challenges may be addressed by mapping supply related information with the demand information. ICT based systems may be of use for creation of nation-wide integrated databases which enables effective resource planning and dynamic allocation. Use of GIS and GPS enabled trace-and-track system will help in capturing movement of food grains. These will help in assessing the requirements of States in a dynamic manner and replenishing them as and when need arises. Developing capacities and linking it with markets would take care of bumper and lean food production. Storage of food grains suffers not only from poor capacity but also in timely pickup of food grains. This becomes more complicated because of uneven production level of food grains across various regions. Information about regional production levels along with capacity of available warehouses will help in taking informed storage decisions. ICT based system may be of use for monitoring the flow of incoming, in-transit and outgoing food grains. Consolidation of demand and transportation of food grains using principles of cross docking[1]. Transportation capacity available in PDS supply chain is inadequate. Coordination among various actors during movement of food grains is poor.

Assessment of needed transportation capacity will help in facilitating smooth movement of food grains. Coordination and collaborative information exchange among various actors will provide better resource utilization. Demand estimation is essential in matching demand with supply. Estimation of micro and macro level demand will help in estimating other needed resources. Forecasting of demand needs to be synchronized with demographic changes. ICT enabled interlinking of state-wide sources of food grains and associated demands will be of immense help. Table 6 depicts challenges, information support and needed ICT enablement.

[1] Movement of food grains from incoming trucks to outgoing truck without much involvement of storage.

Table 6: Challenges, information support and ICT enablement in PDS supply chain

Key Challenges	Information support	ICT enablement
Supply		
Production of food grains are geography specific.	Data about food grain varieties, their origin and capacity of production.	– Nation-wide integrated database. – Estimating the requirements of states in a dynamic manner and replenishing it as and when need arises. – ICT enabled systems for integrated resource planning and allocation. – Forecasting the level, trend and seasonality of food production to manage bumper or lean food production. – Development of GIS/GPS enabled trace-and-track system which captures movement of food grains.
Inadequate allocation of food grains to states.	Correct estimation of demand for each State. Real-time data of demographic profile.	
Dependence of food grain production on rainy season.	Availability of weather related data.	
Flight of food grains to other states.	Monitoring reports generated from trace-and-track data reflecting moment of food grains. Enacting suitable legislation	
Hoarding by various interest groups.	Monitoring and inspection reports	
Warehouse		
Capacity utilization.	Data about capacity and stock build-up at warehouse. Monitoring reports.	– ICT based system to monitor flow of incoming, in-transit and outgoing food grains. – Location of warehouses based on principles of location/network deign. Consolidation of demand and transportation of food grains using principles of cross docking. Use ICT based tools for capturing real-time moment of food grains. – Database system to record: what is in stock? What is its level?
Uneven distribution across geography.	Data about sources and supply destination	
High level of rusting and leakages.	Monitor reports.	
Poor capacity for timely pickup of food grains.	Monitor inspection.	
Transportation		
Inadequate logistical capacity.	Data about capacity requirement needed for movement of food grains.	– Development of specialised ICT enabled transportation system having tools like Geo-Positioning Systems (GPS), Electronic Data Interchange (EDI), mobile devices etc. for data communication.
Lack of coordination in movement of food grains.	Coordination and collaborative information exchange.	
Highly inefficient movement of food grains.	Data about time, resource utilization and service delivered	
Poor responsiveness of the transportation system.	Data about various vehicles involved and their current status.	
Distribution		
Lack of accurate data about food grain needs catering to various schemes.	Estimation of micro and macro level demand	– Packages with forecasting capabilities and its linking with demographic data. – Linking of Nation/State-wide sources of food grains and demands of food grains. – Database systems which gets dynamically updated with changing demographic profile.
Mismatch between supply and demand.	Data about allocation. Possible sources of supply	
Poor reach of distribution network.	Data about demand across the region and possible sources of demand fulfilment.	
	Correct estimation of various categories of population.	

ICT enabled PDS supply chain

Ensuing analysis suggest that current processes of PDS supply chain may be re-designed to address various challenges. Following process changes are recommended to make current PDS system more effective. Procurement activities will be performed by FCI. Warehouses may act as a buffer between market and the FCI. FPS will continue to distribute food grains to targeted underprivileged citizens. Over a period of time this distribution channel may merge with private actors operating in free market. Subsequently FPS owners will transform themselves into full-fledged market players offering wide spectrum of products and services. The competition among public and private players would improve the quality of products and services. Targeted citizens may be provided with coupons/e-coupons which will authorise them to receive food items at a subsidized rate. Unique Identification (UID) Cards may be used for identification and providing of coupons/e-coupons to target citizens. Targeted citizens may receive desired quota of food grain items from various shops in free market place at subsidised rate. Shop owner will swipe the card in card reader machine (like debit/credit card) and coupons will be debited from the card holders card. Financial institutions such as participant banks may credit the show owner's account by the remaining amount. Alternatively targeted citizens may also be provided with mobile phones which may be recharged on monthly basis with suitable amount of e-coupons. These citizens may make purchase at subsidized rate in any shop in the market place against transfer of e-coupons. These transferred e-coupons will be reimbursed by the government assigned banks as per the government guidelines into the shop owner's account. Schematic diagram depicting ICT enabled PDS supply chain is shown in figure 6.

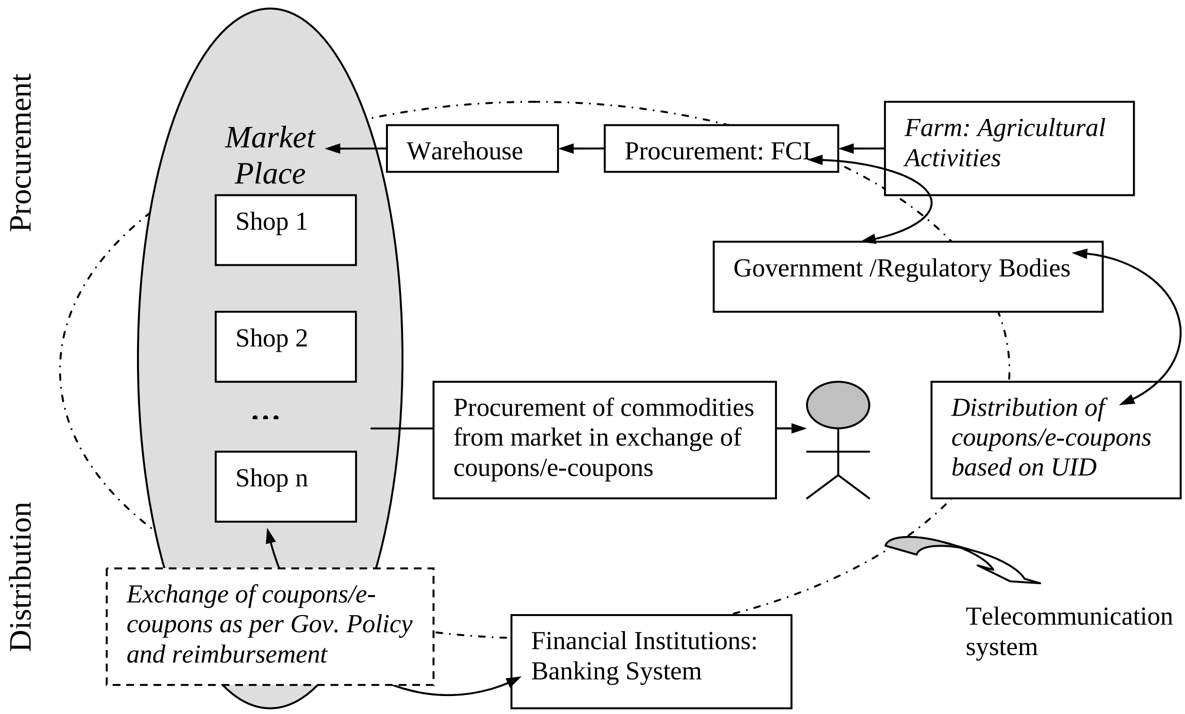

Figure 6: ICT Enabled PDS Supply Chain

CONCLUSION

My analysis of the PDS supply chain in the district of Gwalior reveals that current state of the PDS has developed in a piecemeal and ad hoc fashion, where bureaucratic actors occupy a prominent position which sometimes results in high cost of PDS and low level of service delivery. PDS supply chain operates under various types of State prescribed controls.

PDS supply chain delivers few commodity types of items therefore its operations needs to be efficiency driven. However, almost every stage of PDS supply chain involves inefficient flow of resources. Targeted citizens have poor awareness of their roles and responsibilities and their rights are limited. The involvement of private actors is absent. Requirements of the targeted citizens need to be incorporated in planning of PDS operations. This will also help in planning and delivering enhanced level of quality of service at all stages of PDS. Partnership and coordination among various PDS institutions are weak and each institution is more concerned about its own functions. There is a mismatch in demand and supply of PDS services both in terms of PDS infrastructure and service delivery. In order to address these pain points, PDS supply chain should concern about planning, monitoring and control. Effective planning will involve routine data collection, analysis and estimation of benchmarks at regular intervals. The current PDS supply chain needs to address the issues of procurement along the themes of inventory management, facility location, network design, transportation etc which addresses the issues of bumper crop as well as lean crop. ICT based interventions as described in table 5 and figure 6 will provide real time availability of information for trace and trace of flow of commodities. UID based recognition of citizens will address the issues of ghost cards. The mandate of UID project in India was to develop systems for unique identification of citizens and then linking it with public service delivery. However, Union food and distribution ministry is against the use of UID in PDS and wish to continue with computer system which is developed by NIC (Times of India, February 9, 2012). In various States including Madhya Pradesh, computerisation has so far progressed to varying degree and each State is using its own software and systems. These software systems seems as yesterdays solution to today’s challenges.

The Indian PDS experience strongly highlights the first principal of governance- government should do less and facilitating more. Thus, India needs to redefine its role from that of a doer to a facilitator, and restrict its domain of activities and facilitate the growth of private actors in PDS supply chain. Towards this, regulatory solutions may lie in the areas on assessing needs of all the stakeholders of the PDS, defining roles and responsibilities of various institutions of PDS service delivery, defining pubic private partnerships (PPPs) for sharing of roles, responsibilities and risks, development of benchmarks for recognition and accreditation of PDS facilities, developing mechanisms to attract and retain providers for service delivery in rural and remote as well as far-flung areas, developing guidelines for pricing of PDS service delivery and use of information and communication technology (ICT) based tools to develop an effective PDS surveillance and regulatory system.

This study is subject to some constraints, for example district supply officers did not share much information owing to reluctance. I intended to capture insights into various issues on demand and supply and end user’s assessment of PDS but many respondents shown unwillingness to share in-depth information and sometime needed information was not even documented at the concerned institutions. However, my study lays the foundation to investigate the same themes in other Indian States. Taking a cue from causes of difficulty in PDS as identified in this study, future researchers may use Pareto analysis to identify relative importance of these causes. Relative importance of these causes will help policy makers in addressing most urgent needs of the PDS in Sate of Madhya Pradesh. Conceptualisation of PDS service quality construct and development of its various dimensions would be another interesting area of future work. The dimensions of the construct and their underlying items will be useful for developing a measurement tool based on quality of PDS service delivery which may be used for accreditation and control.

Annexure I

Data Collection Instrument:

1. Which commodities are distributed through PDS and what are their associated limits.
2. How many days of a month commodities are available at the FPS?
3. How many times a month commodities are received from the warehouse?
4. How many commodities are distributed by PDS?
5. How many cases of illegal practice by FPS are reported?
6. Which types of cases are more frequent?
7. What actions are taken against FPS Owners?
8. Which IT based tools are used at FPS?
9. What IT tools are used by government officers?
10. Does PDS supply chain meet demand?
11. Which commodity is most sought after at FPS?
12. Which category of card owners has highest utilization?
13. Which items are low in demand?
14. Which elements of PDS is more important
    a. Availability of food items
    b. Waiting time at shop
    c. Behaviour of FPS owner
    d. Flexibility in purchase of items
    e. Accurate weight and measures
    f. Quality of food received
15. Overall satisfaction with FPS providers. (On a scale of 1 to 5, where 1: Low and 5: Very satisfied)
16. Overall Satisfaction with Government officers. (On a scale of 1 to 5, where, 1: Low and 5: Very satisfied)

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Gyan Prakash earned his PhD from Indian Institute of Technology Kanpur. Currently he is working as Assistant Professor at Indian Institute of Management Indore. His areas of professional interest include supply chain management, IT applications in management and public systems. His work has been published in national and international conference proceedings, and international journals. He may be contacted at gyanprakasha@yahoo.com.

SAFETY AND ENVIRONMENTAL POLICIES FOR HIGH RISK MANUFACTURING ORGANISATIONS EXPANDING TO EMERGING ECONOMIES

Ian Hipkin
École Supérieure de Commerce de Pau
rue Saint-John Perse
B.P. 7512 - 64075 PAU Cedex, France
ihipkin@yahoo.co.uk

Abstract
This paper examines the management of safety and protection in UK high risk parent multinational organisations in the operations of their subsidiaries or alliance partners in emerging countries. Safety and environmental policies in the home country cannot necessarily be replicated in emerging countries where legislation and regulations, operating conditions, worker skills and attitudes are likely to differ. The challenges of functioning in emerging countries are further exacerbated when supply chains are fragmented and lengthened, and when they become more complex and difficult to control.

The study uses the findings of three industrial accidents in western countries (ConocoPhillips oil refinery, BP Texas refinery, Buncefield storage depot) as the basis for determining the attitudes and behaviours of western managers in high risk industries regarding policies for operational safety and environmental integrity in emerging countries. The emphasis is particularly on policies pertaining to the management of plant protection, safety and environmental integrity. Managers in 12 UK high risk organisations were interviewed. The results show a disturbing complacency on the part of managers in developed countries in establishing safety and environmental management programmes beyond narrow adherence to local regulations. It is common for policies adopted in western countries to be transferred to emerging country subsidiaries with adaptation only for local requirements. Frequently no account is taken of widely differing operating conditions, cultures and personnel skills. The challenge for practitioners and researchers is to enhance theoretical and practical knowledge and understanding of protective systems, their failure characteristics and appropriate remedial actions and change management policies within the context of regulatory safety parameters.

Keywords: high reliability; case study; protection; failures; emerging countries

INTRODUCTION
Organisations are increasingly exposed to public scrutiny when their products fail or when environmental disasters occur in their sphere of operation. Firms expanding internationally need to have robust safety and environmental policies in place since devastating accidents will threaten their survival. At a strategic level the safety and environmental consequences of failure may influence location and process decisions. From an operational perspective, meticulous attention needs to be paid by the parent company of safety and environmental issues in the target country. Physical, cultural and regulatory differences and long supply chains do not mitigate the public outcry when disaster strikes.

Failures with severe consequences can threaten not only the future of the organisation, but potentially swathes of society as well. Firms that attribute the highest priority to safety believe that safety is more important than production (Busby and Bennett, 2007). Yet Brill (2010: 22) cynically comments that the attitude that something will never fail "only becomes obvious to corporate boards and senior executives after a critical failure has occurred and earnings and stock prices have taken a hit." Despite assurances of the safety of installations, catastrophic failures continue to occur. As globalisation disperses hazardous industries to emergent countries with less regulated safety standards, the possibility of industrial accidents increases.

This paper is an exploratory attempt to study how multinational firms in high reliability industries view safety policies in their emerging country subsidiaries. The reports of accidents at the ConocoPhillips oil refinery, the BP Texas refinery and the Buncefield storage depot were used as the basis for interviewing corporate managers in UK 12 firms where failures can have serious consequences. The purpose was to establish how western multinational firms view safety and protection in subsidiaries and partner organisations in emerging countries.

The paper is structured as follows: the following section reviews the literature on safety issues, particularly in relation to the management of protection; the methodology used in the study is then discussed; the findings and discussion section analyses interviews held with managers in order to ascertain the extent to which their occupational safety and health policies compare with the recommendations contained in the three accident reports; finally conclusions are drawn and concerns raised about the management of safety related protection by the subsidiaries of high risk multinational companies in emerging countries emerging.

A REVIEW OF THE LITERATURE

A review by the author of US and UK industrial accident reports since 1970 reveals the various broad causes of accidents (Table 1).

Cause of accident	**Percentage**
Human error or non-adherence to safety regulations	54%
Failure or poor maintenance of protection	19%
Unforeseeable equipment failures	10%
Poor design	6%
Unknown (including possible sabotage)	11%

Table 1 Causes of industrial accidents
US Occupational Safety & Health Agency (OSHA); UK Health and Safety Executive (HSE)

Protection and safety systems have become increasingly complex in high reliability manufacturing facilities (Ajimotokan, 2011), frequently resulting in 'technological turbulence' (Song and Montoya-Weiss, 2001), and necessitating additional processing of information and enhanced collaboration among functions in relation to technology, people and organisation (Gupta et al., 1986; Wilson-Donnelly et al, 2005). This review of the diverse literature on protective systems and failure of equipment addresses the term 'high reliability' organisations, and considers a quantitative approach to managing protective systems, as well as certain managerial issues in relation to protective systems.

High reliability organisations and regulations

The organisations selected in this paper operate potentially hazardous installations, defined by Shaluf and Abdullah (2007) as industrial activities that process, use, dispose of, or store hazardous substances. Certain industries are understandably heavily regulated, such as the oil sector (Mekaroonreung and Johnson, 2010). In the US they are subject to a host of federal regulations, such as the Clean Air Act, Clean Water Act, Resource Conservation and Recovery Act, Emergency Planning and Community Right-to-Know Act, Occupational Safety and Health Administration Health Standards and Process Safety Management Rules and a plethora of state and local regulations.

According to the UK Health and Safety Executive (HSE) (2009: 62) high reliability organisations produce output relatively error-free over a long period of time, and are characterised by two key attributes:

- firms do not assume that because they have not had an incident for ten years, one will not happen imminently
- they set a low threshold for intervention: if something appears not to be correct, they suspend operations and investigate.

In order to adhere to these, the HSE demands:

- A clear understanding and definition of roles and responsibilities in relation to safety and protection, process changes, and standards for effective and safe communication
- Appropriate staffing and working conditions to prevent, control and mitigate major accident hazards, and to allow staff to detect, diagnose, and respond appropriately to potential incidents.

Within the HSE the Control of Major Accident Hazards (COMAH) Regulations prioritise, inter alia, leadership, competence and performance measurement and monitoring standards in existing new and emerging technologies.

The American Petroleum Institute's API-653 standards specify maintenance and periodic inspection requirements for protective systems, but failures are not prevented solely through regulation. Self-regulation plays an important part in managing protection. Firms should learn from safety incidents, which frequently result from a combination of failures, rather than a single event, preceded by warnings, potential failures or near misses (Lukic et al., 2010; Sepeda, 2006). Organisations tend to be passive participants that react to external pressures because their reputation, risk and public image are so important (Heras-Saizarbitoria et al., 2011; Kumar, et al., 2009).

Quantitative issues in managing protective systems

The management of protective systems requires the identification of safety critical tasks such as prevention and detection, control and mitigation (Johnson and Hughes, 2002). In the maintenance management literature, many protective functions are termed 'hidden': their failure is not evident during normal operations (SAE JA1012, 2002). Regulations state that these should be subject to 'scheduled failure-finding inspections' or 'operational/visual inspection' (Ahmadi, 2010), which should satisfy a number of conditions, as discussed below, but the SAE JA1012 standard does not specify how intervals for failure-finding tasks should be determined.

Nowlan and Heap (1978) note that preventive and predictive maintenance approaches are often inappropriate since the failure of protection usually does not conform to a time-related failure pattern, nor does it provide consistent warning of imminent failure. The failure of protection does not, in itself, have direct consequences. Its failure only matters when called upon to operate when another failure occurs: this is known as the multiple failure (Nowlan and Heap, 1978). Policy makers are obliged to set protection failure finding intervals that will reduce the risk of a multiple failure to a tolerable level. This can be a complex decision. Where multiple failures have only direct operational consequences, then the frequency of a failure finding task may be calculated on the basis of a comparison of the cost of the failure finding task and the cost of the multiple failure.

The more serious situation, where a multiple failure can have safety and environmental consequences, demands a more rigorous approach (Moubray, 2001): establish what probability is acceptable for a multiple failure (such as a 'Fatal accident frequent rate', typically expressed as 1:1,000,000); determine the reliability of the protected function (how often the protected function fails, triggering the need for protection); then specify the availability required of the protection. Mathematically this may be expressed as:

Probability of multiple failure = Probability of failure of the protected function
x Probability of failure of protection

With a random failure rate of the protective device, Nowlan and Heap (1978) derived a mathematical relationship between required availability for protection and the reliability of protection from which the failure finding interval may be calculated. The situation is more complicated with multiple protective systems or if a danger exists that the failure finding task itself can cause the failure it is intended to detect (as was the case in the Buncefield incident). The methodology of Nowlan and Heap requires the following:

1. A policy for an acceptable occurrence of a multiple failure
2. Data which provides the reliability of the protected function
3. Data which provides the reliability of the protection.

Regulations require evidence-based decisions (Assilzadeh and Yang Gao, 2010), in which IT can play an important role in rationalising work and decreasing dependence on human skills ('automating'), and generating large quantities of information for analysis ('informating') (Zuboff, 1988). Adherence to regulations represents overt control, which is subject to management influence and direction. However, with inexact data and unknown parameters, problem-solving often becomes a trial-and-error exercise in which parameters are modified, learned about, and improved upon. A range of solutions is likely to emerge that may be interpreted in differing ways by multiple stakeholders with possibly contradictory interests (Macher, 2006).

Tools are required for tracking changes over time (descriptive outcomes), and for determining root causes and emerging trends (diagnostic outcomes) (Morrel-Samuels et al., 2009), but difficulties arise when knowledge elements lie beyond an organisation's sphere of expertise (Rosenkopf and Nerkar, 2001). This may be due to novelty, layers of complexity and unfamiliar situations which even knowledgeable operators do not comprehend (Jarvinen and Karwowski, 1995; Sorenson et al, 2006). This is exacerbated when redundancy is introduced: Sagan (1993) cautions that the purported protective benefits of redundancy may be severely compromised by the complexity it introduces.

An important component of risk management is risk based inspection, which is described in the HSE report on the ConocoPhillips accident (2001): gathering information about the plant (e.g. materials of construction, process fluid constituents, temperatures, pressures etc.) and inputting it into a software programme. This requires data analysis and produces confidence reports about the life of the equipment and the relative risks involved. This knowledge is then used to develop an inspection plan to control the risks of a failure. No guidance is given about how data should be 'analysed' nor how an inspection plan should be compiled.

Behavioural issues

New data collection and analysis are essential but complex processes, which challenge existing practices and organisational culture (Lorenzo et al, 2009). Codification of processes requires competent workers with subtle skills and expertise (Cordero, et al., 2009; Liedtka, 1997; Nahapiet and Ghoshal, 1998; Von Hippel, 1994). Busby and Bennett (2008) suggest that firms may be inclined to 'self-censor out' of their analyses those elements where 'data' are lacking. However, they note that once a risk has been identified there is an obligation to take mitigating action. This reinforces the importance of identifying hidden functions: once they have been identified, the firm is obliged to 'manage' them.

Regulatory requirements systemise training, safety related human resources issues and financial resources as components of 'safety capital' (Nuñez and Villanueva, 2011). Yet, regulations and standardised prescriptions may inhibit safety initiatives and freedom of thought and action. This reveals a paradox where managers promise empowerment and participation, but regulations insist on conformance (Hipkin and De Cock, 2000). A common result is a reduction in employees' initiative, trust and commitment (DePasquale and Geller, 1999). Behaviour is affected by levels of autonomy and control, lack of trust and poor communication (Landfred, 2000; Haas, 2006), as occurred in both the BP Texas and Buncefield cases.

Functionality verification, data analysis and corrective action involve several departments and disciplines. The literature addresses this from a number of perspectives (Kristianto et al., 2012; Shamsuzzoha and Helo, 2011), but essentially collaboration invariably takes the form of unstructured relations between disciplines (Pilar et al., 2010). Tu et al. (2006) claim that operators and shopfloor employees have a unique understanding of many production problems and their distinctive insight frequently enables them to offer effective solutions. This point is taken up by Lukic et al. (2010) in their argument that learning from accidents and incidents involves a number of individuals and groups, and follows different approaches: individual, group and organisational learning, and learning in a social context, including all higher levels in the organisational hierarchy.

The way in which firms operate is path dependent, shaped by past experience. Ahuja and Lampert (2001) identify three competence traps affected by path dependency. The familiarity trap results from overemphasising the refinement and improvement of existing knowledge, inhibiting a firm's search for alternate knowledge sources and creating a sense of complacency. Maturity traps arise from a reluctance to search for reliable data. Propinquity (nearness) traps signal a firm's propensity to explore knowledge close to its existing expertise, without searching for radical shifts in the industry. With the pervasive learning and information environment in which firms operate, industrial competence and knowledge are nowadays increasingly situated outside the organisation and widely dispersed geographically (Lynskey, 1999).

Tiwari et al. (2010) stress the need for capturing and analysing process, prediction and radical initiatives. In the context of protection and safety, it is clearly essential to meet regulatory requirements (analogous to the 'performance ceiling' proposed by Tiwari et al., 2010). However, an internal company FAFR policy pertaining to a multiple failure may impose even more stringent failure finding demands than the regulations

METHODOLOGY

The purpose of the research is to study the approach of UK multinational corporations in the management of safety and protective systems in their emerging country subsidiaries. The reports of three industrial accidents have been used as a benchmark against which to assess how emerging country facilities are managed from a safety perspective: ConocoPhillips Humber refinery - Public report of the fire and explosion (2001); BP Texas Refinery - Fatal accident investigation report, Isomerization Unit Explosion Final Report (2005), and Buncefield storage facility - Final report of the Major Incident Investigation Board (2008). This paper does not describe these accidents in any detail, but their findings potentially have wide application in all high reliability organisations. The paper seeks to establish how corporate multinational firm managers view the issues raised in the accident reports.

Managers in 12 UK high reliability organisations were interviewed and asked to score a number of factors pertaining to the management of safety and protection. A broad interpretation of the definition of a high reliability company given above by Shaluf and Abdullah (2007) was used when selecting the UK multinationals: while oil refineries and industrial chemical processing plants clearly fall into the category of 'high reliability', pharmaceutical factories and mining processing plants have been included because of the chemicals used in their establishments, and the fact that serious lost time accidents have occurred in these sectors.

Sector	**Number of managers interviewed**
Oil refineries/installations	4
Chemical processing	4
Pharmaceutical	2
Mining (Processing)	2
Total	**12**

A questionnaire was compiled from the ConocoPhillips, BP Texas and Buncefield reports. Managers (production and/or engineering) were asked to score each item using a Likert scale (1 = strongly disagree; 5 = fully agree). Managers were also asked to indicate whether responsibility for each factor lay at a corporate or local level. These scores are shown in Table 2. Items in Table 2 have been grouped by the author into four overall categories. Factor analysis was not used because the sample size was too small.

Managers were also interviewed to discuss the reasons for their scoring, and thereby introduce a qualitative dimension to the research.

FINDINGS AND DISCUSSION

Managers in UK multinationals were presented with 30 factors which were commented upon, and deemed important by investigators in, the ConocoPhillips, BP Texas and Buncefield accident reports. Respondents scored these on a 1-5 Likert scale with 1 indicating strong disagreement and 5 strong agreement. They were also asked to indicate whether a factor was the responsibility of corporate or local managers. Some of the significant scores are highlighted in the following paragraphs.

Table 2 Scores of safety and protection management factors by corporate managers

	Average scores	Responsibility	
	1=strongly disagree 5=strongly agree	Corporate %	Local %
Change management			
Change mangement programmes (changes to plant, equipment, process) are formalized	2,2	8	92
Procedures are in place to ensure that design changes are carefully documented	3,9	25	75
Procedures are in place to ensure that design changes are communicated to relevant parties	2,3	0	100
Procedures are in place to ensure that changes in operating procedures are carefully documented	3,6	33	67
Specific plans are in operation to make protection more effective and reliable	2,2	42	58
General safety policies			
Safety policies are formally documented	4,3	0	100
Risk assessments are regularly carried out to detect hazardous conditions	3,3	33	67
A high level of risk is not tolerated (e.g. treating fires as commonplace/“fact of life” is unacceptable)	4,4	25	75
Specific action is taken to identify deteriorating plant and safety standards	3,6	25	75
Company policies for safety and protection are geared towards full rather than minimal compliance	4,8	33	67
Policies are in place to ensure reliable data bases of failures, safety and environmental critical events	3,3	33	67
Safety audit results are publicized	2,4	33	67
Regulations and monitoring			
Employees are aware of regulations and company safety standards	3,8	0	100
Safety regulations are consistently followed	3,7	25	75
Company conducts regular audits against current legislation	2,1	25	75
Legal requirements are written into safety related procedural documents	3,5	25	75
Decisions on inspection intervals based on reliable information and previous inspection findings	1,7	17	83
Decisions on inspection intervals based on appropriate formulae and multiple failure policies	1,3	17	83
Policies ensure transparency of inspection priorities and methodology	3,6	17	83
Company policy requires regular updating of safety procedures and protection verification	3,2	17	83
All hidden functions and protective systems have been identified	1,2	8	92
Implementation		0	0
Immediate remedial action follows failures highlighted by monitoring of safety devices/protection	3,5	0	100
Company policy requires an investigation of root causes of safety-related failures	4,0	8	92
Action (e.g. design change) is taken to facilitate maintenance of safety and protection devices	1,9	33	67
Emergency equipment (protective devices, switches) are correctly located	2,3	0	0
Safety comes before production	4,7	0	0
Regular training provided for safety related changes in design, operations, maintenance	2,4	0	0
Organisational structure reflects responsibilities for safety and protection	2,3	0	100
Adequate resources and expertise are available to ensure required safety standards are maintained	4,1	8	92
Off-site (external) expertise is essential for monitoring plant condition	4,0	25	75

Scoring results
Under the factors relating to change management, managers believed that design and operating procedure changes were carefully documented in their subsidiary plants, but respondents were not aware of formalised change management programmes or specific plans to make protection more effective and reliable. Managers felt that all factors under the heading of 'change management' were the responsibility of local managers (although 42% believed that specific plans for making protection safer were the task of corporate level engineers).

Managers felt that the day-to-day management of safety and protection were a local matter. While subsidiary plants were generally designed at corporate level, operations were the responsibility of local managers. Safety policies were formally documented and geared towards full rather than minimal compliance, and high levels of risk were not tolerated.

Adherence to, and monitoring of, regulations showed a variety of responses, although again respondents felt these were primarily the responsibility of local managers. The determination of inspection intervals for protection was an ill-defined area: reliable information was seldom available, appropriate formulae and policies were not used to calculate inspection intervals and corporate managers were unable to confirm that all hidden functions and protective systems had been identified.

While respondents understandably considered implementation issues to be the responsibility of local managers, several areas raised concern as these were specifically raised in the ConocoPhillps, BP Texas and Buncefield report: respondents did not believe design changes were specifically made to facilitate maintenance of protection; they were not particularly concerned with the location of emergency equipment; safety training was limited; organisational structures did not specifically address responsibilities for safety and protection.

Discussion of scoring results with managers
Results of the scoring were discussed with respondents to ascertain their views on the management of safety and protection. Several managers expressed surprise at the nature of the questions, whereupon the author justified these by describing the context in the three accidents that had led to these points being raised.

Plant designs in emerging countries were either developed at corporate headquarters or inherited if an existing facility in an emerging country was acquired. International safety standards were built into such designs. Recording design and operating changes was specifically mentioned in the ConocoPhillips accident report. Respondents claimed that corporate procedures normally required design changes to be recorded, but changes in operating practices were left to local managers, particularly as they managed operational issues. Two managers referred to even greater challenges when dealing with alliance partners in emerging countries.

The question related to tolerance of high levels of risk was a reference to the BP Texas refinery where fires were often considered 'normal'. While respondents rejected that high levels of risk were tolerated and accepted, they acknowledged that developing country personnel had different views of a safety culture. One manager reflected the sentiments of other respondents: "In developing countries people simply do not maintain the standards expected in developed countries; life is just more dangerous generally". While company policy did not accept a balance between production against safety ('is safety too expensive?' – a reference to the ConocoPhillips 'quick fix' solution in installing a water injection point, ignoring a procedure to control site modifications), local managers at times probably compromised safety for the sake of production. Respondents as corporate managers had little influence in improving attitudes towards individual safety (a reference to all three accident reports where employees were rather casual about safety related issues), but they reported that lost time accidents were invariably due to individual carelessness or non-adherence to safety regulations. Operating errors had increased over the past 10 years, and poor maintenance resulted in lower plant availability figures. Skills deficiencies meant that safety-related incidents were not formally investigated or recorded by local managers (because these managers often feared that investigations might reflect poorly on their performance).

Respondents realised that spurious trips and false alarms were increasing in some of their subsidiary plants (a reference to operators ignoring a general degradation of plant in the ConocoPhillips, BP Texas and Buncefield sites), but ascribed these to inappropriate operating and poor maintenance. This is symptomatic of what Busby and Bennett (2007) refer to as 'longer-term patterns of degradation', especially as little is done to investigate.

Respondents felt that it was probably beyond the expertise of local managers to identify all hidden failures and appreciate the consequences of certain failures (Rosenkopf and Nerkar, 2001). This issue was highlighted in the ConocoPhillips accident report, and is stressed in the literature (Moubray, 2001). Corporate managers were hesitant in confirming that the consequences of failure of protection was adequately addressed (an issue raised by the Buncefield report when an inappropriate siting of the fire-fighting pumphouse led to the destruction of the pumps themselves after the explosion).

Although certain respondents (such as those at the refineries) were aware of policies pertaining to a 'Fatal accident frequent rate (FAFR)', they were not sure how this was communicated to managers in emerging country subsidiaries. FAFR policies had almost certainly played no role in setting maintenance intervention activities or functional testing. The logic for determining the frequency of failure finding tasks described earlier in this paper was certainly not followed. Corporate respondents generally believed that safety and protection verification had to meet local regulatory requirements. Managers contended that it was preferable for (relatively inexperienced) local managers to adhere strictly to local regulations rather than explore other ways of determining appropriate functional testing. Few respondents were aware of 'scientific' ways of determining the frequency of failure finding tasks.

The need for collaboration amongst different departments and categories of worker is stressed in all accident reports. In subsidiary plants the importance of enhancing unstructured relations between disciplines (Pilar et al., 2010) was acknowledged, but respondents saw this as a local issue. The desirability of appropriate management of protective systems derived from formalised processes for resolving well-structured problems was recognised. However, respondents again claimed that group problem solving, decision-making autonomy (Haas, 2006) and independence lay with local managers who should encourage an open debate regarding safety.

Local regulations differed for each country. The frequency of checking the functionality of protection was typically based on past practice, perceptions of what regulators would consider acceptable, and supplier recommendations (but respondents apparently did not heed the warning of Moubray (2001) that supplier recommendations invariably fail to take the operating context into account). Corporate managers did not formally investigate the effectiveness or technical feasibility of failure finding tasks, nor had they probed a broader range of solutions (Macher, 2006) that might have arisen if different approaches to failure finding had been considered. They did not see it as their duty to explore skills and technologies, and learn about ‘critical unknowns’ (Govindarajan and Trimble, 2004).

Corporate staff had set up databases which should be used in decision-making. This would equate to the ‘safety capital’ (stock of knowledge and skills) suggested by Nuñez and Villanueva (2011). Local managers would have to make stringent efforts to report failure finding inspections and remedial action. However, the extent to which databases were used was a local matter.

Respondents were ambivalent about installing greater levels of automation and independent protection (highlighted particularly in the Buncefield accident report): automation simplified operator tasks, but complex automation systems presented formidable challenges to inexperienced maintenance teams. A fully integrated protection system had the advantage that in the event of a failure, the system should ‘manage’ the failure, not requiring remedial action from unskilled operators. However, respondents questioned whether an independent protection system could be operated manually in an emergency situation. This illustrates the contention by Sagan (1993) that benefits of advanced systems may be compromised by the complexity they introduce, and aggravated by the difficulties in assimilating additional knowledge.

CONCLUDING REMARKS AND AREAS FOR FURTHER RESEARCH

This paper set out to investigate how corporate managers view the management of safety and protection in their emerging country subsidiaries. The issues raised in the research were derived from recommendations made in the ConocoPhillips, BP Texas Refinery and Buncefield accident reports.

The physical distance between corporate managers and emerging country subsidiaries presents difficulties in imposing management discipline, but even greater are the cultural and intellectual differences. Lengthening and more complex supply chains add a further dimension that is not easy to oversee.

While verification of protection (failure finding tasks, albeit at arbitrary frequencies) was essential, hidden functions were apparently not treated differently from other items of plant. This is cause for concern as the failure of protective devices can have catastrophic consequences in the event of a multiple failure (as testified by the Buncefield explosion). There was little appreciation by respondents of the methodology for determining failure finding tasks on the basis of an acceptable policy for a multiple failure, and then using databases to establish how often protection would be called upon to prevent the multiple failure (alarmingly, this is seldom well understood in developed countries). In this type of situation, which is common even in developed countries, Moubray (1998: 12) states “This lack of awareness and attention means that most of the protective devices in industry – our last line of protection when things go wrong – are maintained poorly or not at all”.

Broader management issues which the literature describes as ‘competence traps’ pose a further threat to safe operations. While corporate managers claimed to appreciate the need for changes in the management of protective devices, they did not institute policies that obliged local managers to explore beyond a firm's existing sources of knowledge.

In a developing country context (Nigeria), Adebiyi and Charles-Owaba (2009) report that human factors, inadequate maintenance of facilities and the working environment contribute to unsafe practices and accidents. It is indeed precisely these issues that corporate managers delegate to local staff. The emerging country context presents difficulties and challenges to firms operating in high risk industries because of inadequately qualified and experienced workers. This is not the place to debate the merits of the use of local staff in emerging countries, but it is a reality which firms must address. Tensions between expatriate and local staff are bound to lead to difficulties in the working environment characterised by resistance to change, a lack of trust, motivation, and so on (which were significant contributors to the management deficiencies encountered in the BP Texas plant despite its relatively uniform 'American' workforce and culture). Acceptance of risk as a fact of life detracts from efforts to reduce process risk. While multinational firms offer safety training to local employees, respondents in this research were unable to provide convincing evidence of its effectiveness, or reassurance of the competence of local managers.

The corporate managers interviewed emphasised the need for rigorous management of safety and protection in their subsidiaries. This was to be expected: managers naturally support safe operating practices. Respondents displayed a distressing degree of complacency, reflecting closely the attitudes that prevailed before the ConocoPhillips, BP Texas and Buncefield accidents. The essential belief was that engineers and managers in the multinational corporate office should provide a safely designed plant. All operational matters were the responsibility of local managers.

There is a need to develop theory that enhances operational safety and environmental integrity, particularly as high reliability organisations operate in countries across the globe, and failures are not constrained to one country or the immediate vicinity. Despite stringent regulations, the ConocoPhillips, BP and Buncefield incidents occurred in developed countries. The research is an initial step in seeking to understand how much more likely is it that such events will happen in parts of the world with limited technical expertise and less strictly enforced safety and environmental laws. Further research will investigate the perceptions of local managers, supervisors and operators regarding safety, protection and environmental integrity. The almost 'default' division of responsibility between corporate and local managers is not as clear as the respondents in this research have suggested. It is understandable that adherence to corporate safety policies and observance of local regulations are best delegated to local site managers. However, multinational firms still retain overall responsibility for safety and environmental integrity. There is therefore no room for complacency. High risk organisations need to be vigilant in addressing the demands of local regulatory documents, but they also need to ensure that internationally safety requirements are respected. Research needs to study how duties and obligations are best apportioned, particularly as catastrophic consequences will affect an entire multinational organisation.

At the time of writing, an explosion occurred at a Venezuelan refinery (25 August 2012), killing 48 people. While it is too early to draw any conclusions about the cause of this accident, comments have appeared in the press (Todayonline) which are uncannily similar to the situations that led to the ConocoPhillips, BP Texas and Buncefield accidents. Strong fumes were coming from the refinery several hours before the explosion and a gas leak went undetected for several hours; there was no alarm (the enquiry will certainly ask whether this was because a gas detector – a hidden function – was not operational). A resident claimed that people were not worried because they had smelled such odours before. It was reported that at least two dozen incidents had been reported at the refinery complex since 2003, including smaller fires and power outages. He was quoted as saying “We know the risks of living beside a refinery … accidents in recent years have been very frequent” (an enquiry will investigate whether this is the type of ‘tolerance’ that was exposed after the BP Texas refinery accident). An observer suggested a lack of safety related planning and behaviour throughout the Venezuelan complex, and emphasised that safety is not only about equipment and maintenance but requires attention being paid to processes and behaviours.

These comments in no way attribute blame and suggest where faults lay, but they remind us that the lessons of ConocoPhillips, BP Texas and Buncefield have yet to be learned in all high risk installations. The respondents in this research did not project a reassuring vision that devastating accidents in their organisations will not occur.

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Models of Supply Chain Portfolio for Industrial Risk Management

Hiroshi Katayama
Department of Industrial and Management Systems Engineering,
Faculty of Science and Engineering, Waseda University, Japan.
e-mail: kata@kata.mgmt.waseda.ac.jp

Abstract: Having had many catastrophic phenomena occurred recent years over the world, supply chain is widely recognised one most important but fragile infrastructure that generates large scale industrial malfunction once tragedy occurs. This paper proposes some supply chain design models for balancing such risk and worth built in its structure through extension of conventional portfolio model. Application to industries such as car manufacturing, electric power service and natural gas import is also examined.

Keywords: Supply Chain Portfolio, Robust Operation, Industrial Parts, Car Assembler, Tire Supplier, Electric Power Supply, Natural Gas Procurement, Disaster Management, Sensitivity Analysis, Multi-objective Optimization.

1. Introduction

Many catastrophic phenomena occurred over the world recent years such as catastrophic earthquakes, large scale floods, countries' economic disasters, political collisions among nations. These tragedies cause malfunction of local industrial activities and, as operations spatially diverge with mutual linkage in terms of supply/delivery network, effects rapidly transfer through out this globe. A typical example is the case of big earthquake in eastern Japan last year, and it caused disastrous damages on Japanese industrial as well as social supply chains. This misfortune suggests that supply chain is one most important but fragile infrastructure that generates large scale industrial malfunction once this sort of event has happened. Therefore, it is crucial to develop the way of recovery or aversion of supply chain disruption.

There are two countermeasures for disasters. One is reactive countermeasure, which is one of the strength of Japanese manufacturing industries. In fact, when the earthquake hit eastern Japan on March 11th, 2011, of which the scale has never been experienced before, many manufacturing factories recovered in a few months with their power of resilient management (Katayama *et al*, 2011). The other is proactive countermeasure which must be taken in the design stage of supply network. In this case, not only the way to averse the risk but also effective usual operation must be taken into account. Needless to say, this consideration is more important than the former, as it mitigates damages.

Focussing on the latter sense of value, this paper proposes some supply chain design models for balancing such risk and worth built in its structure through extension of conventional portfolio model (Hibiki, 2001; Luenberger *et al*, 2002).

2. Supply Chain Portfolio Model for Industrial Parts Procurement

Logistics operation among assemblers and suppliers has two aspects, pull operation and push operation (Katayama, 2009) as described in the left and right hand of Figure 1.

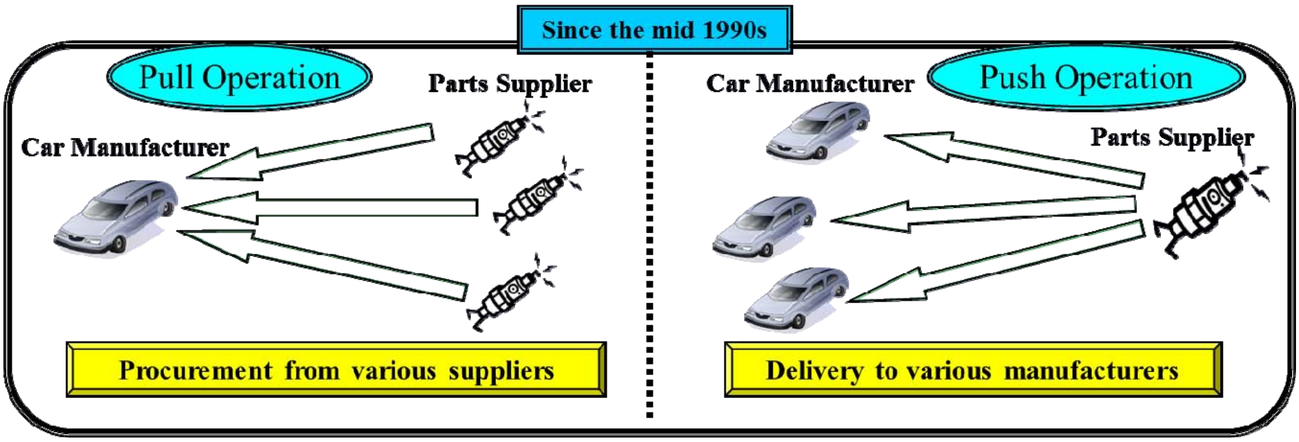

Figure 1. Structure of Car Parts Supply Chain (Isahaya *et al*, 2009; Isahaya *et al*, 2010)

Pull operation is conducted by procurement-side, *i. e.* assembler-side decision model. In this case, problem is to determine how many parts must be procured from which suppliers (Uchiyamada, 2008). These are represented by procurement rates (weighting factors) from each supplier. On the other hand, push operation is activated by delivery-side. So, there could be supplier-side decision model, which is to determine how many parts can be delivered to which assemblers. These are represented by delivery rates (weighting factors) to each assembler. The way of determining these rates is proposed through procurement/delivery portfolio consideration.

2.1. Contract Establishment Model for Stable Procurement with Designed Risk

In this section, contract establishment model among assemblers and suppliers is discussed. For realising risk aversive stable manufacturing, car assemblers, prior to the occurrences of disastrous situation, can consider to establish portfolio-like contracts with various suppliers, which are making the same parts. Suppliers, the counterparts, can also devote to examine making contracts with various assemblers for pursuing stable trade with low risk such as stoppage of purchase from assemblers.

A multi-objective stochastic optimization problem, with which both car manufacturers and parts suppliers cope, was formulated (Isahaya *et al*., 2011) in terms of pull model and push model respectively. Essence of these models is described as follows.

(1) Mathematical Formulation

<Pull Model>

Objective Function 1:

Maximization of the average volume of tires procured from tire factories

$$\text{Max} \qquad J_1 = \frac{1}{T}\sum_{t \in T} B_t \tag{1}$$

Objective Function 2:

Minimization of the variance of expected number of tires procured from tire factories

Min $J_2 = \sigma_b{}^2$ (2)

Constraints:

$$B_t = \sum_{i=1}^{n} b_{i,t} \tag{3}$$

$$b_{t,t} = v_i \hat{S}_{i,t} \tag{4}$$

$$0 \le v_i \le v_{\max} \tag{5}$$

$$\sigma_b{}^2 = \frac{\sum_{t \in T} \left(B_t - \frac{1}{T} \sum_{t \in T} B_t \right)^2}{T} \tag{6}$$

<Notation>

T :Number of periods in time horizon

Bt :Total planned number of tires procured by the specific car factory from tire factory i (i=1,…,n) in period t

bi,t :Planned number of tires procured by the specific car factory from tire factory i in period t

$\hat{S}_{i,t}$:Expected number of tires produced by tire factory i in period t

Vi :Delivery ratio of tire factory i (Portfolio control parameters)

$Vmax$:Maximum supply ratio of tire factory i

$\sigma_b{}^2$:Variance of expected number of tires procured in each period throughout considered time horizon

<Push Model>

Objective Function 1:

Maximization of the average volume of tires delivered to car factories

Max $J_3 = \frac{1}{T} \sum_{t \in T} Q_t$ (7)

Objective Function 2:

Minimization of the variance of tires delivered to car factories

Min $J_4 = \sigma_q{}^2$ (8)

Constraints:

$$Q_t = \sum_{j=1}^{n} q_{j,t} \tag{9}$$

$$q_{j,t} = u_j \hat{D}_{j,t} \tag{10}$$

$$0 \le u_j \le u_{\max} \tag{11}$$

$$\sigma_q{}^2 = \frac{\sum_{t\in T}\left(Q_t - \frac{1}{T}\sum_{t\in T} Q_t\right)^2}{T} \tag{12}$$

<Notation>

T :Number of periods in time horizon

Q_t :Total planned number of tires delivered from specific tire factory to car factory j (j=1,…,n) in period t

$q_{j,t}$:Planned number of tires delivered from the specific tire factory to car factory j in period t

$\hat{D}_{j,t}$:Expected number of tires delivered to car factory j in period t

Uj :Delivery ratio of car factory j (Portfolio control parameters)

U_{max} :Maximum delivery ratio of car factory j

$\sigma_q{}^2$:Standard deviation of expected number of tires delivered in each period throughout considered time horizon

(2) Example Result (Pull Model Case)

A result of pull model case, *i.e.* procurement network design, is introduced in this section. Focused area for this problem is mid-area of mainland Japan called Kwansai-Chubu area as shown in Figure 2. Here, car assembly factories (11 sites) and tire manufacturing factories (6 sites) are considered as down-stream and up-stream manufacturers.

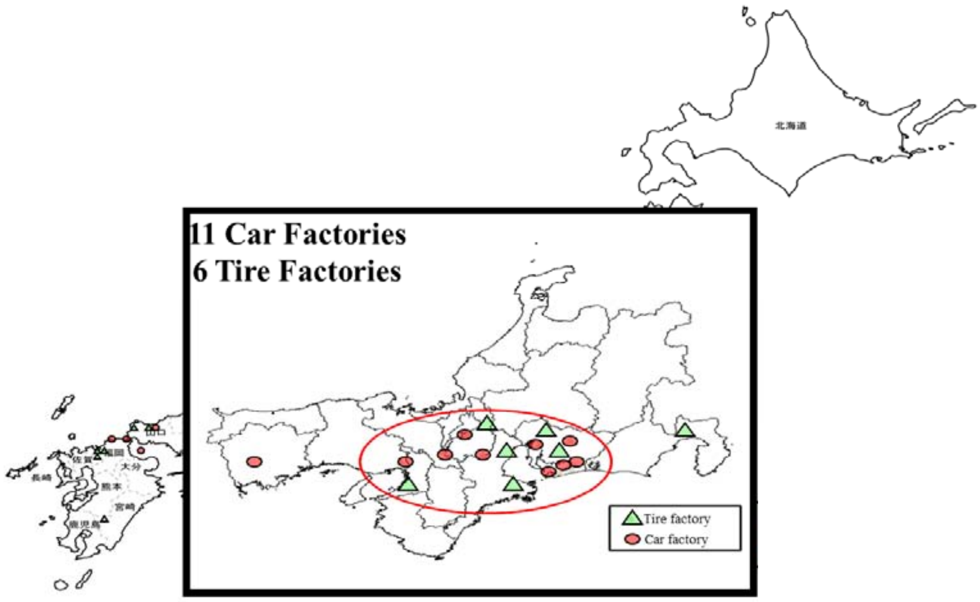

Figure 2. Area in Consideration

Portfolio characteristics of this problem under the supposed business situation, *i. e.* average procurement level and standard deviation of number of tires, is obtained by modifying weighting factors mentioned earlier. Rational trade plan, *i. e.* Pareto optimal solution of portfolio problem, is derived by a smart numerical calculation method (Katayama *et al*, 1988; Fonseca *et al*, 1993) as shown in Figure 3.

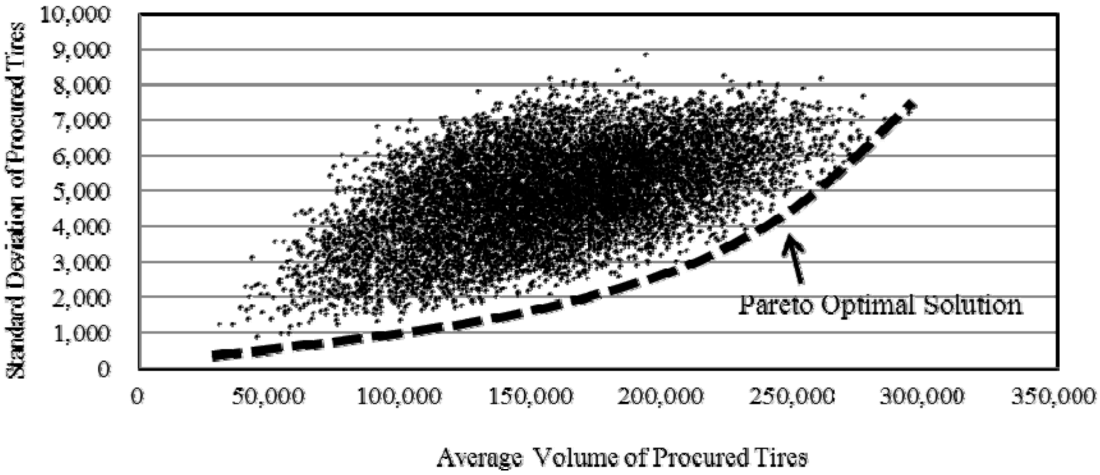

Figure 3. Characteristics of Portfolio Selection and Pareto Optimal Solution

Table 1. Procurement Rates for Pareto Optimal Solution

Low Risk Low Return → High Risk High Return

Standard Deviation		Average Volume	Tires Procured from (Tire Company, Factory)					
Range	Measured Value		(B,H)	(Y,M)	(Y,S)	(S,N)	(S,I)	(T,K)
500-1000	2173.5	59732	0.117	0.472	0.053	0.197	0.133	0.035
1001-1500	5142.7	113586	0.233	0.618	0.043	0.209	0.359	0.447
1501-2000	6861.6	152642	0.307	0.800	0.166	0.203	0.501	0.609
2001-2500	7735.0	189670	0.358	0.989	0.197	0.477	0.681	0.602
2501-3000	10171.4	222026	0.459	0.998	0.183	0.495	0.847	0.731
3001-3500	10418.6	240345	0.472	0.975	0.269	0.899	0.512	0.697
3501-4000	11753.5	266490	0.509	0.990	0.455	0.744	0.632	0.995
4001-4500	13272.3	290674	0.587	0.964	0.527	0.885	0.972	0.752
4501-5000	16450.1	322186	0.722	0.961	0.514	0.842	0.671	0.994
5001-5500	17731.1	340182	0.778	0.947	0.528	0.870	0.955	0.944
5501-6000	17163.3	347398	0.737	0.877	0.804	0.980	0.907	0.944
6001-6500	19216.2	368324	0.840	0.953	0.794	0.929	0.869	0.921
6501-7000	21758.3	398775	0.957	0.988	0.835	0.976	0.802	0.918
7001-7500	22660.4	406790	0.989	0.981	0.939	0.812	0.892	0.963

Push model case can be also analysed by the same way and resultant knowledge might be applicable to the supply-side dominated market. In reality, however, mixture of these cases is popular and to cope with this situation, application of Nash equilibrium model for mathematical formulation is hopeful direction.

2.2. Sensitivity Analysis on Portfolio Performance

In this section, the affects of change of business variables/parameters on Pareto optimal solution derived in the previous section is examined by sensitivity analysis.

(1) Procedure

General procedure of sensitivity analysis is that, Step 1a: Perturbing the values of system variables and/or parameters that affects system performance and then Step 2a: Evaluating system performance. Reverse analysis is also often required, namely, Step 1b: Setting desirable system performance then Step 2b: Identifying the variables and/or parameters and their values that realise desirable performance.

Here, consider the case of manufacturing malfunction of a tire factory as change of business variables, *i. e.* production volume, and examine its affect on Pareto optimal solution, to which the former type analysis is suitable (Ishikawa *et al.*, 2012a-b). The way to extract trade-off relation between average (return) and standard deviation (risk) is the same as described in section 2.1.

(2) Example Result (Pull Model Case)

Figure 4 illustrates Pareto optimal solution (before) and perturbed trade-off relation (after). It is immediately noticed that supplier malfunction brings huge negative affect on procurement performance.

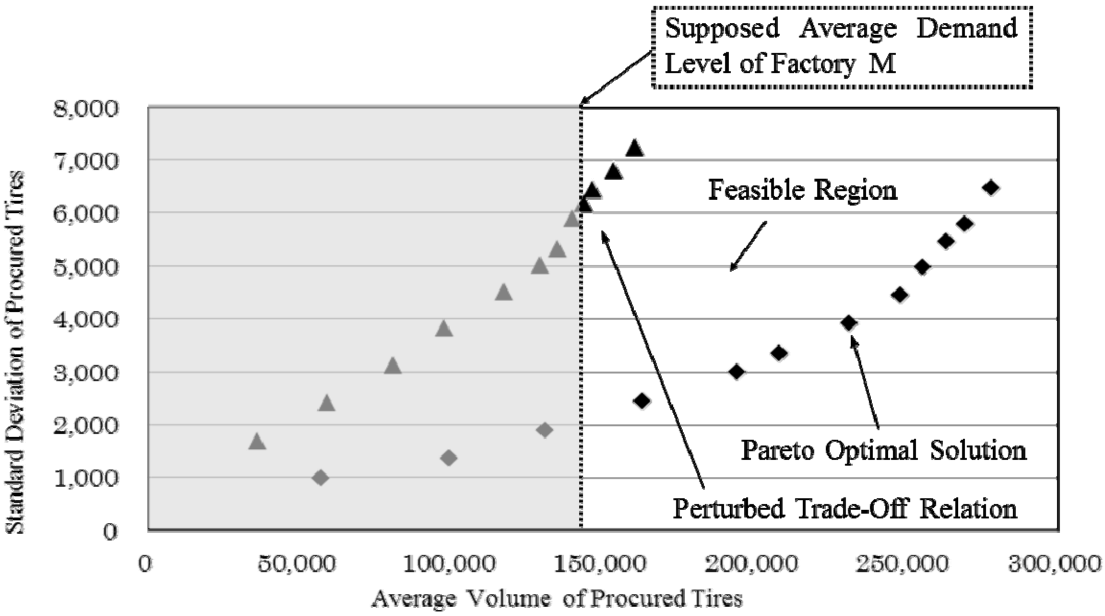

Figure 4. Affect on Procurement Performance caused by malfunction of a supplier factory

3. Supply Chain Portfolio Model for Electric Power Supply

In this chapter, portfolio design problem for electric power supply is discussed. The problem is that how to allocate electricity generation rate to various generation methods for meeting total electricity demand level with stable supply. Resource-wise group of these methods are roughly five categories such as Water, Nuclear, LNG, Coal & Oil and Wind & Solar (NEDO HP, 2012). Therefore, problem has to have pull-type structure.

(1) Mathematical Formulation

In this model, estimated average and standard deviation of electric power supply level are regarded as return and risk respectively in conventional portfolio theory. And different from conventional portfolio theory, specific conditional constraints, such as total electric power supply must be greater or equal to total demand, have to be taken into account. Formulation of the objective functions are given in (13a) or (13b), and (14) followed by constraints given in (15)-(18).

Objective Function 1a: Maximising total supply capability in case that the demand level of electric power is unknown.

$$\text{Max} \quad J_1 = \frac{1}{T}\sum_{t \in T} Q_t \tag{13a}$$

Actually, in this case, electric power companies have to make effort to provide as much as possible capability to meet unknown demand.

Objective Function 1b: Minimising difference between supply and demand levels in case that the demand level of electric power is given.

$$\text{Min} \quad J_1 = \frac{1}{T}\sum_{t \in T} (Q_t - P_t) \tag{13b}$$

Objective Function 2: Minimising fluctuation of electric power generation for stable supply

$$\text{Min} \quad J_2 = \sqrt{\frac{\sum_{t \in T} \left(Q_t - \overline{Q}\right)^2}{T}} \tag{14}$$

Constraints:

$$Q_t = \sum_{i=1}^{n} q_{i,t} \tag{15}$$

$$q_{i,t} = u_{i,t}\hat{D}_{i,t} \tag{16}$$

$$0 \le u_{i,t} \le 1 \tag{17}$$

$$P_t \le Q_t \tag{18}$$

<Notation>

T :Time Horizon
Q_t :Total Electric Power Generation in *t*-th Term
$q_{i,t}$:Electric Power Generation by Generation System *i* in *t*-th Term
$\hat{D}_{i,t}$:Capacity of Generation System *i* in *t*-th Term
P_t :Total Electric Power Demand in *t*-th Term
$u_{i,t}$:Operation Rate of Generation System *i* in *t*-th Term (Control Parameter)

(2) Example Result

Example portfolio design problem for demand-satisfying stable electricity supply is picked up through investigation of electric power company C (Chubu Electric Company HP, 2012), a representative company in this business sector in Japan. Table 2 and 3 respectively show the trend of flow rate as an example data, which is a key indicator affecting performance of hydroelectric power generation, and average and fluctuation of power supply level of each category of generation system.

Table 2. Trend of Flow Rate in August in Japan (Past 10 years) [%](Company C)

Fiscal Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Flow Rate	80.1	143.5	88.8	85.9	90.5	85.8	66.9	117.7	109.1	120.5

Table 3. Approximate Average and Standard Deviation of Power Supply by Each Generation System Estimated from Past 10 Years Record [Billion kWh/Year] (Company C)

Generation System / Total Generation	Water	Nuclear	LNG	Coal & Oil	Wind & Solar	Total
Average	11.9	21.5	63.8	41.7	0.46	139
Standard Deviation	4.6	22.9	23.0	9.3	1.9	12.5

Based on these data, possible portfolio selection is derived by generating various weighting factors through random numbers and applying them to the data described in Table 3. Figure 5 illustrates the result of this examination. Where, minimum expected electricity demand is supposed and indicated by the vertical line.

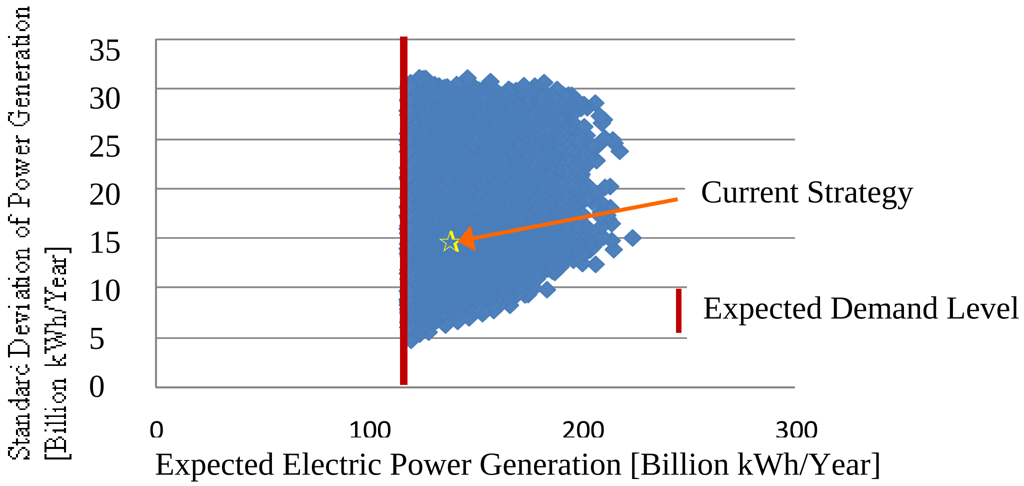

Figure 5. Example Result of Portfolio Analysis

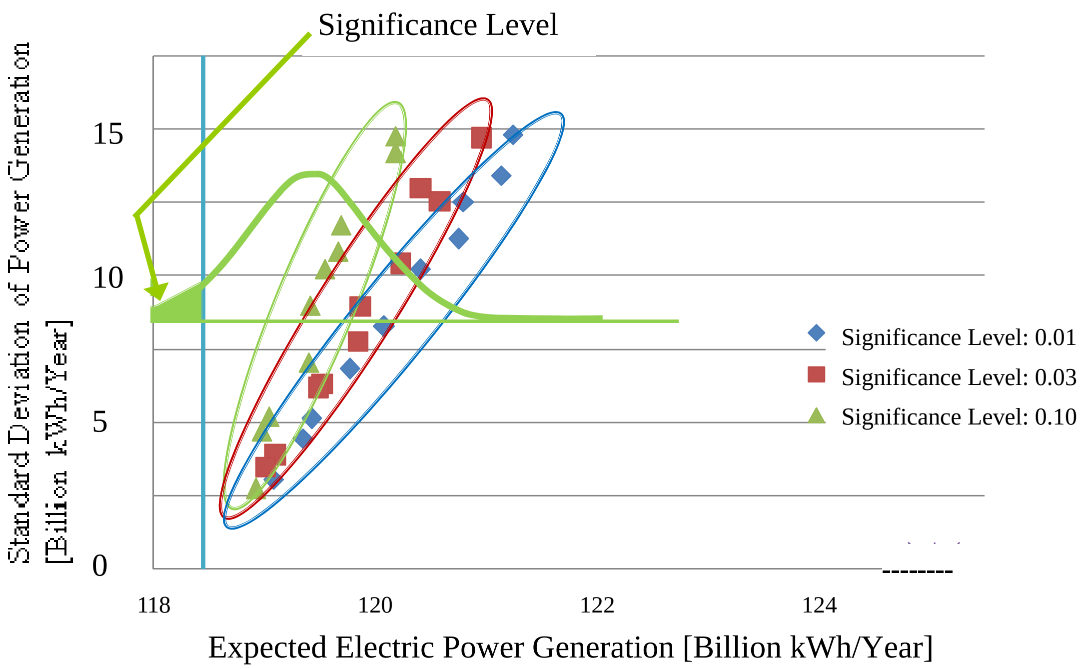

Figure 6. PARETO Optimal Solution for Each Significance Level

Figure 6 shows Pareto optimal solutions derived from the data in Figure 5. Each of these trade-off characteristics is the case of significance level 0.01, 0.03 and 0.10 respectively. Where, significance level means the probability of the event occurs that the case total electricity supplied is not able to meet demand level.

4. Supply Chain Portfolio Model for Natural Gas Procurement

This chapter discusses a portfolio design problem for natural gas procurement by import activities. The problem is to design the way of enough resource procurement for domestic industrial consumption with low volume fluctuation. For meeting this requirement, the problem how to allocate procurement rates in the context of long-term contract to various resource-supplying countries must be examined. Procurement rate from natural gas spot market must be also considered as temporary procurement is always necessary for over-demand with stable supply.

(1) Mathematical Formulation

Formulation of the objective functions are given in (19) and (20) followed by constraints given in (21)-(23).

Objective Function 1: Maximising total procurement volume.

$$\text{Max} \quad J_1 = \frac{1}{T}\sum_{t \in T} C_t \tag{19}$$

In this case, simple objective function such as formula (19) can be suitable as the industrial demand level is unknown and this resource might be imported as much as possible due to poor energy resources in Japan.

Objective Function 2: Minimising fluctuation of imported volume for stable supply.

$$\text{Min} \quad J_2 = \sqrt{\frac{\sum_{t \in T}\left[C_t - \frac{1}{T}\sum_{t \in T} C_t\right]^2}{T}} \tag{20}$$

Constraints:

$$C_t = \sum_{i=1}^{n} v_i \times A_{i,t} + u_t \times B_{ave} \tag{21}$$

$$v_{i,\min} \le v_i \le v_{i,\max} \tag{22}$$

$$u_{\min} \le u_t \le u_{\max} \tag{23}$$

<Notation>

T : Time Horizon

$A_{i,t}$: Average Procurement Level from Supplier Country i (i=1,…,n) in t-th Term by Long-term Contract

B_{ave} : Average Procurement Level by Spot Contract

C_t : Total Procurement Level in t-th Term

v_i : Procurement Rate from Long-term Contract Supplier Country *i* (Control Parameter)

$v_{i,\min}$: Lower Bound of Procurement Rate from Long-term Contract Supplier Country *i*

$v_{i,\max}$:Upper Bound of Procurement Rate from Long-term Contract Supplier Country *i*

u_t : Procurement Rate by Spot Contract (Control Parameter)

$u_{\min}$: Lower Bound of Procurement Rate by Spot Contract

$u_{\max}$: Upper Bound of Procurement Rate by Spot Contract

(2) Example Result

Example portfolio design problem for volume-keeping stable import is picked up through investigation of a power company T, a representative company in this business sector in Japan. Table 4 shows the trend of natural gas procurement in the past ten years. Where, import from 6 resource-supplying countries is experienced in this time horizon.

Table 4. Natural Gas Procurement in the Past Ten Years [10 Thousand Ton/Year] (Company T)

Country / Fiscal Year	Procurement by Long-term Contract						Procurement by Spot Contract
	Malaysia	Australia	Brunei	Indonesia	Qatar	USA	
2000	330.8	78.0	98.0	78.2	36.1	28.8	0.0
2001	340.3	95.2	120.0	83.9	30.0	28.9	0.0
2002	341.5	133.9	123.7	83.7	36.0	32.2	0.0
2003	378.4	164.7	133.0	83.9	47.5	31.0	12.7
2004	399.8	219.7	126.9	78.4	41.8	30.3	0.0
2005	381.6	305.8	125.2	72.9	45.9	31.2	11.8
2006	330.9	339.5	151.4	62.6	59.8	28.1	46.9
2007	376.7	328.9	140.5	74.0	71.5	19.4	76.3
2008	448.2	284.7	125.7	74.2	63.1	17.6	102.7
2009	427.4	241.6	116.6	73.0	29.7	14.1	52.3
Average	375.6	219.2	126.1	76.5	46.1	26.2	30.3
Standard Deviation	38.7	91.8	13.5	6.3	13.7	6.2	35.3

Based on the model described in the formulation and the data above, two investigations were performed, which are evaluation of past ten year procurement strategy (Case 1) and derivation of future procurement policy (Case 2).

Case 1 is that using average and standard deviation of the data during the year 200 and 2009, possible portfolio selections are generated and extract Pareto solution. Case 2 is that disposing the data in Table 4 and using maximum production capability of each resource-supplying country (Nishiwaki, 2010), possible portfolio selections and extracted Pareto solution are obtained. Obtained result of each case is illustrated in Figure 7 and 8 respectively.

<Case 1>

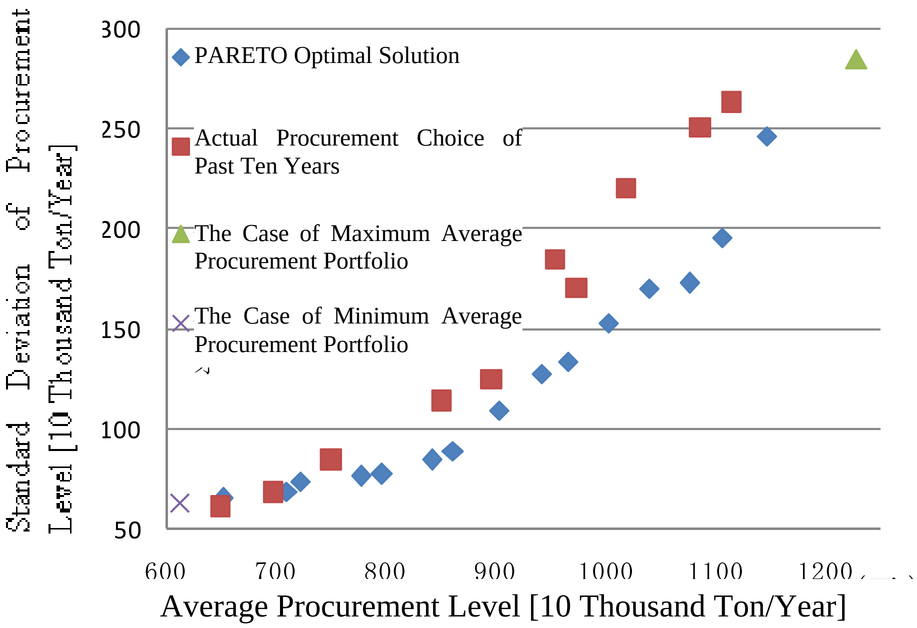

Figure 7. Result of Portfolio Analysis (Case 1)

Where, $v_{i,\min}$, $u_{\min}$: Minimum Level in the Past Ten Years

$v_{i,\max}$, $u_{\max}$: Maximum Level in the Past Ten Years

<Case 2>

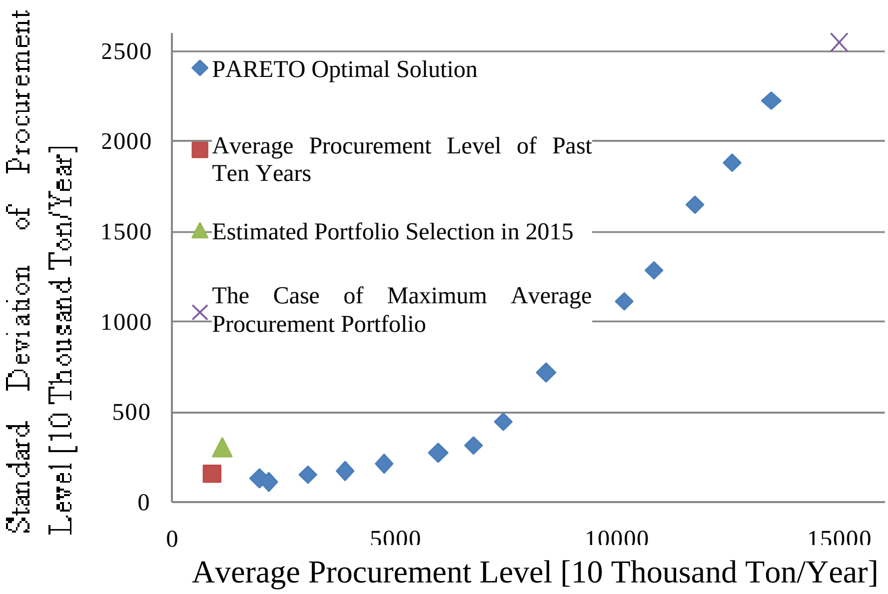

Figure 8. Result of Portfolio Analysis (Case 2)

Where, $v_{i,\min}$, $u_{\min}$: Zero Level

$v_{i,\max}$, $u_{\max}$: Annual Productive Capacity of Country i, Maximum Procurable Level in Spot Market

5. Concluding Remarks

This paper proposes some supply chain design models for balancing risk and worth built in its structure through extension of conventional portfolio model. Three cases, *i. e.* supply/delivery network design for car industry, design of electric power generation/supply system and design of natural gas procurement system through import were examined as applications of this idea to industrial risk management.

For possible extension of this research might be further application to supply network with different structure such as to multi-stage supply chain of car industry including final assembler and various level of tier suppliers.

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Hiroshi Katayama is the third generation professor managing operations and production management laboratory at the Department of Industrial and Management Systems Engineering, Faculty of Science and Engineering, Waseda University, where he received BS, MS and Dr. of Engineering degrees. His current research interests are manufacturing strategy, lean/agile manufacturing, continuous improvement methodologies, international logistics systems, technology management, etc. He is currently head of department of his organisation, chairperson of The International Federation for Logistics Systems (IFLS), vice chairperson of The Japan Society of Logistics Systems (JSLS) and official assessor of TPM (Total Productive Maintenance and Management) Scheme.

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Quality Risk Management in Global Supply Networks: An Agent-Based Approach

Johannes Book[1]; Mukesh Kumar[2]; Gisela Lanza[1]; Jag Srai[2]
[1]Institute of Production Science (wbk)
KIT - Karlsruhe Institute of Technology, Kaiserstraße 12, 76131 Karlsruhe, Germany
[2]Institute for Manufacturing (IfM)
University of Cambridge, Cambridge, UK
johannes.book@kit.edu

Abstract
This paper presents an agent-based risk management approach to manage quality risks in global supply networks. The presented methodology blends qualitative and quantitative approaches to the exploration of quality risks in global supply networks by incorporating case study and agent-based modelling methodologies. Manufacturing companies are becoming part of global fragmented supply networks due to the increasing operational specialisation. One threat in these multiple actor networks is the risk that product quality standards are not maintained. The quantification and mitigation of this risk is theoretically and practically challenging due to the special characteristics of supply networks like varied objectives of participating actors or decentralised network governance. A two-step methodology has been developed to identify and evaluate the quality risks and then evaluate the effectiveness of possible mitigation measures. This approach is based on an agent-based simulation model that simulates the impact of quality risks and the acceptance of mitigation measures.

Key words: *Supply chain risk, quality management, quality risk, quality control strategies, agent-based simulation, and manufacturing networks.*

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1. Introduction

Organizations are challenged by assessment and mitigation of quality risk, induced by longer and wider supply networks with more diverse actors. For manufacturing companies it is highly important to control their supply networks with regard to quality. Recent examples of possible effects of supply chain originated quality risk in the automobile sector even have reached the public media (see Table 1), though many other industries are facing the same risk as well.

Several factors contribute to an increasing importance of quality risk management in supply networks. On the one hand, the on-going trend towards specialization and concentration on core competences decreases the in-house production depth of manufacturing companies and leads to a reduction of direct influence on quality characteristics of a product. On the other hand, the diversity of companies in many supply networks has increased due to globalization and integration of abroad suppliers, i.e. from low-cost countries (Weiler et al. 2011). Suppliers from low cost countries often show less awareness of quality and high variation of product characteristics (e.g. measures, tolerances, etc.). Additionally, these suppliers often have different and, in many cases, stronger monetary focused objectives. Diversity may also be increased by cooperation of organizations from different industry sectors like the automobile and the electronic sector.

Table 1. Examples of supplier originated quality issues and their consequences in industry companies

Company	**Case description**	**Root cause**	**Consequences**
Volkswagen AG (Schaal 2012)	Defective timing chains on 1.4 litre gasoline engines	Process deviations at a supplier due to worn out stamping tools	Repair cost; potential image loss
Daimler AG & Delphi Corporation (Hamprecht 2009)	Defective diesel fuel injectors in 2009	Deviations in production processes which could not be identified by the implemented inspections.	Call-back of more than 4500 engines for repair; Dissatisfaction of customers due to decreased usability and long waiting times; production stops
Toyota Motor Corporation (TMC) & CTS (Toyota 2011; Focus 2010)	In the year 2010 Toyota had to call back 4 million cars due to potential malfunction of the accelerator pedal.	Insufficient robustness of product design and potentially variations in production processes	Call-back of 4 million cars; image loss

A supply network consist of different companies, where each company has its own objectives and acts autonomously, hence there is a crucial difference between the hierarchy-based management of processes within an organization and that of supply chains (Tapiero & Kogan 2007). Furthermore, the prediction of a supply network's behaviour is complex due to the interdependence of actions between the actors (Witthaut & Hellingrath 2009). Since each supply chain has its own structure and consists of diverse actors with individual objectives, universal management approaches are difficult to establish or apply (Möller 2006). Therefore an effective analysis and management of supply networks should consider the companies' individual objectives as well as the specific network configuration. To do this, firstly a product's quality characteristics, which have high significance and contain a high financial risk if quality requirements are not met, must be identified. Secondly, suitable quality risk mitigation measures need to be found. There exist several internal and external quality risk management and mitigation measures. For a company, the quality of supplied parts can be controlled by incoming inspections, quality data analysis or exchange as well as management or development of suppliers for example. For first-tier suppliers, possible measures for quality management can be the supplier´s development, risk-sharing (i.e. via contracts), incentives, or company integration. Typical measures of supplier development and support are auditing, employee training, or technical support (Geiger & Kotte 2008). Which of these measures is most suitable and effective with respect to a company's specific situation and its individual supply network needs to be identified though.

In summary, it can be said that, since the behavior of the supply networks' actors varies and suitability of risk mitigation measures depends of the network configuration, quality risk mitigation strategies in supply networks need to be evaluated and identified individually. This

paper addresses this topic and an evaluation method using an agent-based approach is proposed and presented.
The paper is structured as follows. In chapter 2 relevant fields in literature are reviewed. Chapter 3 points out the existing research gap which is addressed with the methodology presented in chapter 4. Content of chapter 5 is an identification and analysis of influencing factors for quality risk in supply networks. The results are used to derive a framework for a model of quality in supply networks presented in chapter 6. In chapter 7 the understanding model of quality in supply networks is described in detail. A blend of the model with literature from the field of qualitative risk management is content of chapter 8. In chapter 9 and 10 an agent-based model for simulation of quality risk in supply networks is presented. Results of a preliminary implementation sample are shown in chapter 11. Chapter 12 is used for evaluation and discussion of the papers content. The paper is summarized in chapter 13.

2. Literature review

Within this section relevant definitions and perspectives from several fields of research are presented. The research fields in regard are institutional economics and supply network theory, management approaches of supplier management and supply chain management, quality management, risk management as well as the field of agent-based modelling and simulation.

2.1 Global supply networks

Networks are described as polycentric groupings of companies, exhibiting a varying degree of strategic leadership which depends on their characteristic power relationships (J. Sydow 1999). Supply networks are a hybrid form of cooperation between market and hierarchy, characterized by relatively stable cooperative relationships between legally independent but economically interdependent companies (Jörg Sydow 1992). In practice, organizations, as part of a network, are legally independent units and has economic interdependencies (Jörg Sydow 1992; Przygodda 2004).
The description of the characteristics of supply networks, its companies or organizational units is focus and motivation of various theoretical approaches originating from several disciplines and perspectives. Depending on the goal and the background of the researching party, the developed theories exhibit various covered topics, research focusses and degrees of abstraction (Wolf 2011). Approaches from organizational theory include game theory, contingency theory, system theory or the resource dependence theory. Transaction cost theory and the principal agent approach both stem from new institutional economics.

Coordination of supply networks

According to Malone and Crowston, coordination means management of dependencies (Malone & Crowston 1994). Kaipia defines that “the purpose of coordination is to achieve collectively goals that individual actors cannot meet" (Kaipia 2007). Determinants that influence the coordination of value-added networks are (De Miroschedji 2002; Kaipia 2007; Walther 2010):

- power relationships, interdependency and autonomy of decision
- exchange of information
- trust between the actors

Some of the coordination mechanisms in supply networks are (De Miroschedji 2002; Kaipia 2007; Walther 2010):

- instruments to increase interdependency

    - price changes
    - incentives
    - sanctions
    - contracts
- instruments to influence trust and reputation
- instruments to improve information exchange
    - administrative control
    - instructions, routines
    - measures for information exchange (e.g. by using IT technology)

2.2 Management approaches for supply networks

In the following three topics from practical oriented management of supply networks are described. These are the fields of supplier management, normally performed by the purchasing department, and supply chain management, a more strategic oriented field with a more holistic focus on several suppliers in the supply network, that in larger organizations even gets assigned to a dedicated department. The third field is quality management with a special focus on its function to control supply material and external processes.

2.2.1 Supplier management

Supplier management is described as market-oriented planning, management and control of individual supplier-customer relationships (Arnold et al. 2008).
In literature there are various categorizations of the activities in supplier management. In the following, an overview according to the approaches of Becker, Melzer-Ridinger und Arnold is given (Becker 2006; Melzer-Ridinger 2007; Large 2006):

- *Supplier selection:* identification of new suppliers on the basis of requirement criteria.
- *Negotiation:* contractual definition of conditions, delivery terms and aspects of cooperation.
- *Supplier progression:* uses measures of supplier development, albeit they are used prior to a fixed supply relationship.
- *Supplier integration:* includes all activities concerning the optimization of interfaces, aligning of systems or transferring work packages of product development.
- *Direct supplier development:* if a customer pursues direct supplier development, this leads to specific investments in the supplier and to direct interference of the customer with the supplier's processes.
- *Indirect supplier development:* the customer is a passive actor; no direct investments in the supplier are made by the customer.
- *Supplier management:* the general task of supplier management is to align supply relationships anew, if these are differing from the original objectives. Used measures may range from regulations and directives (indirect supplier development) to contractual renegotiations and contractual changes.
- *Increase of the attractiveness of collaboration:* Measures to improve a customer's attractiveness may lead to improved means of managing a supplier as well as increasing his motivation.
- *Supplier relation care (supplier partnership):* Supplier relation care mainly refers to the improvement of a supply relationship's interpersonal aspects. This may be done e.g. by

objectivity and honesty during meetings, compliance to obligations, avoiding undue pressure on prices and by giving feedback on offers.

- *Supplier controlling (supplier assessment):* regular assessment of suppliers e.g. via key performance indicators or audits, is a necessary tool for an early identification of and reaction to deviations and poor performance.
- *Supplier acquisition:* One of the last options is to take over the supplier. Supplier acquisition especially improves the possibilities of influencing and designing processes.
- *Change of Supplier:* Another way to avoid problems in the collaboration is changing suppliers.
- *Insourcing:* Besides supplier acquisition, insourcing is a way to gain high influence on production design and control.
- *Termination of supply relationship:* The termination of the supply relationship is the last possible step in collaboration. The consequences of the termination are determining the possible influence within the supply relationship.

2.2.2 Supply chain management (supply network management)

Supply chain management is an established expression in literature and therefore is used in this section, while the understanding of the phrase “supply chain” is equivalent to “supply network” within this paper.

Supply chain management is meant to design the physical material and goods flow within and between companies as well as the associated tasks. The goal is to ensure an error-free, robust, fast and economic supply of the customer (Melzer-Ridinger 2007). It is thus based on the idea of integration of business activities along the value chain in order to efficiently meet the customer’s needs (Kummer & Grün 2007). The measures to achieve the stated objectives of supply chain management are diverse and comprehensive. Measures in supply chain management may be categories as follows (Melzer-Ridinger 2007):

- *Compression:* Refers on the one hand, to the reduction of nodes in the network by reducing the number of stages in the supply network. On the other hand, it may also mean the reduction of the distance between the different actors.
- *Cooperation:* The partners in a supply network aspire to use economies of scope by collaborating in specific fields.
- *Virtualization:* The term “virtual company” denotes a temporary fusion of core competencies of various companies. This structure appears to the customer as a unit though having no legal or organizational conjunctions.
- *Standardization:* Forming standardized modules facilitates data exchange within the supply network as well as reducing the variety of parts.
- *Integration:* Integration denotes a formation of alliances. This can take place horizontally, along the supply chain, as well as vertically, on one stage.
- *Customer focus:* The activities in a supply chain should ideally be based on the customer. In this case, activities are only initiated in case a specific customer need exists. This reduces stock and thus costs while increasing flexibility.
- *Optimization:* The optimizations are often based on mathematical and analytical models and are intended to reduce informational barriers between the partners.

To manage whole supply networks, there are postulations to establish comprehensive target systems for entire networks (Winkler 2006). In this context, approaches towards an expansion of the balanced scorecard methodology are presented (Richert 2006; Brewer & Speh 2000; Bhagwat & Sharma 2007).

Prerequisite of these approaches is an agreement of the actors in the supply network based on negotiations. Since real supply networks consist of individual companies with divergent and competing target systems that are only in limited direct contact with each other, a cooperative solution using the balanced scorecard approach may be difficult to implement.

2.2.3 Quality management in supply networks

A product's quality depends on the quality of its components and materials. The quality requirements on a product cannot be met if components and materials of insufficient quality are used (Bowersox et al. 2002).

Manufacturing of quality products in supply networks is the result of successfully meeting the customers' needs and demands. Quality is achieved by delivering a product with a certain functionality, which arises from a compilation of quality characteristics, to the customer at the right time, to the right place and in the right quantity. There is a connection between the two aspects of manufacturing and logistics, though the manufacturing of products and parts with good functional quality is a precondition to the punctual delivery of the finished products or assemblies (Heid 2008). In this article, the focus has been put mainly on manufacturing as an influence factor.

A company can control its supply network with respect to quality by using different measures. These measures can be distinguished in five categories: specification of product characteristics, transport conditions, quality inspections, quality management agreements (i.e. risk-sharing), and measures of supplier management (see section 2.3.1). The quality inspections can be either incoming inspections or outgoing inspections, conducted at the supplier side by the customer himself or by a third party service provider. For a company, the applicable approach for possible measures to consider all the suppliers in the supply chain is not easily identified. Several studies focus on just the analysis of individual measures from the above mentioned. Chao et al. determine the influence of risk sharing, enabled by the form of contract, and offered incentives on a value-added network's quality capability (Chao et al. 2009). Another study discusses the modelling of quality in a supply-chain on a theoretical basis and introduces examples for modelling with discrete and stochastic quantities (Batson & McGough 2007). In his thesis Durst (2011) presents an evaluation of the influence of supplier development methods on supply chain performance (Durst 2011).

Studies that evaluate the effects of strategic actions and support measures on the suppliers for specific network configurations do not exist yet. Therefore, the challenge is to develop a suitable planning support model that approaches this issue.

2.3 Risk management in supply networks

Risk can be defined as a measurable uncertainty of an event happening within a system. The consequences of the event can have positive or negative effects. Another important factor for the understanding of risk in a system are the sources or risk categories within a system (Merna & Al-Thani 2005). These sources are always system specific and change as the systems changes (Barrese & Scordis 2003; Crouhy et al. 2006; Merna & Al-Thani 2005; Miller 1992). Hence, the context is an important factor within risk management. An understanding of risk can be generated by a separation of four components:

- *Context of a risk:* the definition of a certain risk requires a defined environment, otherwise it becomes impractical.
- *Nature of a risk:* The nature of a risk can be defined by available tangible quantitative historical data. If data is available then risk is objective in nature otherwise it is subjective. The nature of risk determines the approach of risk assessment.
- *Measurable uncertainty of a risk happening:* assessment of chances of a risk materializing.
- *Measurable uncertainty of a risk impact:* assessment of impact in case a risk happens.

Since the first two of the four described components depend on the specific context, like i.e. the configuration of a supply network, risk management requires a case-specific approach.

Issues of risk management are becoming increasingly important in the supply network contexts because of the growing international concern over the consequences of unregulated risk. Although significant progress has been made in the awareness and articulation of risk related to supply, demand, supplier and procurement separately, there appears to be little evidence of systematic management of risks associated with supply chain networks and limited integration of network capabilities and risk mitigations. The following are the key limitations of existing literature on supply network risk management, summarised in Table 1.

Table 1: Research in supply network risk

Relevant academic contribution areas	**Key academic contributors from operations research**	**Key theoretical and empirical research method limitations with respect to risk and resilience**
Supply network configuration and capabilities	(Srai et al. 2010; Srai & Gregory 2008; Christopher et al. 2006)	Less importance of risk in configuration and capability research. Qualitative research has created border frameworks whereas quantitative research is too narrow to be useful in varied industrial contexts
Supply network risk	(Trkman & McCormack 2009; Schmitt & Singh 2012; C. Tang & Tomlin 2008; Christopher 2011)	Various supply network risk categorisations exist; however, a widely recognised risk categorisation doesn't exist due to varied units of analyses and research scope. Risks are not identified within the scope of materials/substances to product delivery.
Scope of supply network risk management	(Manuj & J.-T. Mentzer 2008; Manuj et al. 2009; M. Kumar & Gregory 2012b; Margerin 2012)	Mainly developed by studying few functional activities
Supply network risk management process	(Manuj & J.-T. Mentzer 2008; Sodhi et al. 2012; M. Kumar & Gregory 2012a)	Sub processes are not well defined. Appropriate risk analysis approaches are not discussed

In summary, the concept of Risk management is scattered and lacking a uniform framework and definitions. Risk is largely understood as consequences of risk and there is no agreement on risk sources. Risk management can be two sides of a coin, however, the relationship is not well understood. Limited global supply network theories have been proposed based on extensively functional and sector based investigation. Additionally there appears to be little evidence on uniform frameworks for identifying and evaluating quality related risks in supply networks quantitatively and qualitatively.

2.4 Agent-based modelling of supply networks

One suitable approach to map a network model with several target systems is the application of software agents (Macal & North 2005). In general, a software agent denotes a self-contained autonomous system that interacts with its environment and pursues its own goals. Having individual goals, an agent can derive output values based on input data from the environment by conclusions via algorithms or learning ability. The values are selected from the range of possibilities according to the optimal fulfilment of the agents' individual goals and its actual state. Software agents communicate with users or with the other agents in their environment through the exchange of messages and, in doing so, are also able to cooperate (Wooldridge 2002).

These characteristics of software agents correlate highly with supply networks' peculiarities, thus, software agents have already been employed in several ways in planning and operation support tools for supply networks (Leitao 2009). Analogous to the decentralized management of intra-site production systems through agents, agent-based systems for the operative cross-company management were developed (Stiefbold 1997; Jiao et al. 2006). Other approaches use software agents for strategic planning of supply network configurations (Akanle, O. M.; Zhang 2008). Under the concept of enterprise integration, Shen et al. summarize agent-based approaches, which use simulation to evaluate the impact of the actions of individual units of a network on the entire supply network (Shen et al. 2006).

Giannakis and Louis develop a theoretical framework for an agent-based risk management approach in demand-driven supply networks. The focus of their work is on ordering and inventory politics only. The application of quality management measures is not integrated into the model (Giannakis & Louis 2011).

In summary, agent-based modelling and optimization of supply networks allows the decision-making structures and individual target systems to be considered. Current approaches on agent-based simulation do not consider the quality aspects in operative management of supply networks.

3 Research gap

Within the literature review before it was showed that identification and mitigation of quality risk in supply networks is addressed by various disciplines. The chosen approaches maybe pragmatic or theoretic as well as on an abstract or concrete level. In this scope there are two research gaps to be identified. On the one hand it can be said, that qualitative approaches in the field of risk management need to be extended towards a quantitative analysis. On the other hand, do management approaches for supply networks, as they are applied in organizations, lack of a sufficient consideration of specific characteristics of supply networks. Accordingly, the specific configuration of individual supply networks needs to be integrated as a decision factor.

Because of the difficulty to model complex interrelations mapping a network model with several actors and decentralized decision-making using conventional modelling and optimization approaches seems unsuitable. One suitable approach is the application of software agents for modelling and simulation (Macal & North 2009).

The agent-based approach with its characteristics has the prerequisites for consideration of these influencing factors. Yet, present approaches of agent-based simulation either focus on operative planning and control or on the strategic configuration of networks.

The challenge therefore is to derive a blended approach from qualitative and quantitative research in the above mentioned fields and to implement it using agent-based modelling and simulation.

4 Approach

4.1 Goal and purpose of the approach

The goals for the development of the new approach for managing quality risk in supply networks consist of the following four parts:

a) Prediction of emerging effects of quality-related risks in supply networks
b) Identification of a methodology to identify suitable quality control strategies (consisting of a combination of risk mitigation measures) under consideration of situation-specific parameters like:
    a. Configuration of the supply network, i.e. transport distances, number of suppliers, length of the supply network etc.
    b. Individual target-systems of the supply networks' actors
    c. Existing interdependencies of the companies within the supply network
    d. Configuration of the product and the manufacturing system

4.2 Methodology

The methodology to achieve the above mentioned goals consists of the following five steps:

1) Identification of quality-related influence factors
2) Analysis of certain influence factors
3) Development of a model for understanding the interrelation of influencing factors on quality in a supply network
4) Blending of existing analysis of risk in supply networks (by (M. Kumar & Gregory 2012a)) and the developed understanding model to a cause-effect matrix of quality-related risks, by pattern matching technique with respect to model parameters.
5) Implementation of an agent-based simulation model for supply network quality risk to:
    a. Identify the relation between manufacturing and logistical quality problems of supplied parts and their effect on a company's profit as well as the existing risk.
    b. Evaluation of the applicability of alternative mitigation measures to ensure an adequate product quality and identify optimal quality control configurations.

The result of step 5 represents a two-step methodology to identify quality risks and then evaluate the effectiveness of possible mitigation measures. The method is based on an agent-based simulation model that simulates the impact of quality risks from tier-1 to tier-n suppliers of a global supply network. It provides the controllability of suppliers with the help of several risk mitigations strategies by considering their individual target systems.

5. Development of a supply network quality model

To describe the relevant processes and interdependencies within a supply network, that are influencing product quality, influencing factors are collected from literature and mapped out to a supply network quality model.

5.1 Identification of influence factors

For the identification of influencing factors on quality risk in supply networks, the research fields of supply networks, quality management and supplier management were analysed in the following categories:

- Structure: What is the preliminary structural understanding in the research area?

- Decision-making: Which guidelines are relevant for decision-making?
- Influencing-parameters: What are parameters that influence the decision-making process?
- Coordination instruments: Which instruments for coordination are named within the research field?

The identified influencing factors are shown in Table 2.

Table 2. Identification of influencing factors for quality risk management in supply networks

Category	Research field		
	Global supply networks	**Quality management in supply networks**	**Supplier management in supply networks**
Structure	Multi-actor structure with decentralized decision-making	3 perspectives on quality: • Nominal condition of product • Production of product • Actual product condition	Buyer-supplier relation
Decision taking	Target systems of actors	• Definition of quality (Achieved quality) • Quality-related costs	Strategic decisions on focal company interests
Influencing parameters	• Power balance (interdependence) • Trust • Availability of information	• Influences on quality in general – human, machine, material, method, environment, management, measurability • Decision on quality level - Interest of companies, public interests • Legal aspects • Size of quality feedback loops	Strategic importance of parts or suppliers
Coordination instruments	Instruments acting on: • Interdependence • Trust • Information sharing	• Prevention measures • Appraisal measures • Management concepts	• Supplier integration • Direct supplier development • Indirect supplier development • Controlling of suppliers • Increasing buyers attractiveness • Fostering of suppliers (relationship) • Evaluation of suppliers • Acquisition of supplier

5.2 Analysis of influence factors

To improve the understanding of further influencing factors on quality risk in supply networks the below listed influencing factors are subject of further analysis in the following:

- Quality understanding in supply networks

- Quality change root causes
- Quality risk mitigation measures
- Product-related interdependencies
- Process-related interdependencies

5.2.1 Quality understanding in supply networks

Following actual customer-centred quality definitions, quality is the fulfilment of customer requirements. In context of quality creation in supply networks, the customer requirements are not only focusing on the physical appearance of the product, but also process-related characteristics. These may be service characteristics like time and place of delivery or process-related characteristics like social standards within the manufacturing process chain (see Figure 1). Since the focus of this work is set on the creation of quality characteristics within the supply network, neither the identification of customer requirements nor the definition of quality characteristics within product design is subject of optimization.

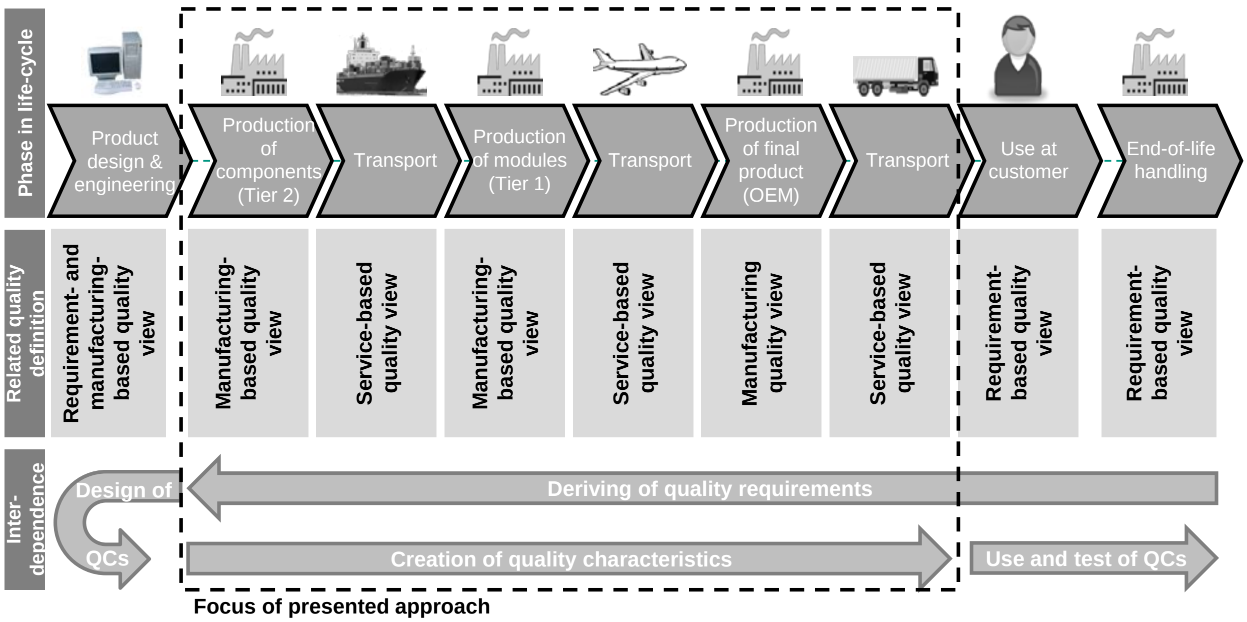

Figure 1. Quality definitions and interrelation within the supply network

As a precondition for quality management in supply networks, the customer-related quality requirements need to be translated into manufacturing and service-related quality requirements as an input value for optimization of the quality strategy (see Figure 2).

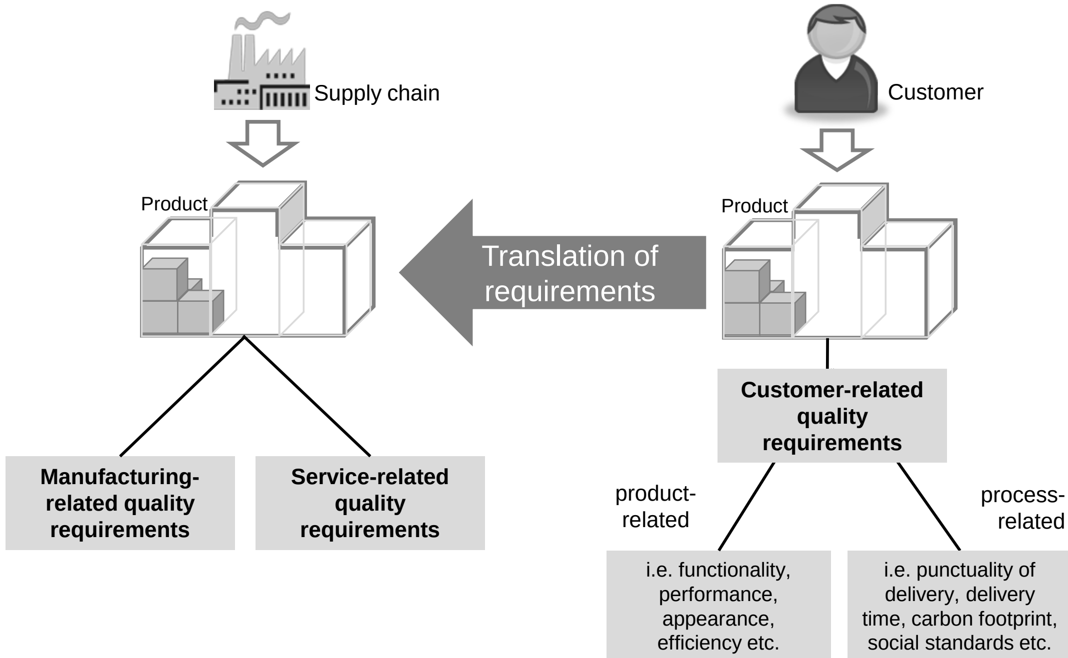

Figure 2. Quality requirements in manufacturing and use phase of the supply network

5.2.2 Quality change root causes

Basic quality management literature distinguishes 7 influencing factors on quality. These factors are the human factor, the equipment factor, the raw material factor, the methodology factor, the environment factor, the management factor as well as the measurability factor. The developed methodology in this paper separates 4 levels of supply chain itemization. Within all of these levels the 7 above mentioned influencing factors are potential root causes for product quality change. Examples for the emerging root cause effects are given within Figure 3 for all levels.

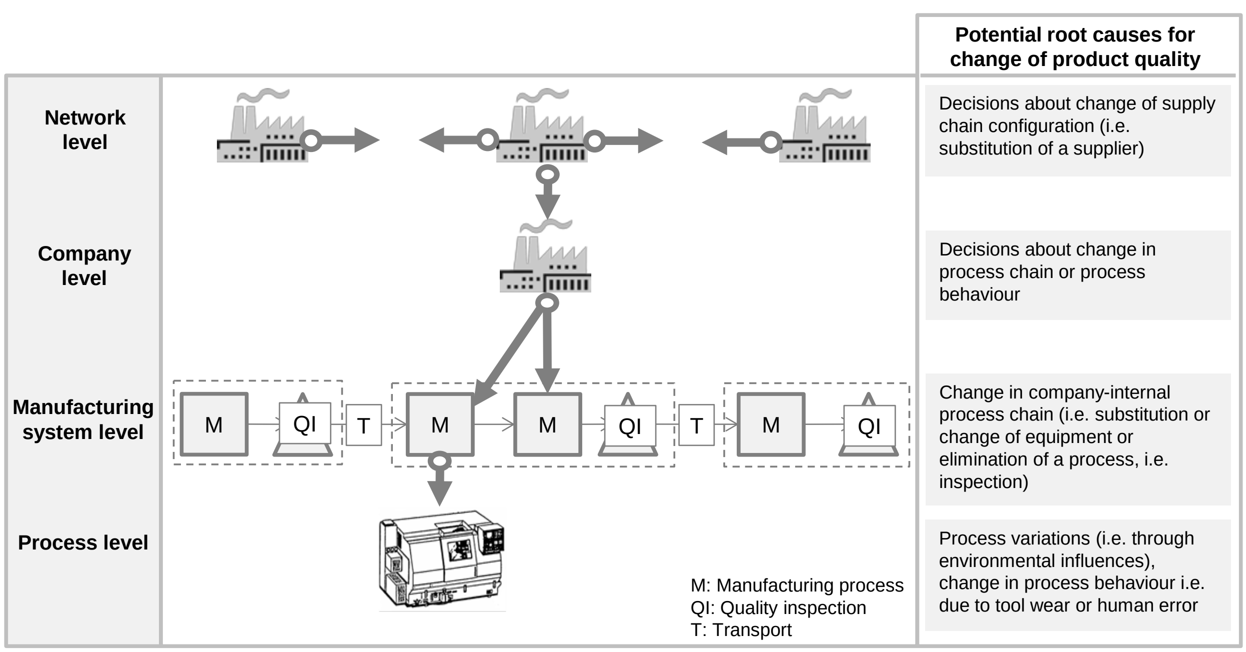

Figure 3. Potential root causes for change of product quality

5.2.3 Quality risk mitigation measures

For characterization of quality risk mitigation measures a two-step approach is chosen. In the first step categories for characterization of resulting effects and required input in case of application of various measures are derived from literature (see Figure 4). The content of the second step is a qualitative description of identified quality risk mitigation measures based on the categories defined in step one (see Table 3).

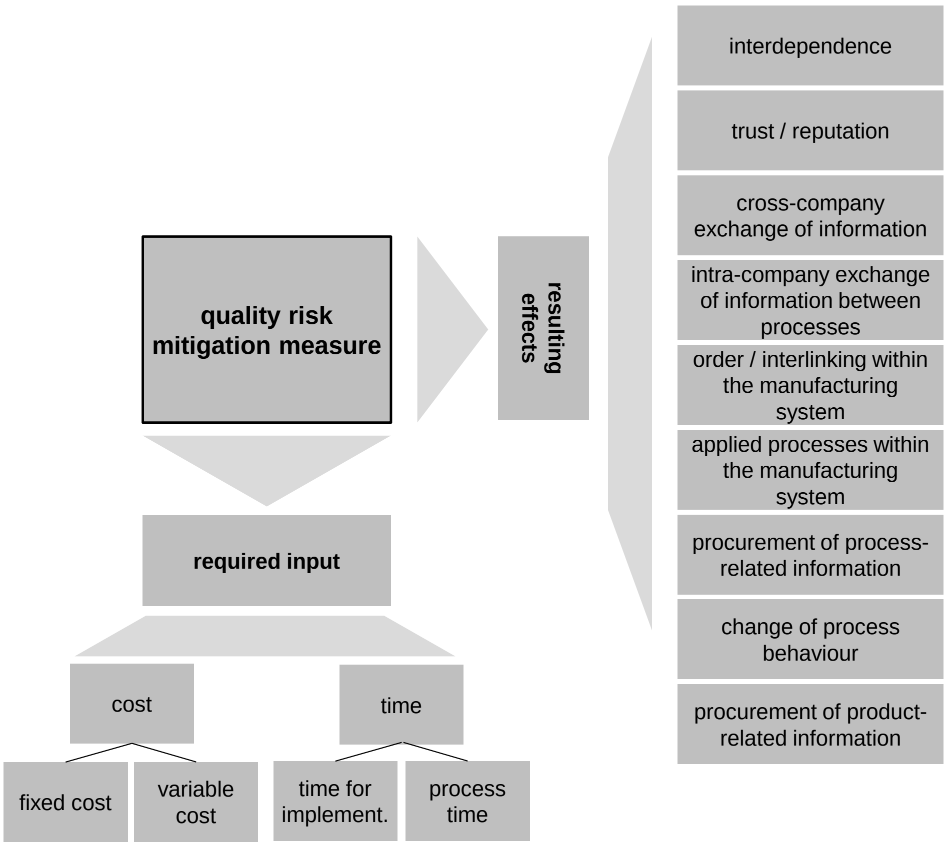

Figure 4. Characterization categories for quality risk mitigation measures

Table 3. Characterization of quality risk mitigation measures

Categories of mitigation measures			Mechanisms of quality risk mitigation measures								
Categories from the research field “supply networks”	**Categories from the research fields “supplier management” and “quality management”**	**Examples for measures**	interdependence	Trust / reputation	Cross-company exchange of management level information	Cross-company exchange of process level information	Order / interlinking within the manufacturing system	Applied processes within the manufacturing system	Procurement of process-related information	Change of process behaviour	Procurement of product-related information
Price alteration	Controlling of suppliers	• Renegotiation	●	○	○	○	○	○	○	○	○
Incentives	Indirect supplier development	• Positive incentives • Fostering of competition between suppliers • Awarding	●	○	○	○	○	○	○	○	○
Sanctions	Indirect supplier development	• Negative incentives	●	○	○	○	○	○	○	○	○
	Controlling of suppliers	• Sanctions									
Contracts	Negotiation	• Quality management agreements	●	●	○	○	○	○	○	○	○
	Fostering of suppliers (relationship)	• Long-term contracts									
Reputation	Indirect supplier development	• Awarding		●	○	○	○	○	○	○	○
Administrative control	Evaluation of suppliers	• Key performance indicators • Auditing		○	○	●	○	○	●	○	●
	Acquisition of the supplier	• Increased influence through acquisition	●	○	●	○	○	○	○	○	○
Directives, routines	Negotiation	• Technical delivery terms	○	○	●	○	●	●	○	●	○
	Indirect supplier development	• Praise or criticism • Evaluation of suppliers • Performance objectives	○	○	●	○	○	○	○	○	○
Exchange of information	Negotiation	• Technical delivery terms	○	○	●	○	○	○	○	○	○
	Supplier integration	• Knowledge transfer • Alignment of (business) processes									
	Indirect supplier development	• Praise or criticism • Evaluation of suppliers • Performance objectives									
	Evaluation of suppliers	• Auditing • Prototype testing	○	○	○	●	○	○	●	○	●
	Evaluation of suppliers	• Key performance indicators • Auditing • 8D-Reports • IT-solutions (i.e. joint database)	○	○	○	●	○	○	●	○	●
	Procurement of process-related information	• Incoming inspection • Product inspections • Process inspections (i.e. statistical process control (SPC))	○	○	○	●	○	●	●	○	●
Process improvement	Direct supplier development	• Consulting • Knowledge transfer • Transfer of specialists • Financial support	○	○	○	○	●	●	●	●	●

5.2.4 Product-related interdependencies

Quality characteristics within a product can be interlinked due to emerging characteristics like i.e. the reliability of the product. The interdependence of the characteristics is influenced by the product design. Figure 5 shows potential interdependencies for a car engine as a practical example.

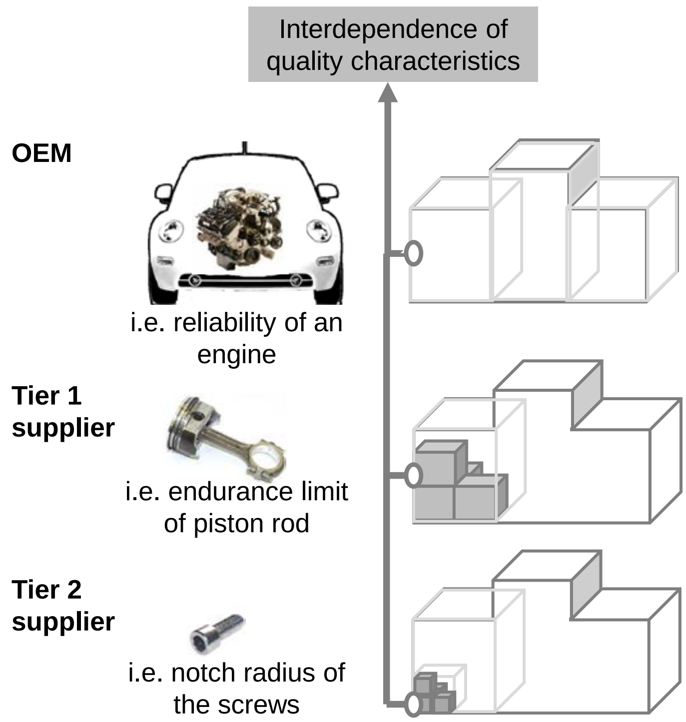

Figure 5. Interdependence of quality characteristics within a product

Decision-relevant parameters from product design perspective are (see Figure 6):

- Correlation between hierarchical characteristics
- Correlations of defect rates and probability of error occurrence
- Deriving of non-conformity cost.

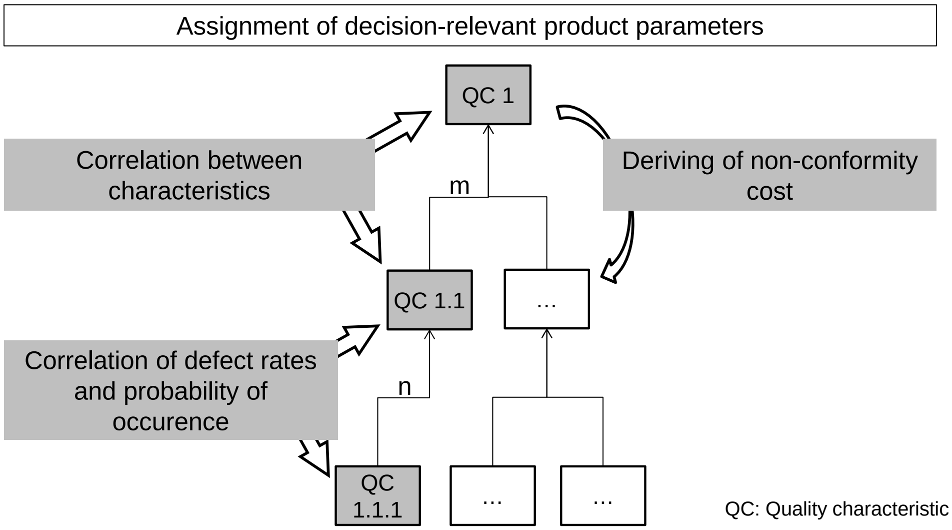

Figure 6. Assignment of decision-relevant product parameters

5.2.5 Process-related interdependencies

The production in global supply networks can be regarded as a composition of manufacturing, transport and quality inspection processes. Within this process chain, two forms of interlinking with influence on quality are to be named. On the one hand, interlinking between subsequent manufacturing processes can be existent (see Figure 7).

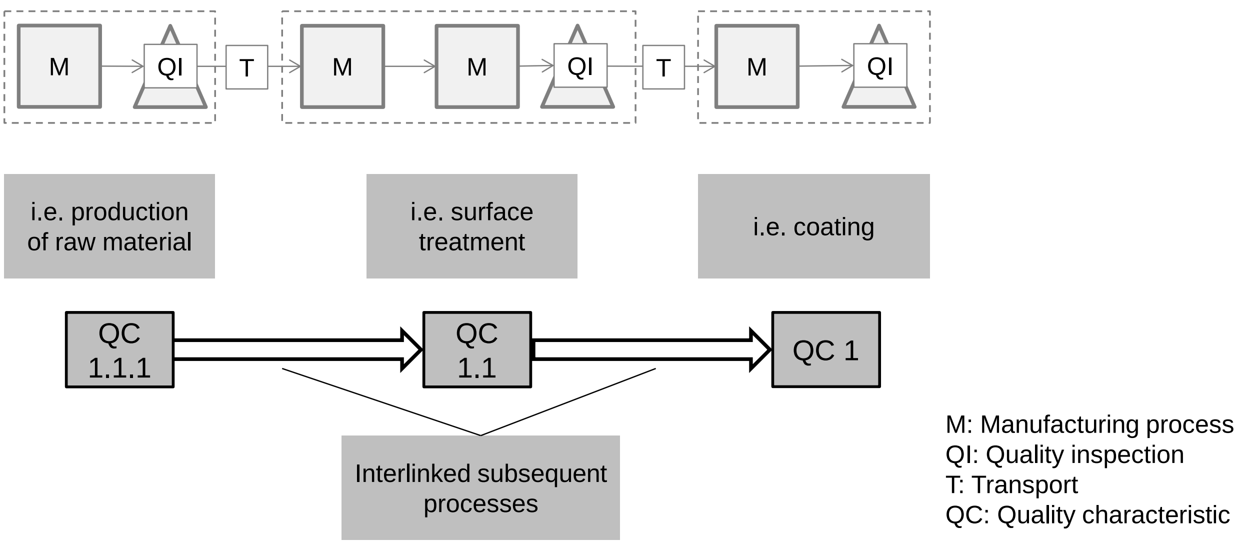

Figure 7. Interlinked subsequent processes

On the other hand, production processes and their related quality inspections can form quality feedback loops and consequently the delay between the processes leads to interlinking of subsequent products in their quality characteristic values (see Figure 8).

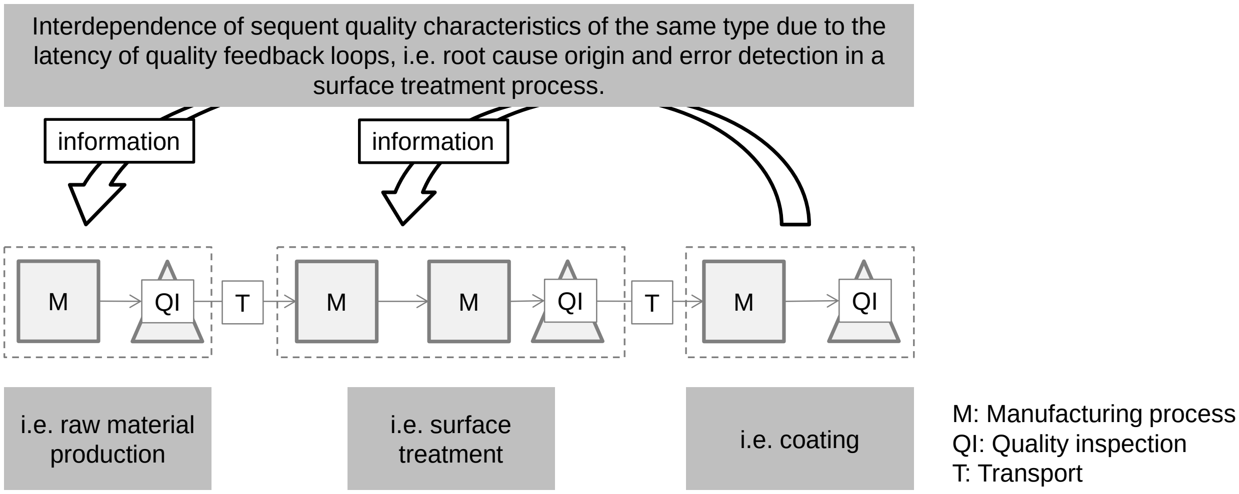

Figure 8. Interlinking through quality feedback loops

6 Framework for modelling quality risk in supply networks

Based on the influencing factors identified in section 4.1 and 4.2, a framework for a model understanding of manufacturing in supply networks under the aspect of quality and quality risk was developed (see Figure 9). The framework comprises of five black-box models and their interrelations. The derived placeholders are a central supply network model and a description model of a product in terms of quality. Furthermore, models for risk mitigation measures and quality change root causes are linked as influencing factors to the supply network model. The evaluation of the supply network performance is assigned to a model of quality understanding and non-conformity risk effects within the supply network.

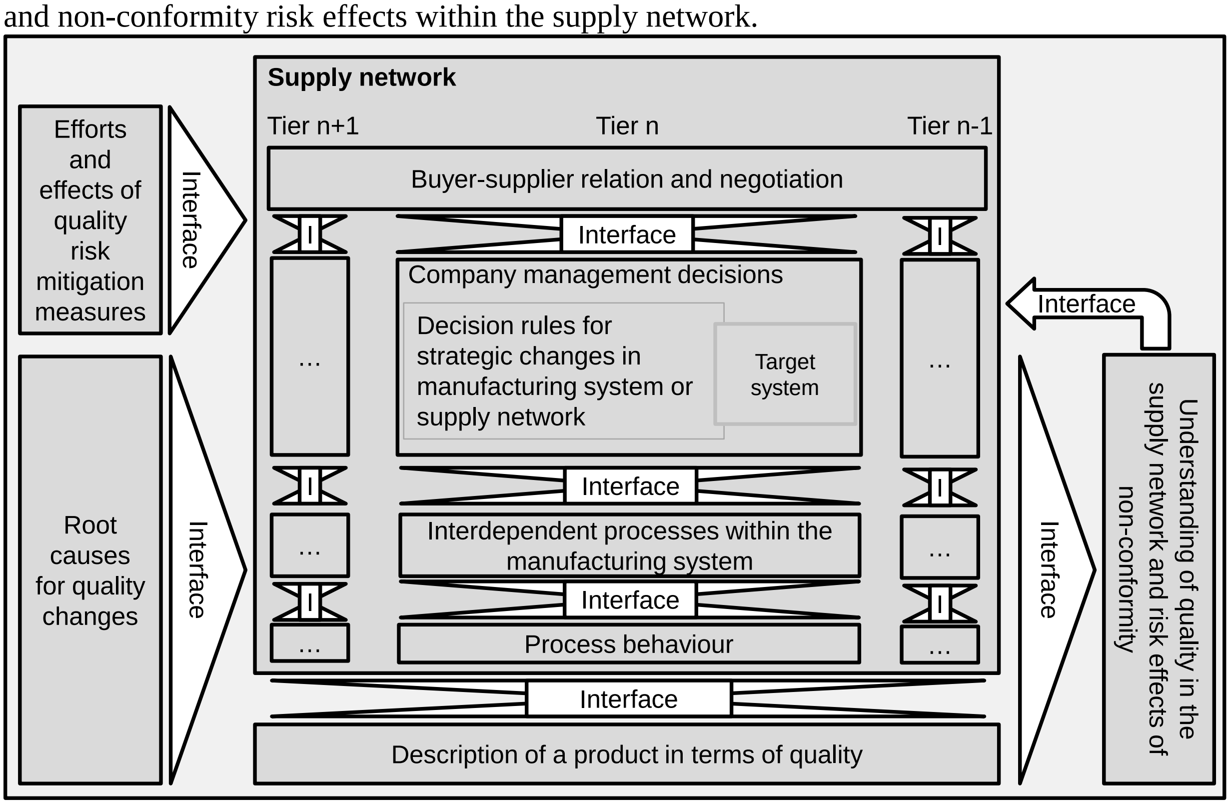

Figure 9. Derived framework for modelling quality risk in supply networks

7 Understanding model of supply network quality

The framework for modelling of quality risk in supply networks presented in section 5 is further detailed in the following chapter.

7.1 Product model

The product model describes the modelling of product and part characteristics and their creation during the production process. Therefore, a suitable solution to a simple mapping of the complex and company-individual interrelations of a product's cross-company creation process, with its composition from self-contained parts, that each have individual quality characteristics and their respective significance for the products functionality, has to be found.

The selected model (as shown in Figure 10) is set apart from the actual composition of a product. In the product model the product is regarded as a template, containing placeholders for selected, predefined quality characteristics. During a simulated cross-company production process, these quality characteristics are created and defined. Assigned to each characteristic are specifications about the value of the characteristic (specifies fulfilment of requirement), the cost of its production as well as the duration of processing.

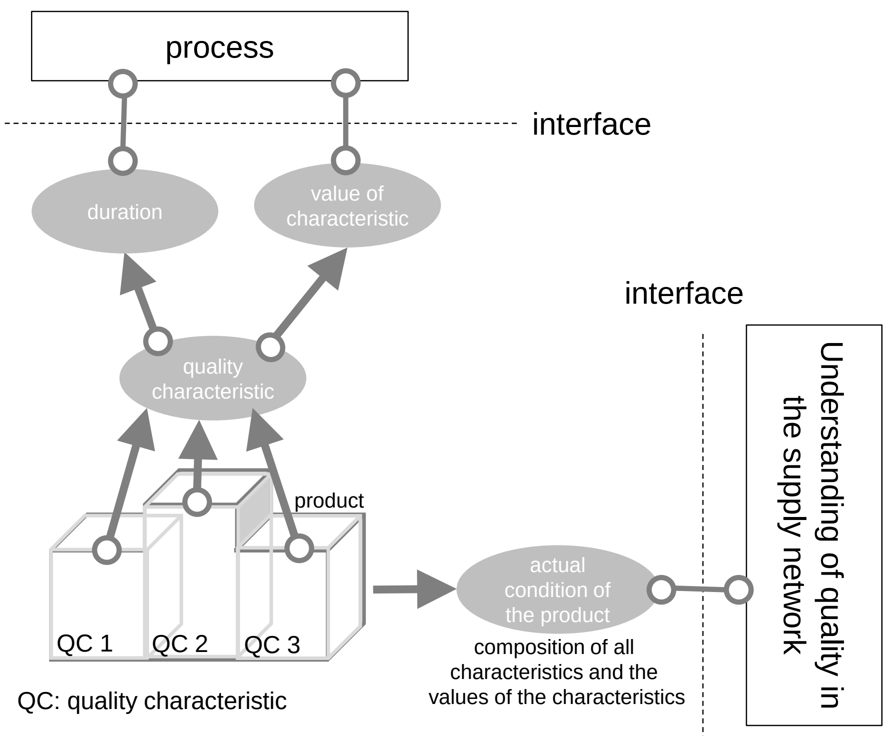

Figure 10. Model of a product in terms of quality with selected quality characteristics (QC)

7.2 Model of quality understanding

The quality understanding model (see Figure 11) is based on the customer-focused definition of quality, where quality is defined as the fulfilment of customer requirements. Therefore the achieved quality is determined by a comparison of the actual condition of a product with the customer requirements. Accordingly, non-conformity cost and information are introduced into the supply network by the final customer.

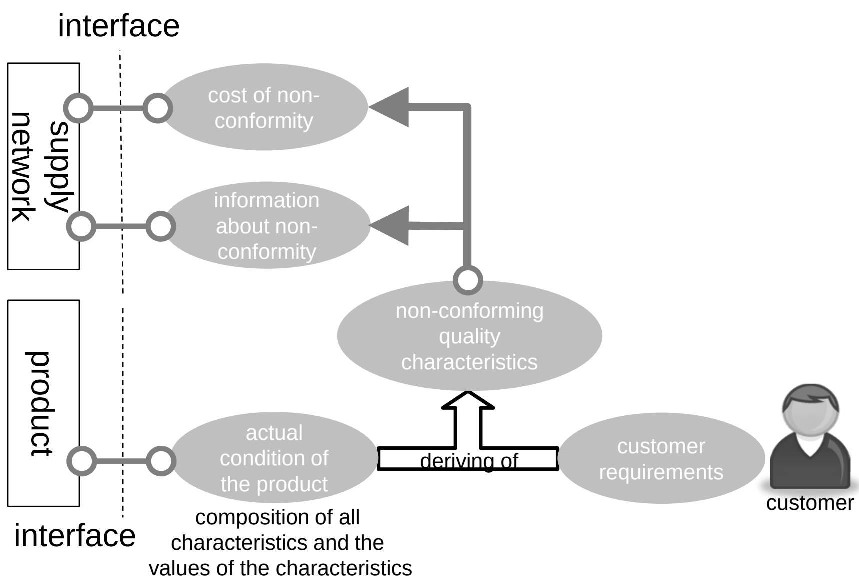

Figure 11. Model of quality understanding in a supply network

7.3 Process model

A manufacturing or transport process within a supply network is part of a manufacturing system and can be subject of improvement initiatives (see Figure 12). It is characterized by its processing time and quality capability and is the link to creation of the quality characteristics of a product.

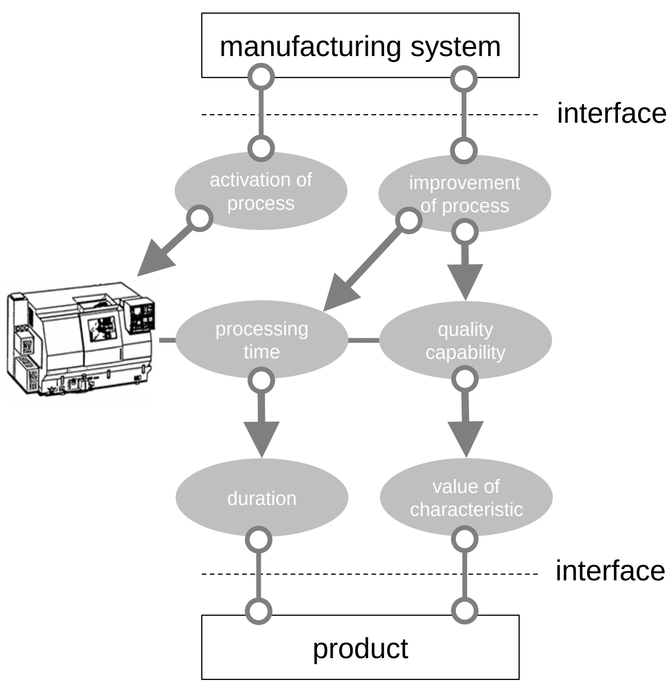

Figure 12. Process model for manufacturing or transport processes

7.4 Manufacturing system model

Content of the manufacturing system model is the configuration of the manufacturing system consisting of manufacturing, transport and quality inspection processes (see figure 13). Further interface parameters between the company level and process levels are only passed over through the manufacturing system model.

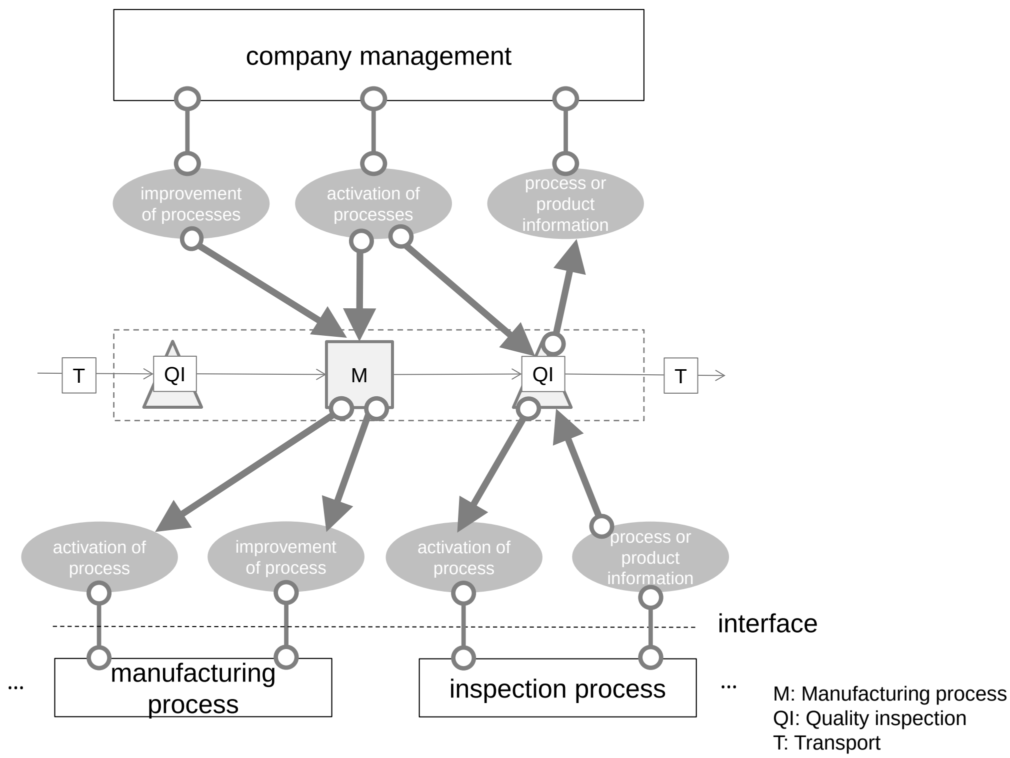

Figure 13. Manufacturing system model

7.5 Company model

The modelling of a company with regard to the attributes which are relevant for the quality control strategy is done with respect to the fact that every enterprise is a self-enclosed unit being able to make, to some degree, autonomous decisions. The company model (see figure 14) maps this characteristic in analogy to reality. Each enterprise has a central decision-making entity that makes decisions about internal changes and responsive actions to the outside, based on incoming information and requirements as well as internal data. Furthermore, under consideration of the model's goals, the product creation process is reduced to a manufacturing, transport and quality inspection processes. Attributes with relevance to quality, like process quality, can be subject to change through improvement initiatives. Besides the representation of the quality capability, the cost aspects are integrated in the model as well. Moreover, the effects and costs of process improvements induced, e.g., by supplier development measures, are mapped in the model.

Quality characteristics created by an upstream tier of the supply network (suppliers or sub-suppliers) can be examined in view of their fulfilment of quality requirements during the incoming inspection. Whether a quality characteristic should be examined is decided by the central decision-making entity based on the given data and the company's target system.

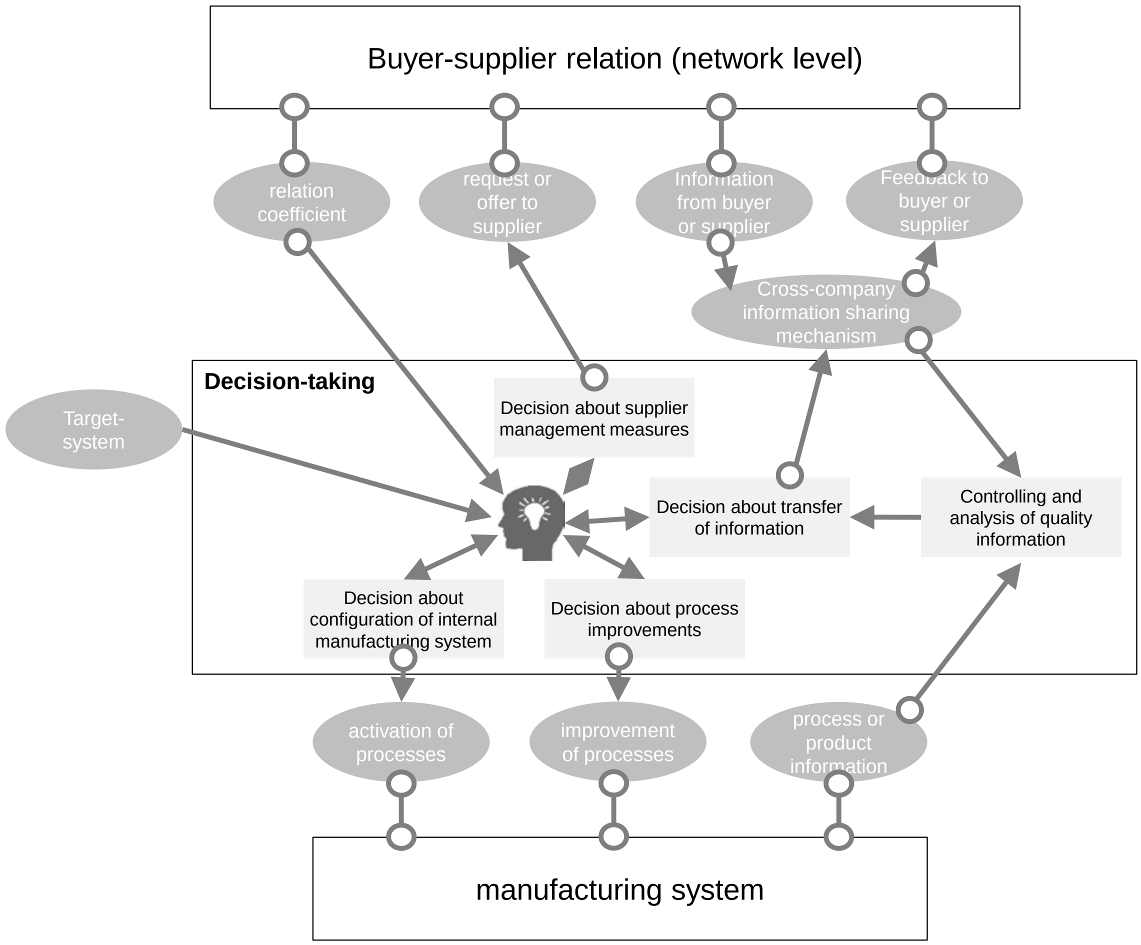

Figure 14. Company model

7.6 Buyer-supplier relationship model

In the developed simulation model, the cross-company relations in the supply network are modelled by negotiations between the enterprise entities. The model described in the following is shown in its negotiation procedure in figure 15. The negotiating approach is based on the assumption that quality demands emanate from the final customer (user) and are introduced into the supply network by him. In the example of Toyota, this would be the compensation payments on the one hand, and on the other hand, also the customers' strong claim for error-free security-relevant components in their cars. An enterprise obtains either direct or indirect knowledge of these demands and can decide on this basis which actions to take for the internal processes. Concerning characteristics that are created by suppliers, the enterprise will try to influence the suppliers in various ways. This exertion of influence is a customer demand for the supplier and the supplier has to decide about internal or external actions to fulfil this demand. Via the communication between the enterprise entities, the influence of customer demands and the corresponding actions taken by the OEMs on the supply network are modelled.

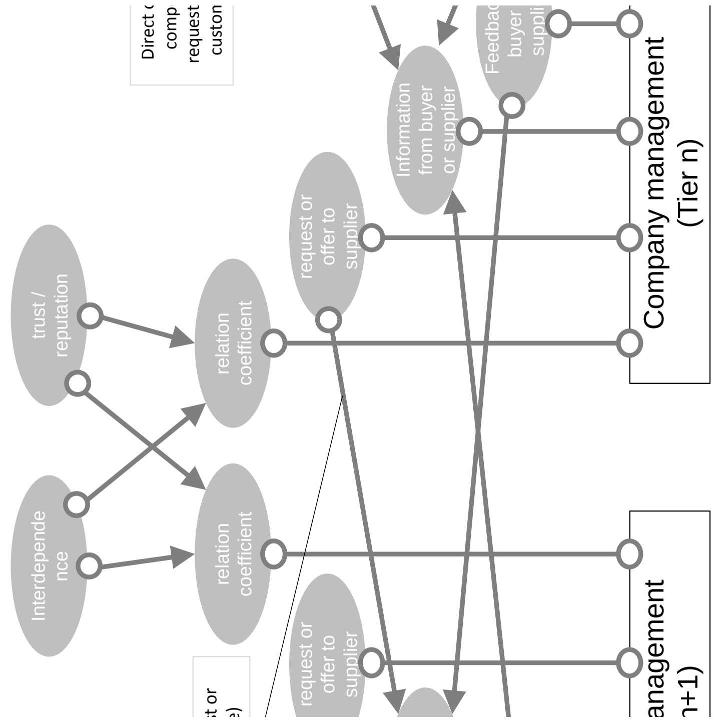

Figure 15. Model of buyer-supplier relationship (network level)

7.7 Total model

The total model (see Figure 16) links the model of the quality-relevant production processes in the supply network, signifying the material flow in direction to the final customer, with the model of the backwards oriented information flow and the actions taken, in opposite direction. These two models correlate strongly.

Figure 16. Total model

The products, manufactured in the supply network, with their specific characteristics, which are determined by the configuration of quality control and production processes at each network entity, are entirely inspected at the end of the supply network and then translated into payment demands. These demands are returned back into the supply network by the final customer. Depending on the network's configuration (e.g. interdependencies between the entities), these demands cause changes of the quality control and production processes, which again affect the characteristics of the created products.

8. Blended qualitative and quantitative risk management approach

Based on the developed model of quality risk in supply networks, a categorization of identified supply network risks has been conducted (see Figure 17 for excerpt of the complete list of risk from Kumar (M. Kumar & Gregory 2012a)). The categorization was done in the following multiple steps:

1. Identification of risks that meet either of the following categories:
   a. Risks that meet operative production in terms of time or product quality.
   b. Risks that meet customer's perception of the product (or emerging from this) and are related to manufacturing (not design of product).
2. Categorization and evaluation of the risks in above mentioned category a in the following categories and subcategories:
   a. Resulting effect
      i. Processing time
      ii. Process quality capability
   b. Place of origin in
      i. External actors
      ii. Focal company
   c. Place of origin or appearance in the company
      i. Buyer-supplier relation (network level)
      ii. Company management
      iii. Manufacturing system
      iv. Process level (manufacturing, transport or quality inspection processes)

Figure 18 shows the results of the categorization exemplarily.

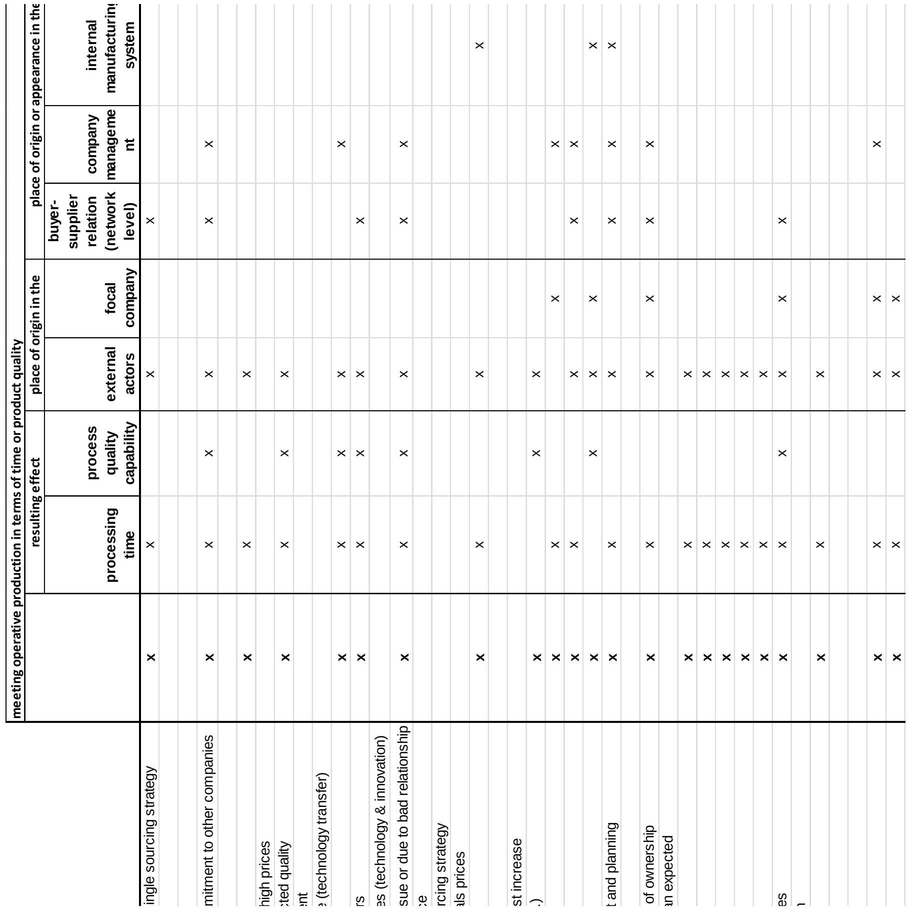

Figure 17. Categorization of supply chain risks – excerpt (based on list of Kumar (M. Kumar & Gregory 2012a))

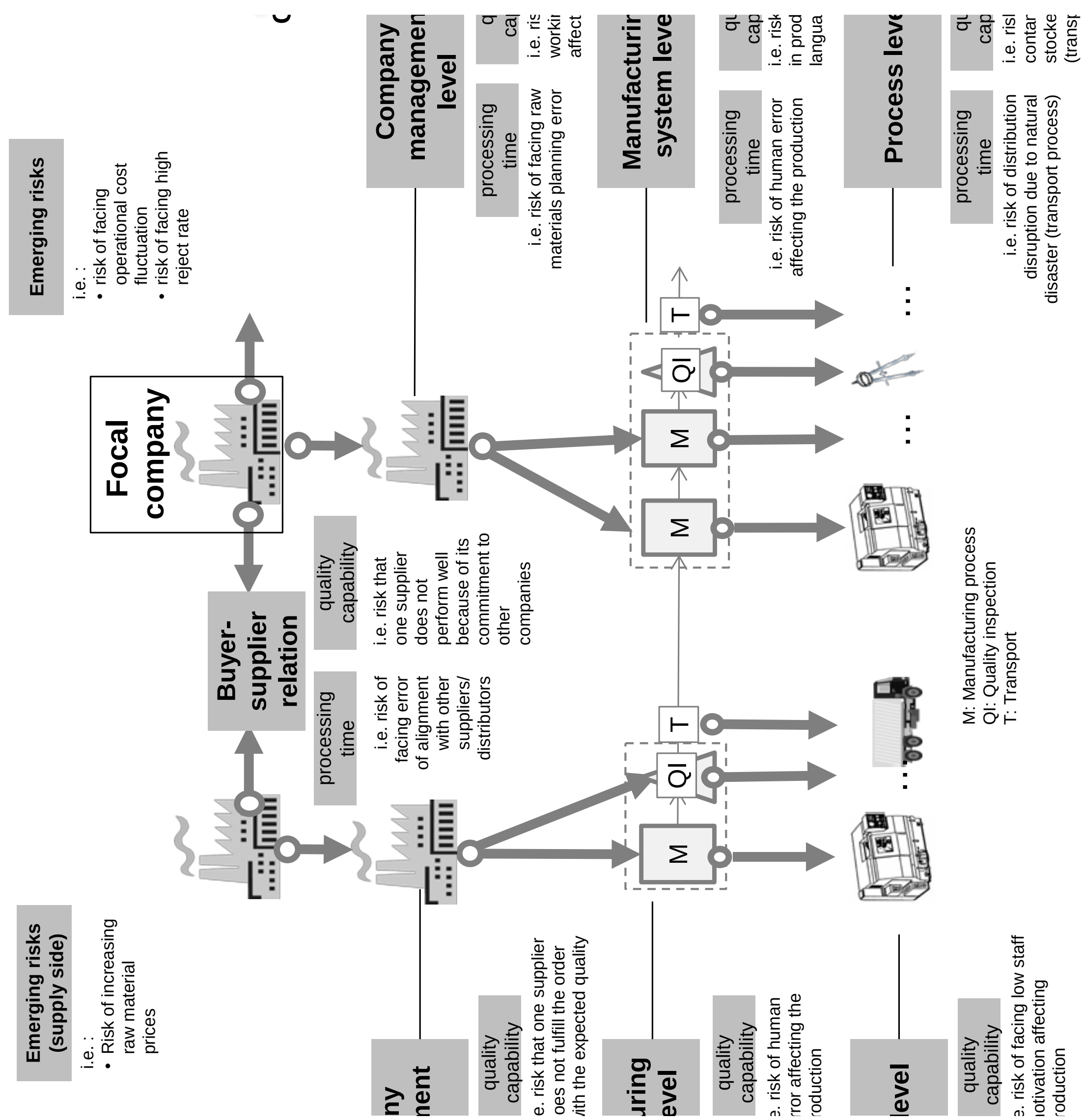

Figure 18. Allocation of supply network risks to quality risk supply network model (based on list of Kumar (M. Kumar & Gregory 2012a))

9 Agent-based simulation model for supply network quality

9.1 Model structure

The agent-based simulation model consists of two basic elements: agents and resources, which are part of a surrounding environment. A model of a supply network is set up by addressing the position of the companies in the supply network to the agents. Depending on the position the agents act based on different functionalities, distinguishing between the position categories final customer, intermediate company and raw material supplier (or most upstream company in the considered supply chain). Figure 19 shows a supply network model of four agents as an example with basic functions of the simulation model visualized. Products that are manufactured within the supply network are described as resources.

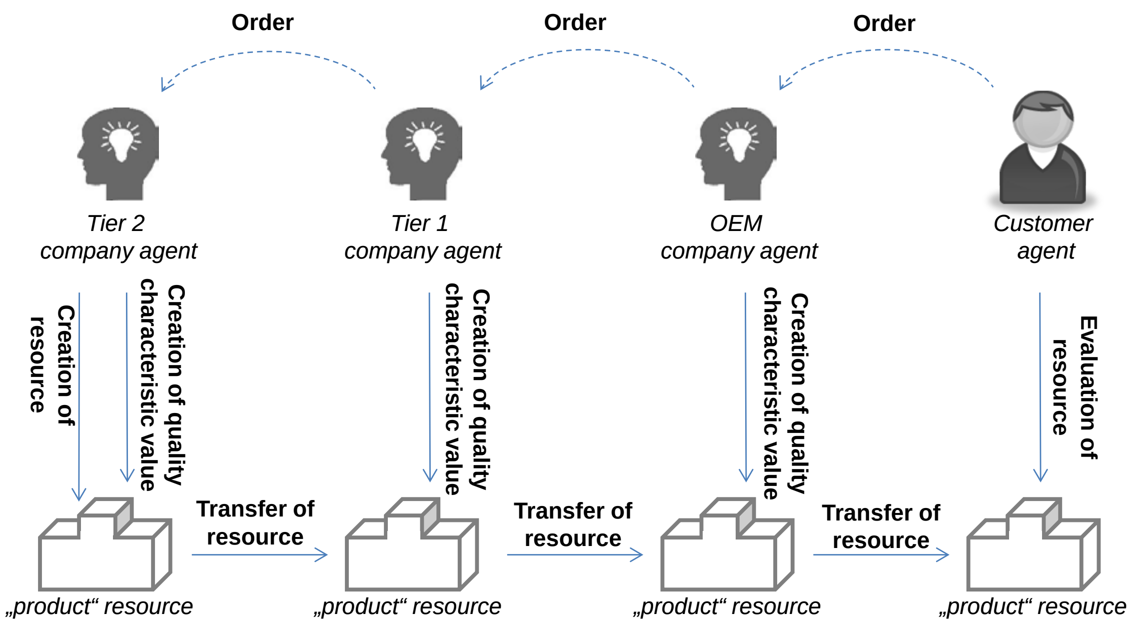

Figure 19. Basic functionality of the agent-based model

9.2 Basic functionality of the agent-based model

The simulation model is operating in cycles. Each cycle contains a certain amount of products which are split up in separate orders and introduced into the supply network by orders of the customer agent. An incoming order will be analysed by an agent if it can be accomplished and if the required resources are available. If the resources are not available an agent will place an order to an agent which is dedicated as a supplier for this resource. In case an agent is on the last stage of the model (most upstream supplier) this agent is assigned the functionality to create "product" resources. The resources can be modified by the agents and transferred from one agent to another. To simulate production processes, agents consecutively add variables with unique identifiers to the resources. Additionally, values which represent the value of a specific quality characteristic are written into these variables according to the internal model behaviour of the production processes. When a resource reaches the customer agent, all of its variables will be read and compared with reference values, so that it can be identified which of the values of quality characteristics meet the customer requirements. The evaluation of the resources, representing products, is the basis for an analysis and distribution of quality-related cost in the supply network. At the end of a cycle an agent can take decisions based on the quality-related costs. In result the length of a cycle defines the amortization time of any changes made by the agents.

9.3 Modelling of influencing factors on quality

The agent-based model integrates influences on the quality behaviour on the four different levels pointed out above (see section 5.2.2). While the influences on network, company and manufacturing system level are modelled as changes based on the agents' rational considerations (see Figure 20), the influence on process level can also consider fluctuations due to unknown external influences.

9.4 Modelling of quality risk mitigation measures

The quality risk mitigation measures that are integrated into the agent-based model are shown in Figure 20. On the network level, indirect and direct supplier development measures are modelled. In both ways a certain process improvement at the supplier is proposed by the buyer. In case of the indirect supplier development the costs for the improvement are completely taken on by the supplier, whereas the buyer offers a certain amount of money in case of the direct supplier development. Process improvements can also be taken on by a company itself if they offer an improvement of the companies target system.

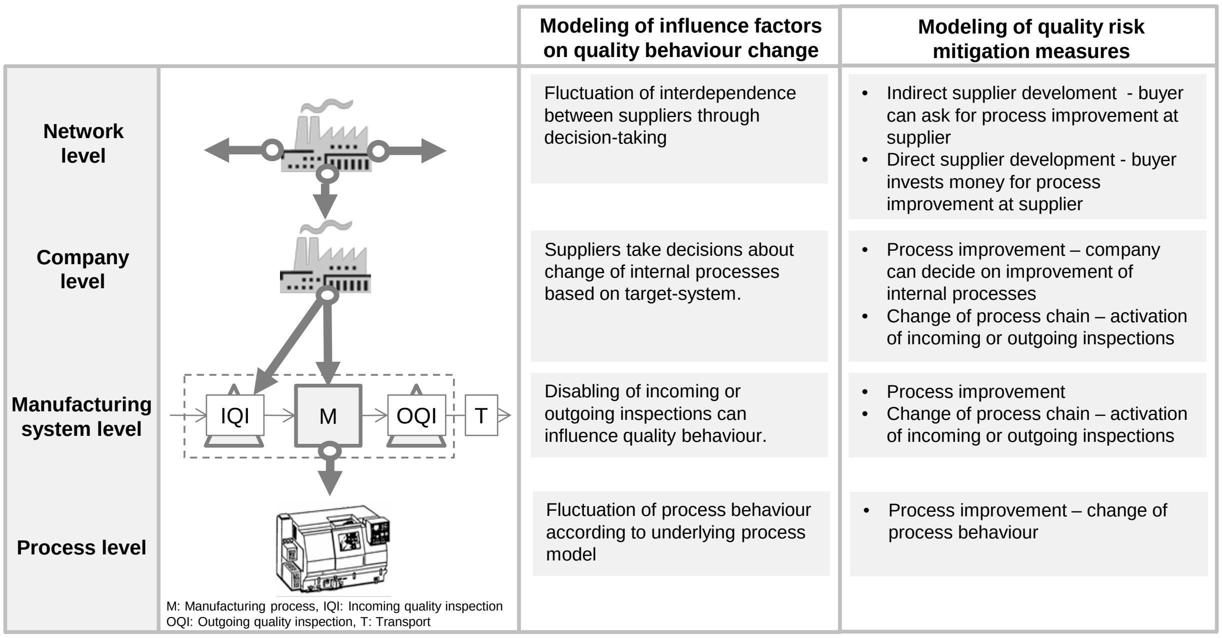

Figure 20. Quality risk mitigation measures within the agent-based model

The characteristics of the process and the modelling of a process improvement are located on the process level. Production processes are modelled as a stochastic process with two-sided boundaries for the process parameters, though the process model may vary depending on the regarded processes and influences in reality. An improvement of the process is modelled as narrowing of the process distribution (see Figure 20).

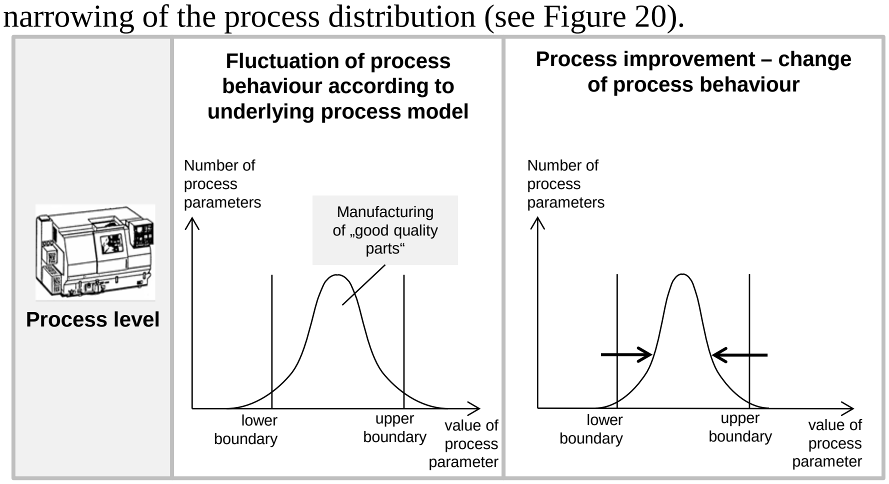

Figure 21. Process model within the agent-based simulation model

9.5 Recording of quality-related cost within the agent-based model

The fundamental quality-related costs within the model are failure costs, prevention costs and appraisal cost. These costs are monitored for every agent and every quality characteristic within the model (see Figure 20). Furthermore, the cost categories for prevention and appraisal cost are separated into categories for each individual prevention or appraisal measure. Failure cost are divided into cost due to defective supply parts, internal failure costs originating from own production, but without integration of the customer and external failure costs due to defect parts detected at the customer.

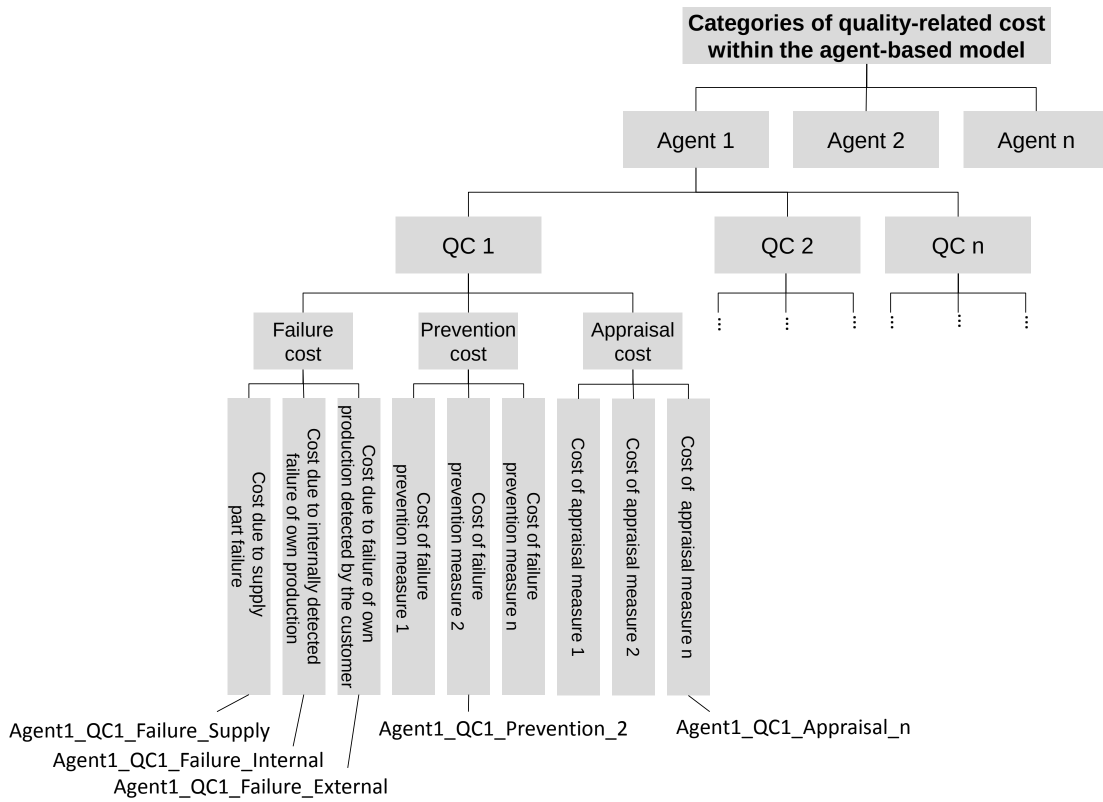

Figure 22. Categorization of quality-related cost within the agent-based model

Allocation of failure cost

Failure cost can be induced by the final customer or other agents in the supply chain or originate from the internal product inspections. To distribute the failure cost inside the supply network according to the specific configuration and address it to the correct cost categories, the agents follow a certain decision-tree as shown in Figure 20.

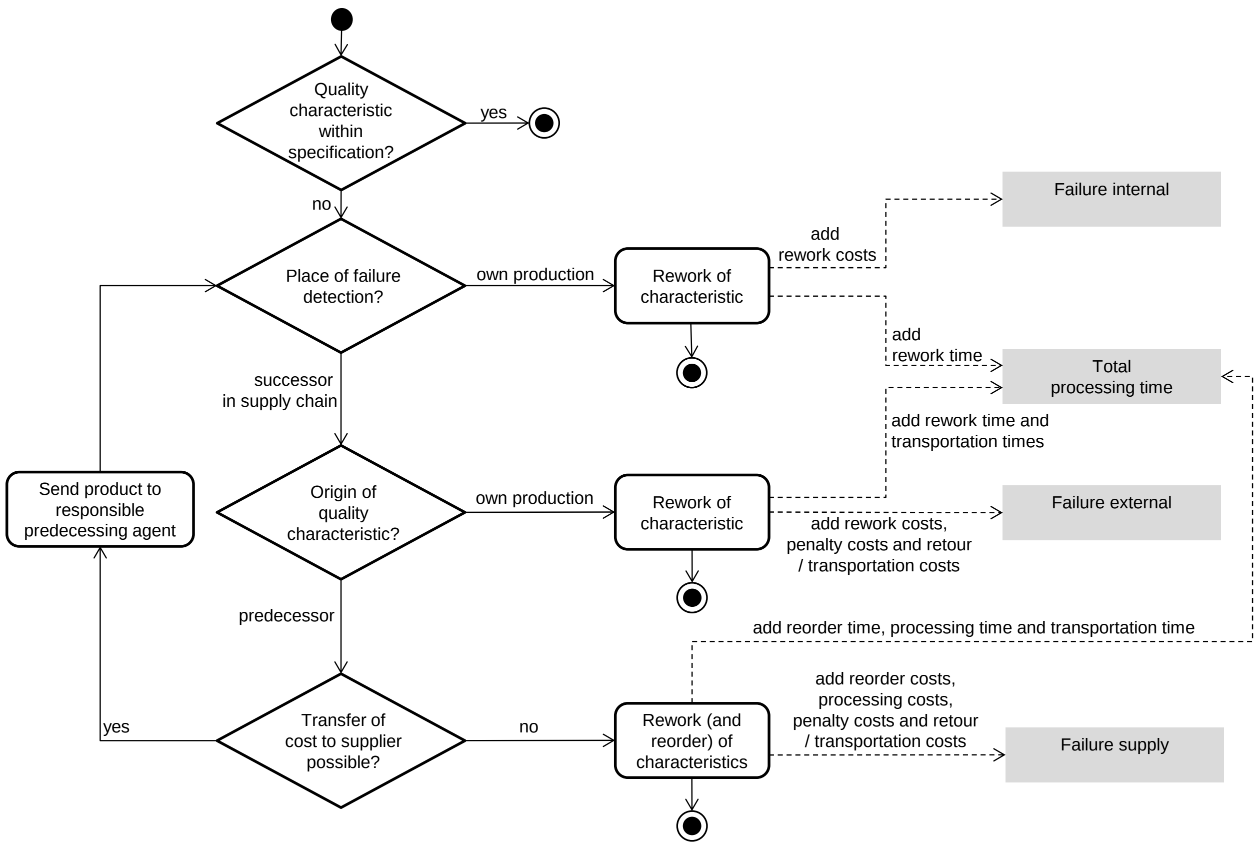

Figure 23. Allocation of failure cost and processing time

Allocation of prevention cost

Prevention cost is generated within the agent-based model if a certain prevention measure is activated. According to the agent and the quality characteristic where the certain measure is applied the costs are added to a certain cost category variable.

Allocation of appraisal cost

Cost of appraisal measures is allocated in the same way as prevention cost. While a certain prevention measure like, i.e. supplier development can generate costs at two agents simultaneously, appraisal cost are always linked to the agent of application.

9.6 Decision-making of agents

The decision-making processes of the agents are based on a comparison of recorded costs in the above mentioned categories and estimated costs for the specific future state.

Activation or deactivation of inspections

The precondition for an *activation* of an *incoming inspection i* for an agent x and quality characteristic n is:

$$Agent_x\_QC_n\_Appraisal_{i,estimated} < Agent_x\_QC_n\_Failure\_Supply$$

If the accumulated failure costs referring to the supply side are higher than the cost of the regarded incoming inspection, the measure will be activated.

For *deactivation of an incoming inspection* measure the following precondition must be true:

$$Agent_x\_QC_n\_Appraisal_i > Agent_x\_QC_n\_Failure\_Supply_{estimated}$$

The precondition for an *activation of an outgoing inspection i* for an agent x and quality characteristic n is:

$$Agent_x\_QC_n\_Appraisal_{i,estimated} + Agent_x\_QC_n\_Failure\_Internal_{estimated} < Agent_x\_QC_n\_Failure\_External$$

The measure will be *disabled* if the following statement is true:

$$Agent_x\_QC_n\_Appraisal_i + Agent_x\_QC_n\_Failure\_Internal > Agent_x\_QC_n\_Failure\_External_{estimated}$$

Process improvement of internal production

An agent x decides to activate an improvement of an internal production process y for quality characteristic n if the following general statement is fulfilled:

$$Agent_x\_QC_n\_actual\ cost > Agent_x\_QC_n\_future\ cost_{estimated} + Agent_x\_QC_n\_Prevention_y$$

The actual cost is calculated as follows:

$$Agent_x\_QC_n\_actual\ cost = Agent_x\_QC_n\_Failure\_Internal + \sum_i Agent_x\_QC_n\_Prevention_i + \sum_j Agent_x\_QC_n\_Appraisal_j$$

And the future cost is calculated based on estimated costs according to the following rule:

$$Agent_x\_QC_n\_future\ cost_{\ estimated} = Agent_x\_QC_n\_Failure\_Internal_{estimated} + \sum_i Agent_x\_QC_n\_Prevention_{i_{estimated}} + \sum_j Agent_x\_QC_n\_Appraisal_{j_{estimated}}$$

Direct supplier development

An agent x decides to *offer a development measure* z for quality characteristic n to a supplier if the following general statement is fulfilled:

$$Agent_x\_QC_n\_actual\ cost > Agent_x\_QC_n\_future\ cost_{estimated} + Agent_x\_QC_n\_Prevention_z$$

The actual cost is calculated as follows:

$$Agent_x\_QC_n\_actual\ cost = Agent_x\_QC_n\_Failure\_Supply + \sum_i Agent_x\_QC_n\_Prevention_i + \sum_j Agent_x\_QC_n\_Appraisal_j$$

And the future cost is calculated based on estimated costs according to the following rule:

$$Agent_x\_QC_n\_future\ cost_{estimated} = Agent_x\_QC_n\_Failure\_Supply_{estimated} + \sum_i Agent_x\_QC_n\_Prevention_{i,estimated} + \sum_j Agent_x\_QC_n\_Appraisal_{j,estimated}$$

An agent z decides to *accept a development measure* z for quality characteristic n from a buyer x if the following general statement is fulfilled:

$$Agent_z\_QC_n\_actual\ cost > Agent_z\_QC_n\_future\ cost_{estimated} + \left(Agent_z\_QC_n\_Prevention_{z,estimated} - Agent_x\_QC_n\_Prevention_{z,estimated}\right)$$

The actual cost is calculated as follows:

$$Agent_z\_QC_n\_actual\ cost = Agent_z\_QC_n\_Failure\_External + \sum_i Agent_z\_QC_n\_Prevention_i + \sum_j Agent_z\_QC_n\_Appraisal_j$$

And the future cost is calculated based on estimated costs according to the following rule:

$$Agent_z\_QC_n\_future\ cost_{estimated} = Agent_z\_QC_n\_Failure\_External_{estimated} + \sum_i Agent_z\_QC_n\_Prevention_{i,estimated} + \sum_j Agent_z\_QC_n\_Appraisal_{j,estimated}$$

10 Implementation

The implementation of the presented model is based on the simulation platform SeSAm (Shell for Simulated Agent Systems). The software is characterized by its ability to allow modelling and simulation as well as the evaluation of the simulation runs. The behaviour of the individual agents can be defined by state diagrams (reasoning engines) with a graphical user interface. Each of the states can be described with actions characterized by programming code fragments. A single agent can have several state diagrams, which run in parallel during simulation.
The implementation of the four concept levels is described in the following:

Based on the simulation tool SeSAm, the *product* is modelled as a resource item with variables that represent quality characteristics. The values of the variables are set at different times during the simulation run of the production process. A resource item in the model thereby is a passive unit, which does not own state diagrams and concluding cannot act individually.

The individual *companies* in the model are implemented as agents. Due to a standardized and universal design of the agent models, a supply network can comprise of agents of the same type, which are dedicated to different stages. Each agent consists of multiple reasoning engines, which represent the different functions as well as the cross-functional work processes in a real enterprise.

These functions are: Purchasing of goods, production (of quality characteristics), quality inspection and shipping of goods. Beyond this, reasoning engines are implemented, which make decisions on the initiation of quality management measures based on collected data. The overall behaviour of an agent is defined by the interaction of the reasoning engines. Figure 20 shows an example of a decision tree about supplier development measures. From the pool of existent suppliers those are identified in a first step, where supplier development has the highest potential. In a second step an internal cost calculation to evaluate the financial benefit of the measure is conducted. In case of a positive result, an offer is sent to the supplier. If the supplier accepts the development offer in the next step a payment as a representation of a conducted measure is executed. If the offer is denied by the supplier a negotiation with defined limits is started.

The communication of the single agents and the negotiation in a *customer-supplier-relationship* is realized by the exchange of messages, which are based on the standardized communication language ACL (Agent Communication Language). Due to the usage of ACL-type message formats the autonomous character of the agents is maintained.

The *total model* of the supply network is comprised out of the individual company agents by addressing the specific tier to each of the agents as well as the information about the direct neighbours. This allows an easy adaptation of the model to company-specific forms of production networks.

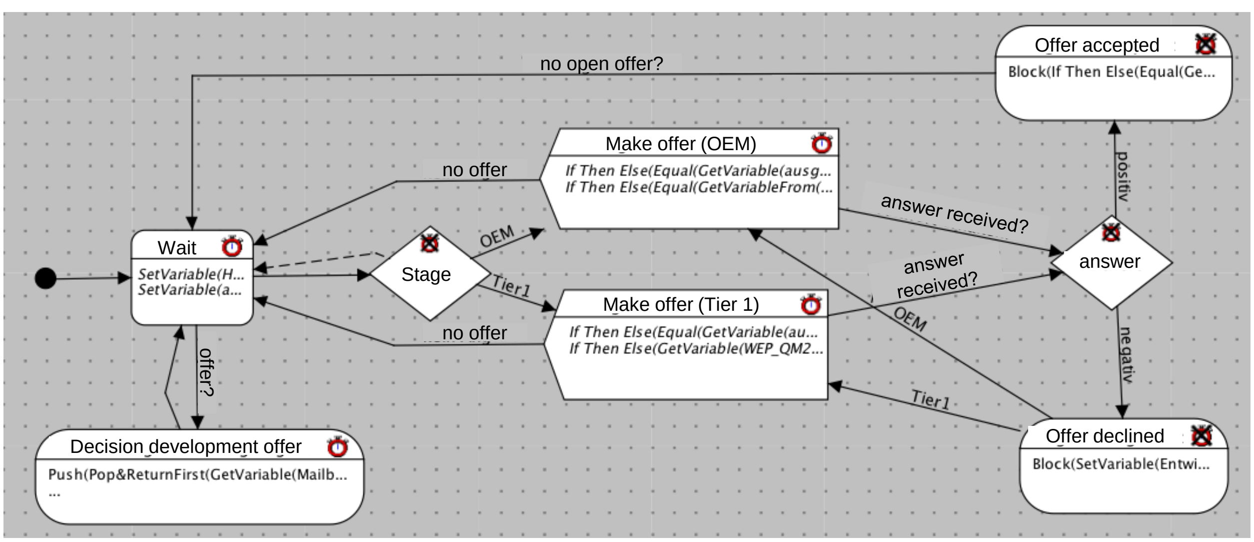

Figure 24. Decision tree for supplier development measures

11 Implementation sample

Using the implemented simulation model to analyse the quality management behaviour of the company agents in a supply network, several loops of the simulation run are needed. Exemplary, a simulation run of a four-stage supply network was conducted. The hereby resulting development of the quality cost, summed up out of failure cost, prevention cost and appraisal cost, over several simulation runs was recorded for a single company agent, representing an OEM in the supply network (see Figure 20). The quality costs were monitored in two scenarios of differing degrees of freedom. In the first case the agents could decide freely between the different quality management measures. In the second case, a certain configuration of incoming and outgoing inspections was pre-set. The simulation run showed that the autonomous acting entity can realize substantial savings in quality cost in the supply network by choosing specifically suitable quality management measures.

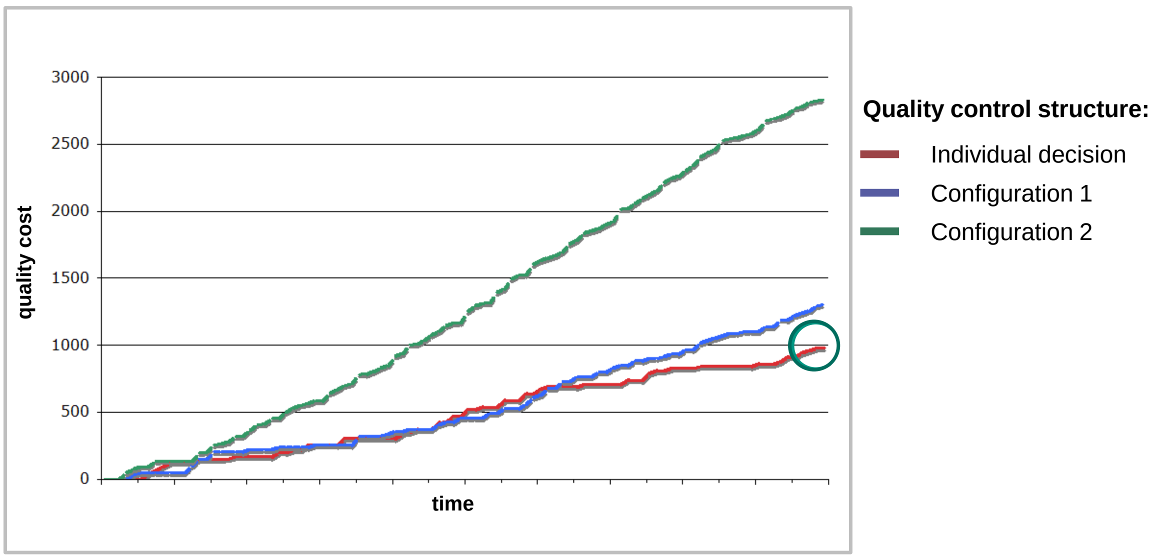

Figure 25. Development of quality-related cost on the OEM level

Regarding the quality-related costs of all four entities in the supply network (Figure 20), a further property of the simulation model becomes visible. The results show that, given the agents act autonomously, the overall quality cost configuration in the supply network is not optimal. This can be explained by the fact that a global cost optimum does not mean that each agent reaches its cost optimum as well. The autonomy of the agents in this example constricts the achievement of a global cost optimum of the overall supply network. This resembles the experiences in real supply networks, where individual target systems of the companies hinder the achievement of a globally optimal quality cost. The advantage of the agent-based simulation approach is that it allows these effects.

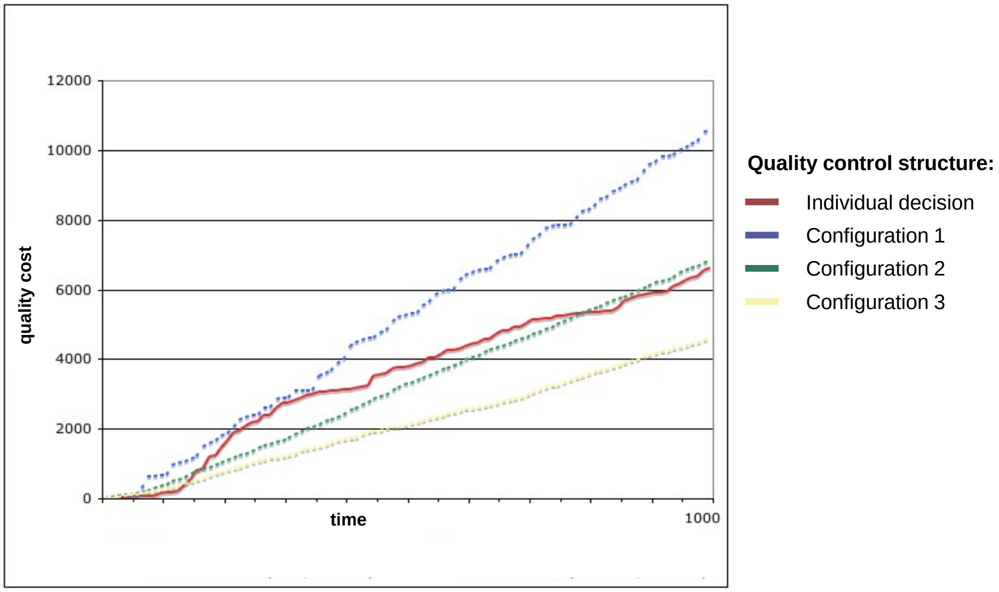

Figure 26. Development of quality-related cost in the overall supply network

12 Evaluation & discussion

The approach presented in this paper is based on a combination of research in the fields of network theory, quality management, supplier management, supply chain management and risk management. Within this paper the above mentioned fields are analysed with regard to an understanding of quality risk in supply networks and mapped out in an understanding model. This model can be used for various purposes and is contributing to an understanding of manufacturing processes in global supply chains since it links several levels of detail, from a single manufacturing process to buyer-supplier relationships within supply networks.

Within this paper, the understanding model is used for blending with qualitative research in the field of supply network risk management to identify different sources and forms of quality-related risk. As a result, an improved understanding of forms of quality risk within supply networks can be derived.

The second application of the developed understanding model within the presented work is its quantification within an agent-based simulation model. The implemented simulation model can be used for agent-based simulation of the effects of quality risk within a supply network and its behaviour against mitigation measures. In a first example, it could be showed that the behaviour of the model and its company agents resembles the conditions in real supply networks.

The developed approach is considering the need of situation-specific evaluation for decision-making, as asked for in research fields like network theory or risk management, in especially strong degree. Therefore it is forming a basis for further analysis of supply network risk and risk mitigation studies. Also for future survey or case study based research with regard to interdependencies within supply networks, the developed approach can provide a suitable framework.

Further improvement of the developed approach should focus on the test and validation of the agent-based model in an industry case study, as well as an extension of the functionality of the agent-based model towards the understanding model of quality risk in supply networks.

13 Summary & outlook

This paper presents an approach for the evaluation of quality risk in supply networks and identification of suitable mitigation measures. The method is based on an agent-based simulation model. To develop the method and agent-based model systematically firstly relevant influencing factors from several research fields were identified and analysed. For example supplier, quality or risk management measures for the inter-company use were considered. As a result, a modular framework and model of quality risk in supply networks was generated. Based on this model a blended approach of the quantitative approach of this work and other qualitative risk management approaches in literature was derived. This shows existing linkages between qualitative risk management approaches and quantitative analysis of quality management in supply networks. The model was implemented using the simulation platform for agent-based simulation SeSAm. The desired behaviour of the model was proven successful in first applications. The developed simulation model will be applied to company-specific production networks for strategic decision-making regarding the control of the supply networks.

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Credit Bubble Burst and New Sustainable Economy Opportunity in the Baltic States

Olli-Pekka Hilmola
Lappeenranta University of Technology, Kouvola Research Unit,
Prikaatintie 9, FIN-45100 Kouvola, Finland
Fax: +358 5 344 4009, E-mail: olli-pekka.hilmola@lut.fi

Abstract
Baltic States became independent in early 90's, when iron wall collapsed in whole Eastern Europe. Thereafter, development in economic terms was rapid and particularly manufacturing and transportation sectors were responsible for prosperity formation. However, after late 90's situation changed, and boom was apparent in credit led real estate, finance, retail and construction sectors. As these sectors are all domestically oriented, and while Baltic States in this credit boom period did not experience any trade surpluses, it was evident that credit crunch in 2008-2009 affected economies severely. This research work shows that Baltic States need to change again weight in Foreign Direct Investment (FDI) for manufacturing and transportation, sectors which have been supported previously only by European Investment Bank and EU Cohesion fund. FDI is vital for Baltic States, since they have been for long time net receivers of capital, and GDP has greatly dependent on these inflows. However, future prosperity is only built with export oriented FDI.

Keywords: Baltic States, FDI, loans, EU cohesion, manufacturing, transportation

1. Introduction

Credit crunch of USA during years 2008-2009, which led to global economic slowdown, hit hard all Baltic States (Kumpikaite et al., 2011). Experienced change in downsize was very sudden, and even private sector actors were entirely unaware of its magnitude (Kumpikaite et al., 2011). Therefore, unemployment increased within very short time (Sakiene, 2011; Kumpikaite et al., 2011) and construction sector was severely hit (Sakiene, 2011; Bobinaite et al., 2011). However, not only domestic economy led sectors were suffering, but e.g. metal industry was experiencing 40 % slump in orders in Latvia (largest export industry; Priede & Skapars, 2012).

However, root problem in Baltic States for these sudden negative changes was the economic structure formation and renewal, which took place during previous boom time. Relatively loose monetary policy of banks (international phenomenon then) resulted in fixed capital investments, and e.g. in the case of Lithuania during years 1995-2009 these fixed capital investments alone explained 91.54 % from GDP change (Bobinaite et al., 2011). Even if investments soared, and construction industry experienced boom period (Sakiene, 2011), other sectors, like export based manufacturing was continuously declining (Saboniene, 2011a; Shatrevich & Zvanitajs, 2011). Similar situation happened with e.g. agriculture (Bobinaite et al., 2011); EU support has been argued here to be effective, that this branch even exists in Baltic States today (volumes were continuously declining before EU membership; Veveris & Kalis, 2011). So, problem of Baltic States in general was that there did not exist any seriously taken industrial export arm, which could have aided their recovery out of the crisis with agreed and implemented lower salary levels. Baltic States economies remind in miniature scale that of USA; in large extent their economic growth model was based on demand alone, not on supply. Therefore, e.g. Latvia has stated that export based manufacturing is their main development objective (Shatrevich & Zvanitajs, 2011). Challenge in export industries is that they are low technology companies (e.g. food and beverages;

Saboniene, 2011b; Shatrevich & Zvanitajs, 2011), and main customers are in Europe (Bernatonyte, 2012). This low-technology status mostly concerns Lithuania and Latvia. Based on research of Bernatonyte (2011), Estonia is the most competitive in export industries, and two other Baltic States follow it with considerable distance.

Situation is not entirely hopeless, e.g. EU cohesion funding is plenty during program period of 2007-2013 for all Baltic States. Most of this granted funding was unused before the crisis, e.g. Lithuania only had used one third of them before the credit crunch (Dumciuviene, 2011). Similarly Estonia reports in program webpages, that half of the entire funding is used in their country now, but rest of the projects for the end of 2013 are agreed, and costs will accumulate in late year 2012 and 2013 (EU Structural Assistance to Estonia, 2012). These funds are of course hope for better future, since their use now in the challenging times is replicating Keynesian stimulus of economic downturns.

This research is structure as follows: Section 2 portrays economic development in Baltic States within recent decade. Strengths and weaknesses are reviewed briefly in this section too. Thereafter, in Section 3 FDI inflows are examined in long-term perspective from all Baltic States by industrial branches and countries involved in this activity. Role of international lending organizations (like EIB and ERBD) is analyzed in Section 4, where it is shown that loans and especially the role of EIB has increased in recent years. EU cohesion funding is reviewed in longitudinal perspective in Section 5. Research work is concluded in Section 6, where also avenues for further research are being provided.

2. Economic Development in Baltic States

All Baltic States were growth tigers in the previous decade, and economic prosperity in national currency terms grew at least 10 % p.a. before credit crunch. However, if we measure GDP change in euro terms, Latvia was experiencing some IT bubble burst problems in 2002-2003, but recovered strongly out of this (in national currency GDP growth was still 10 %, but this mostly caused due to depreciation of currency). Signs of overheated economy were very much present in year 2007, when GDPs grew 20-30 % p.a. (Figure 1). As will be shown later on this research work, overheating was caused by the massive capital inflows to the countries, particularly improvement of FDI inflows. However, as uncertainties in the world economies started to be present, investment activity disappeared suddenly as confidence on future growth was hurt. This eroded economic growth rather suddenly. Of course long-term loans taken from EIB and structural funds used out of EU cohesion helped a bit, but we may note that in year 2009 decline was massive. GDPs declined by 15-19 % then. Thereafter all three countries have experienced recovery process, but still in absolute terms GDPs of year 2011 are below the level of year 2008.

Among investment attraction, all three Baltic States hold naturally important role as transit cargo locations for eastern (Russia, Ukraine, Belarussia, Kazakhstan etc.) export of raw materials and/or import of consumer goods. This also affects greatly on employment and consumption, in turn having connection on GDP growth. In period of 2000-2009 these three countries had continuously changing position in transit cargo handling (e.g. Hilmola, 2011). For example, Estonia lost significantly coal transports during the decade perspective (development was in part fostered by small political crisis with Russia in 2007), but in turn Latvia was able to grow significantly in coal transit with sea port of Riga (capital city). However, in oil handling and fertilizers Latvia and Estonia have experienced decline in decade perspective, while Lithuania has grown considerably. In containers (general cargo) only Riga sea port in Latvia has been able to show in decade perspective clear growth – Lithuania is looking also promising in this respect. So, we could argue that transit transport is messy topic to be connected directly in GDP growth (as it changes between three Baltic States so rapidly), however, we may conclude that crisis in year 2009 took significant part from handling volumes away, and in turn caused GDP slump in crisis year. Declines before this crisis year were in parts caused due to rapidly deteriorating business climate, but also due to political tensions.

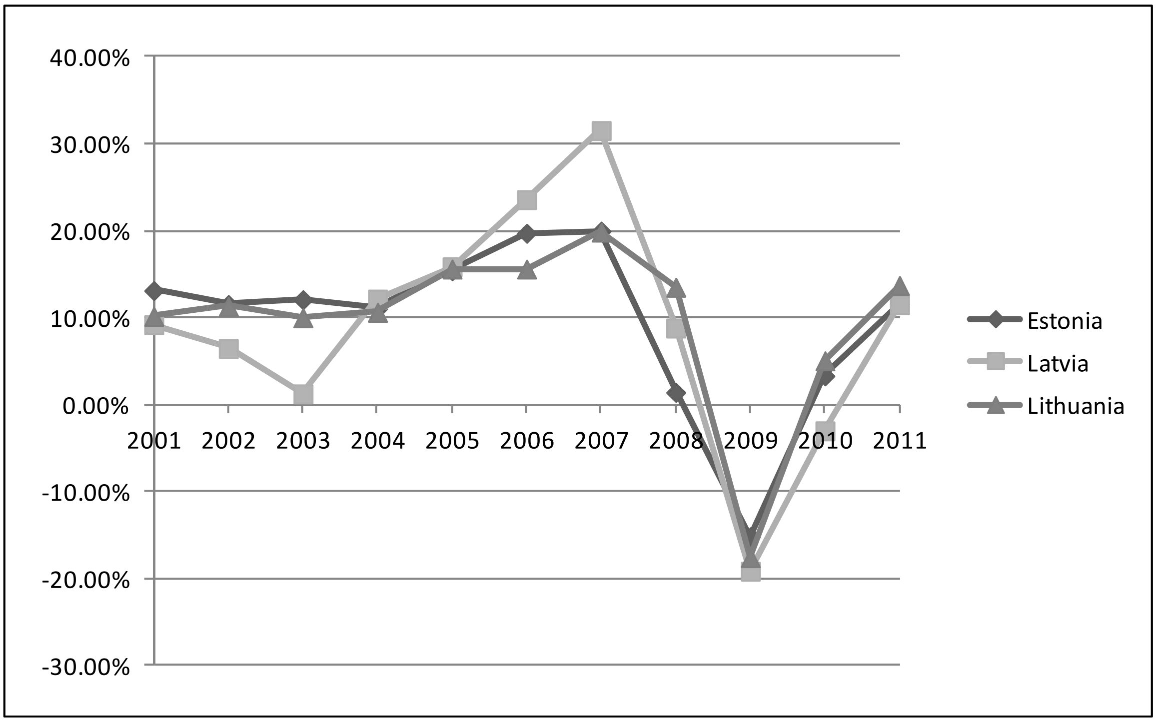

Figure 1. Gross Domestic Product (GDP) change in Baltic States during previous decade (GDP converted to Euros with BOF, 2012). Source: Statistics Estonia (2012), Central Statistical Bureau of Latvia (2012), Statistics Lithuania (2012)

As an anomaly to Baltic States acts United States. Similarly to USA, all Baltic States have recorded for years significant trade deficits (these considerably widened after early 2000). After credit crisis situation has still remained, mostly due to high priced oil (was of course problematic also during growth period; see e.g. for Switzerland, Atukeren, 2011), which all Baltic States need to import from abroad. However, boom period of early 2000 was mostly caused by domestic sectors, and investments did not see manufacturing as an opportunity. Actually it is so that Baltic States enjoyed healthy manufacturing development in 90’s, but in ten recent years Asia has took over its share from this activity. Typically this meant that manufacturing units (e.g. subcontracting) were relocated to Asia. This concerns very much such branches as electronics and light weighted product production. So, in simplistic terms trade deficits mean that all three countries are in need of more capital (loans), either to be taken by private or public sector. Of course capital could appear in form of FDI too, or as EU structural support. It is open question, how long time capital in-flight could substitute uncompetitive export structures.

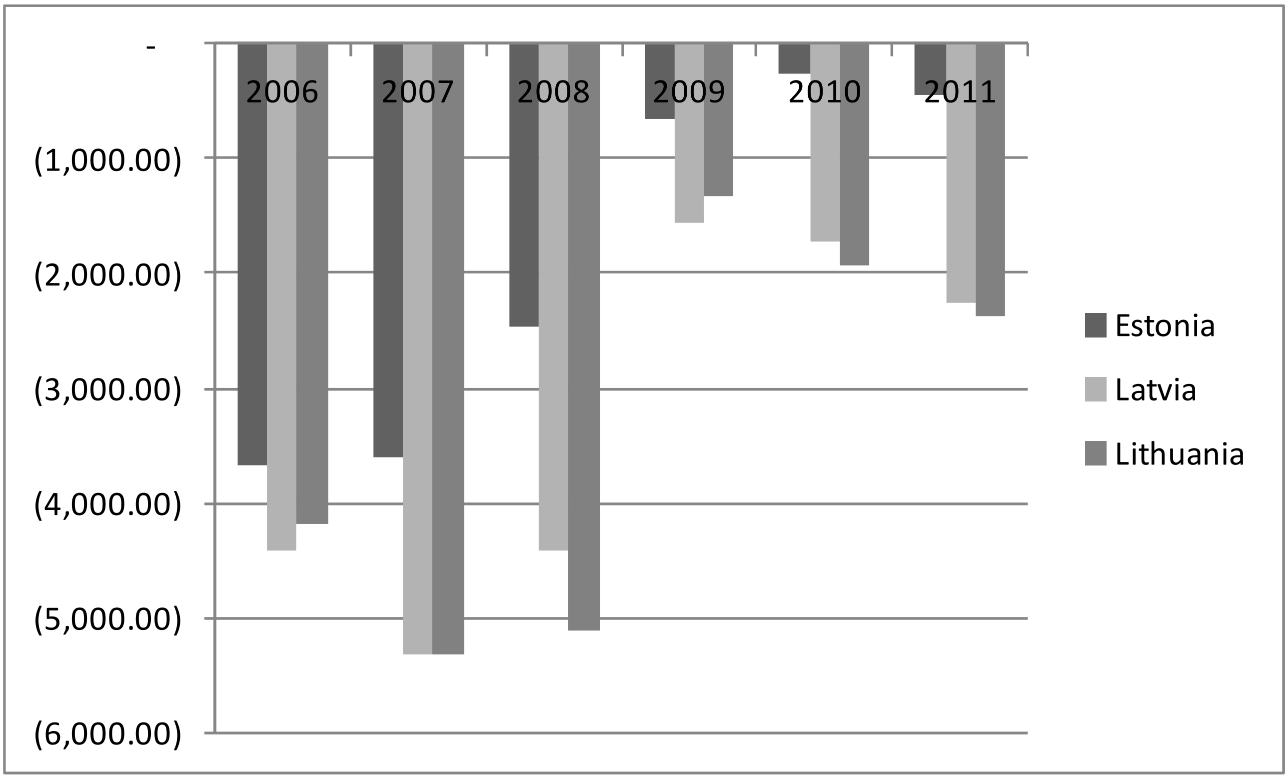

Figure 2. Trade deficit of Baltic States within period of 2006-2011 (in mill. euros). Source: UN Comtrade (2012)

As observing the development of trade account after crisis, only Estonia has started to show development, where exports could potentially in forthcoming years to be in parity with imports. However, situation in Latvia and Lithuania is repeating life before crisis – trade deficits in year 2011 were already more than two billion euros, and trend in both countries is strikingly downwards. This is not minor issue as in year 2011 Lithuanian trade deficit was one fourth from GDP, and Latvian in turn roughly one sixth.

3. Background: Foreign Direct Investments in Baltic States

As Baltic States could be classified as emerging economies in European landscape during the previous decade time, their Foreign Direct Investment (FDI) have followed same emerging pattern. This experienced development was also the main reason, why GDP contracted in such significant manner during credit crunch, and in turn resulted in high unemployment rates. Three Baltic States economies experienced severe boom in real estate, finance, wholesale and construction sectors and in their interaction (growth was domestic oriented and endogenous interactions with increasing amount of foreign investments that created bubble). As world economy was in general going through very loose monetary policy after IT bubble burst, these sectors attracted impressive amount of funding from foreign investors. This is apparent in longitudinal development of FDI in Estonia (Figure 3), Latvia (Figure 5) and Lithuania (Figure 7). It is interesting to note that in Estonia these four mentioned domestic market focused sectors accounted more than 70 % of total FDI position in year 2007, as in Latvia more than 65 % in year 2008 and in Lithuania more than 45 % in year 2008.

During the last decade time period all Baltic States were experiencing high GDP growth (until credit crunch slump), which was accompanied with continued deficits in trade accounts (also concluded in Ojala et al., 2005). Mostly much higher amount of FDI as compared what Baltic States themselves invested abroad was the success formula. FDI dominance is the case still today, in Estonia country has more than 3.5 times investments from abroad than what it has invested to other countries, Latvia in turn has more than 13 times, and Lithuania nearly 7 times.

Economy overheating in year 2007 could be detected from Figures 3, 5 and 7. FDI inflows just spiked in this year rather significantly, and of course resulted on GDP growth of 20-30 %. This growth stopped entirely on credit crunch crisis during years 2008-2009, but mostly caused FDI to halt (not new inflows, but investments remained). Only Lithuania experienced declining FDI development, so namely FDI outflows. It also could be argued that most recent recovery is caused by the strength of FDI inflows, particularly growth experienced in year 2011.

As domestic oriented sectors were taking in attention during the previous decade, manufacturing and transportation have been rather slow growing in terms of FDI. However, in positive respect these two sectors have all still shown some growth in three Baltic States within chosen observation periods. What is not apparent from FDI statistics is that manufacturing has transformed increasingly as low tech and local. Export industries which are left are most competitive in Estonia. In Lithuania large proportion of manufacturing in FDI could be explained with oil refinery ownership changes.

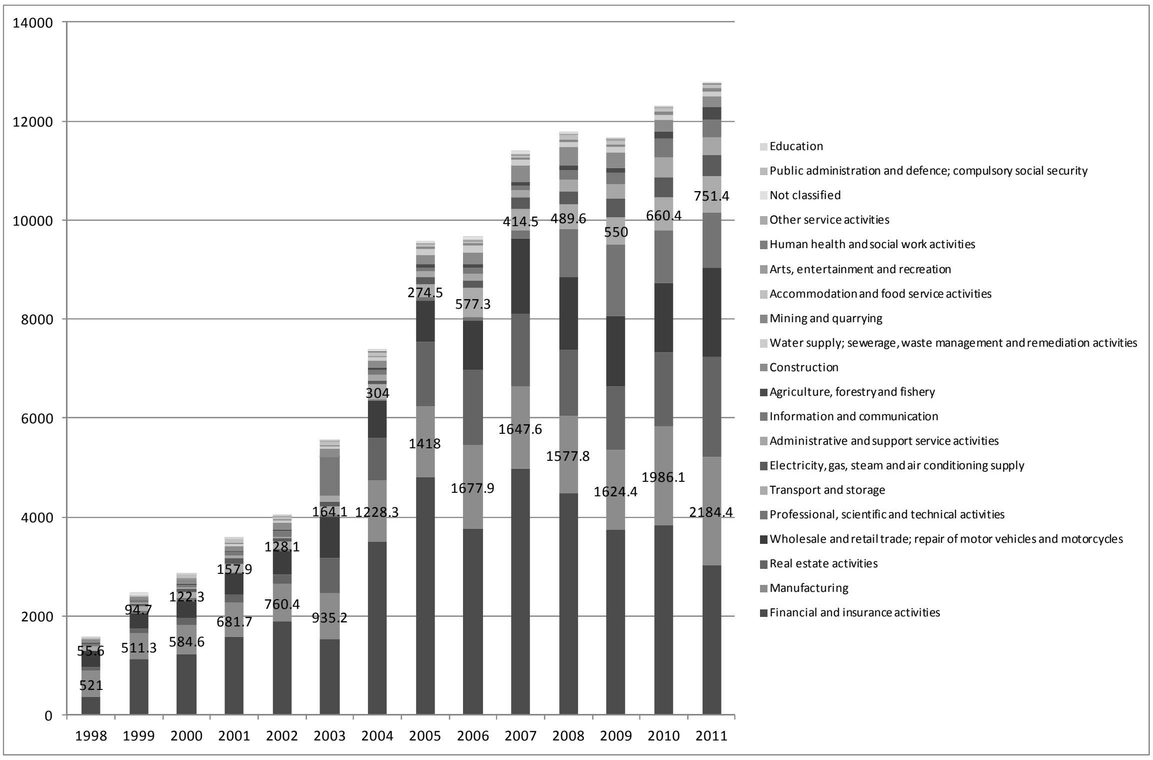

Figure 3. Foreign Direct Investments to Estonia (in million Euros) by branch within period of 1998-2011 (position in the end of the period). Source (data): Bank of Estonia (2012)

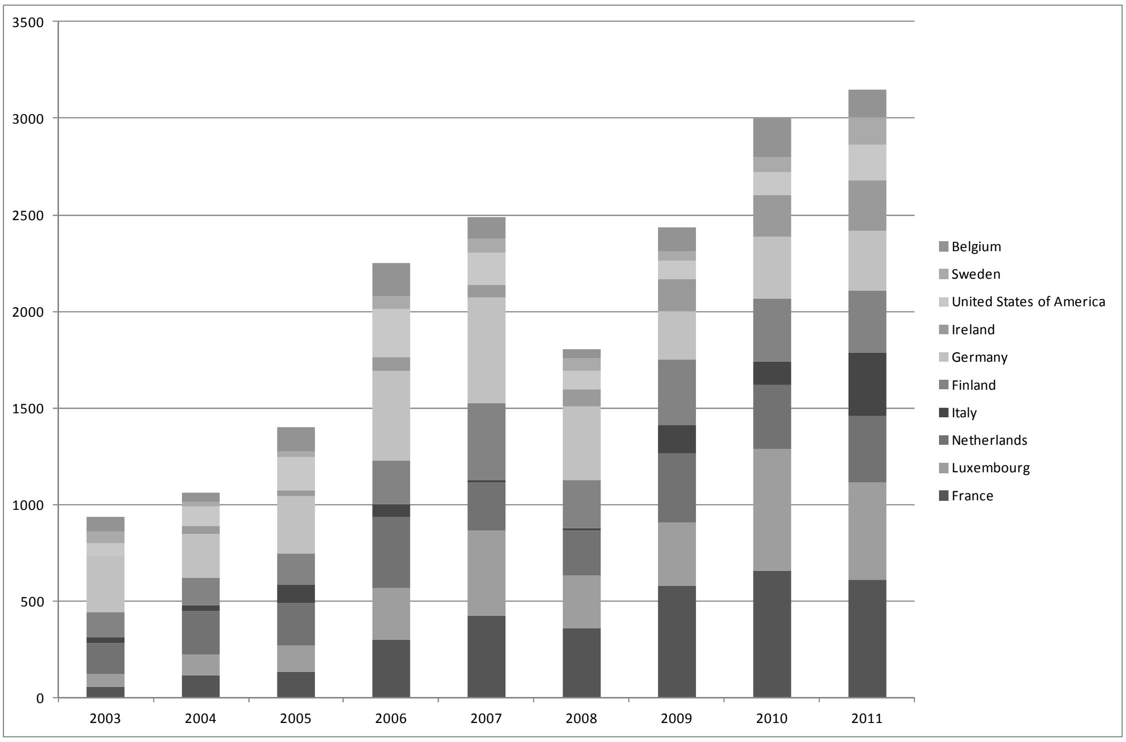

Figure 4. Ten most important FDI countries (in million Euros) for Estonia (ascending order with most recent year, 2011). Source (data): Bank of Estonia (2012)

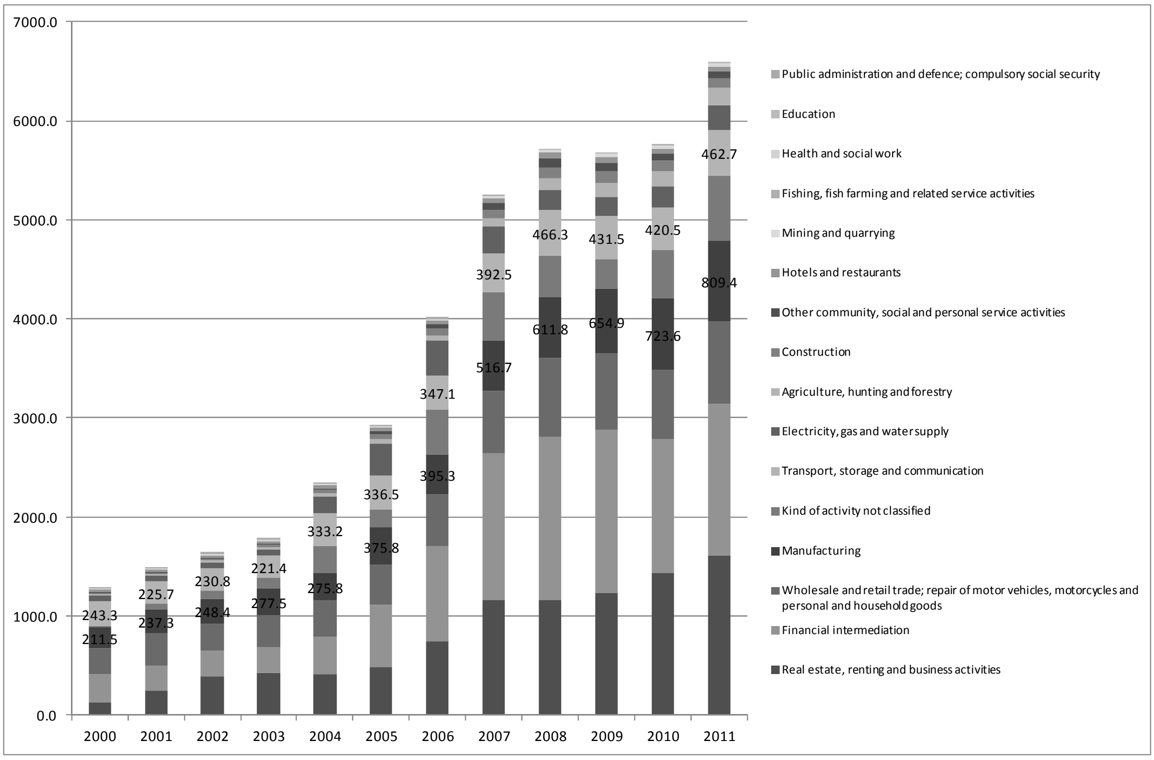

Figure 5. Foreign Direct Investments to Latvia (in million Lats as 1 Lat was 1.423 Euros in the end of 2011) by branch within period of 2004-2011 (position in the end of the period). Source (data): Bank of Latvia (2012)

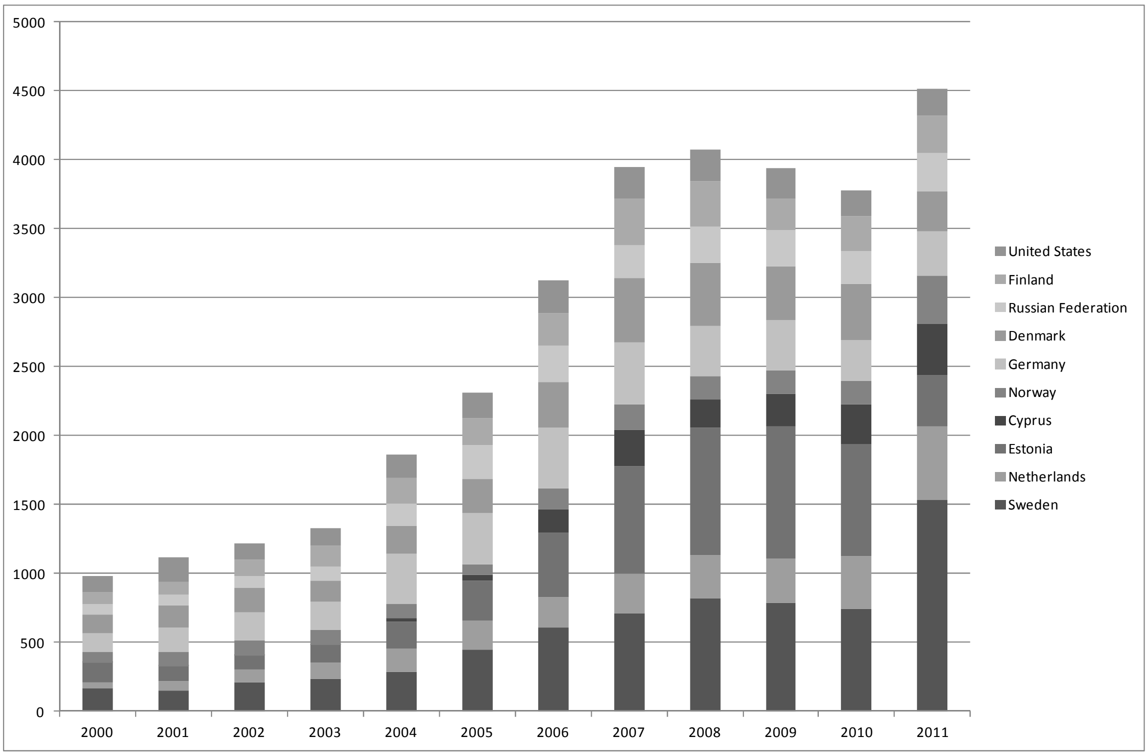

Figure 6. Ten most important FDI countries (in million Lats) for Latvia (ascending order with most recent year, 2011). Source (data): Bank of Latvia (2012)

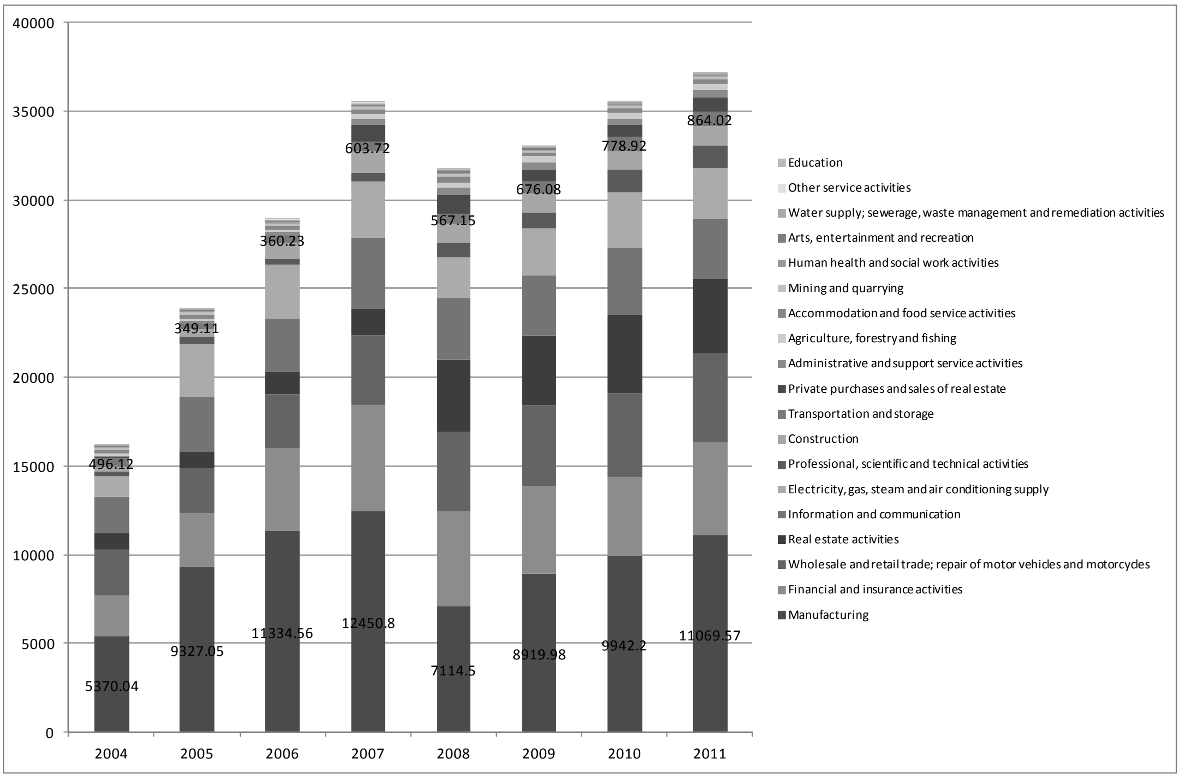

Figure 7. Foreign Direct Investments to Lithuania (in million LTL as 1 Lita was 0.29 Euros in the end of 2011) by branch within period of 2004-2011 (position in the end of the period). Source (data): Lithuanian Central Bank (2012)

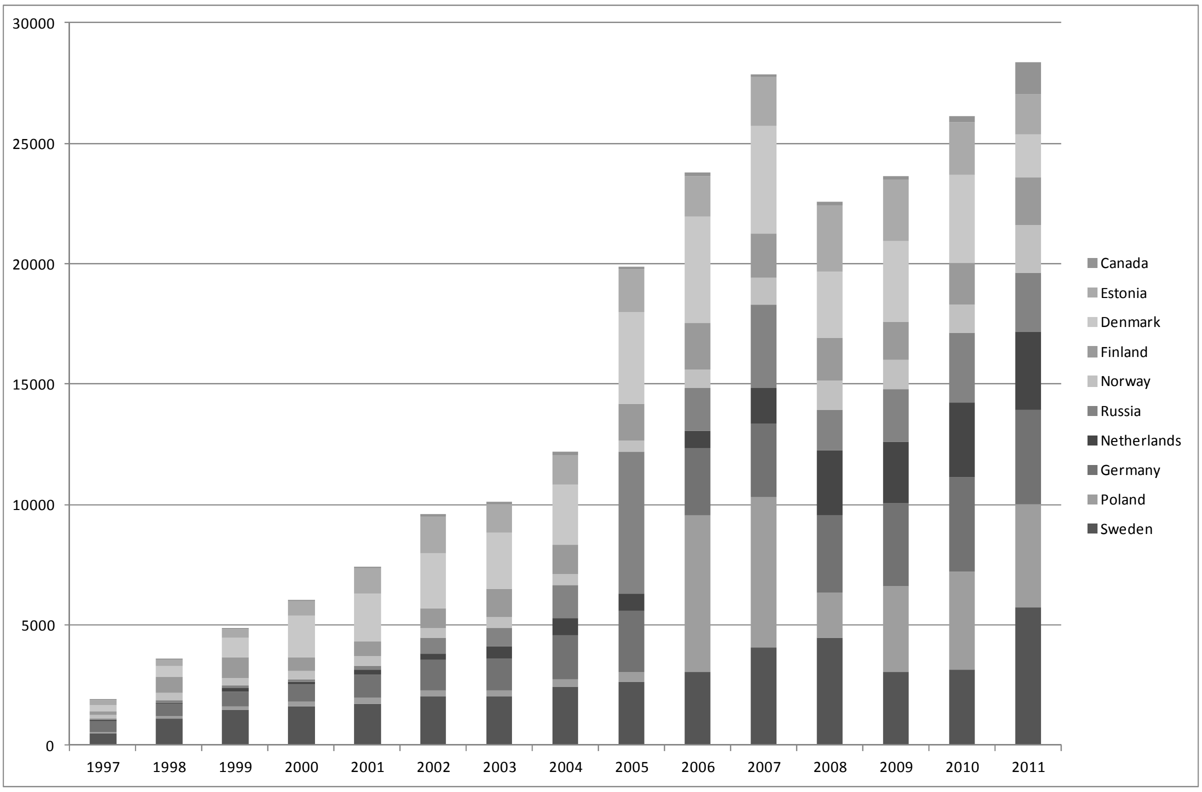

Figure 8. Ten most important FDI countries (in million LTL) for Lithuania (ascending order with most recent year, 2011). Source (data): Lithuanian Central Bank (2012)

In country and Baltic Sea perspective, Sweden and Finland have been active in seeing and acting upon FDI front in all Baltic States (Figures 4, 6, and 8). However, it should be emphasized that Sweden has been extremely active in Latvia and Lithuania, while Finland has been mostly interested from Estonia. Investments differ in a manner that Swedish activity is centered in banking sector. Along these two countries, Germany and Netherlands are present in ten most active countries of FDI in all Baltic States. Also Estonia has been active in other two Baltic States, but mostly so in Latvia. Country peculiarities exist too, like high importance of France and Luxemburg in Estonia and Poland in Lithuania.

As it is today with employment and export manufacturing competence (e.g. Bernatonyte, 2011), it is also so with overall FDI attraction during observation period: Estonia leads in absolute amounts two other Baltic States, and its FDI activity was not that greatly interrupted by credit crunch. It should be noted that Estonia is having clearly lowest population from all of the evaluated countries.

Analyzed time period in three Baltic States is over-emphasizing importance of finance and real estate sectors – as these were the boom sectors during the late IT bubble burst era. However, it should be reminded that in Baltic States main FDI target sectors were during 90's telecommunications and transports, but also in parts manufacturing. It could be explained that these sectors prospered as advances of mobile telecommunications were rapidly developing and neighborhood countries, like Sweden and Finland, had leading positions in them (e.g. during 1999 from Estonian FDI Sweden and Finland together accounted 70%; see Lesser, 2000). So, in other hand these two countries were active (with Danish) in FDI in telecommunication sector (operators), but also in related manufacturing of devices and infrastructure. Transportation sector received vast interest too, but it did not turn out to be high success within eastern transit business. For example, Latvian stock market listed from governmental program, Ventspils Nafta (transit business of oil and petroleum, mentioned as case already in Ojala & Queiroz, 2001), did not turn as major success (it has profitability, but not growth story), and could be eyed as an example that huge growth in this sector was and still is not in sight in Baltic States. Similar constrained growth story could be set up from Estonian transit oil business and railway freight company privatization, and later on its followed re-nationalization (Laisi and Poikolainen, 2010; Terk et al., 2007).

4. Role of International Lending Organizations

Among cohesion funds of European Union, international lending organizations such as European Bank for Reconstruction and Development (EBRD), European Investment Bank (EIB), Nordic Investment Bank (NIB) and World Bank have played important role in the support of the development of economies in Baltic States (e.g. comprehensive analysis from the past transportation logistics projects is given in Ojala et al., 2001 & 2005). However, as all Baltic States developed in economics terms so rapidly in recent decade time period, role of direct aid type of finance changed as loans. This also increased the presence of some banks, like EIB: Growth of lending in most recent observation period (years 2008-2012) increased by factor of 3-5 times. Figure 9 illustrates this drastic change further. However, it should be emphasized that EIB loans have mostly been taken during years 2008-2009 in the most recent spike period (detailed analysis on Ketels, 2012: 94).

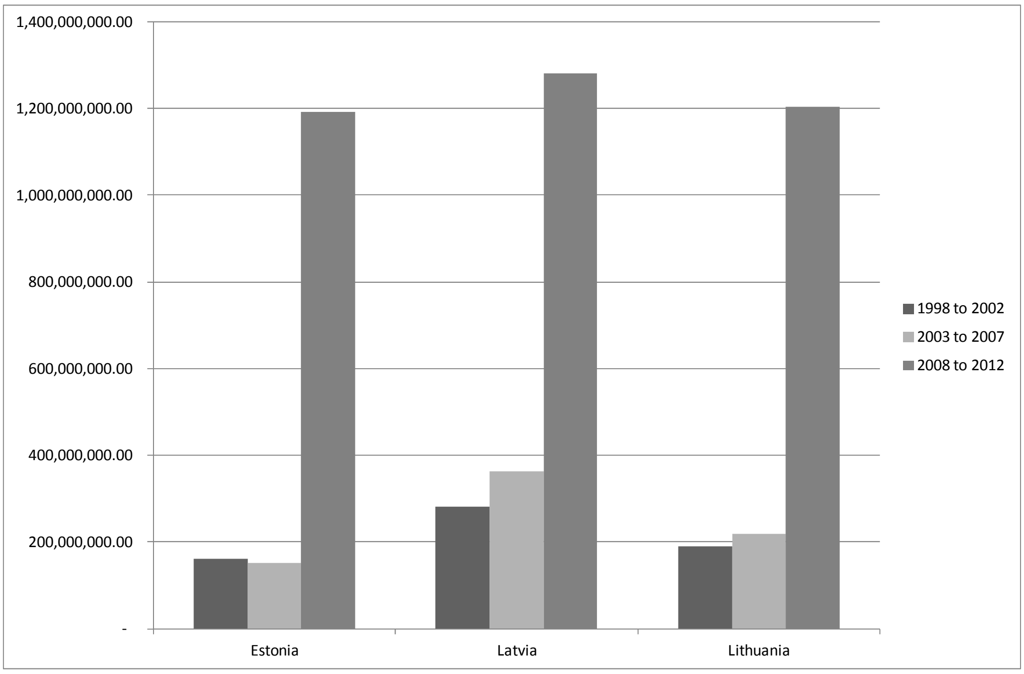

Figure 9. Amount of European Investment Bank (EIB) loans (in Euros) for Baltic States during period of 1998-2012 (March). Source: EIB (2012)

Although funding amounts have increased significantly from EIB, they have concerned transport, energy or industrial sectors in recent analyzed period (2008-2012) with not that impressive share. At least this is the case of Latvia and Lithuania (25 % from overall funding; Tables 2 and 3). In Latvia only company investing in large-scale into energy sector is state-owned Latvenergo, which is replacing old gas turbines and improving distribution network. EIB finance is 200 million EUR, but it should be reminded that EBRD provides additional 150 million EUR for this large project

(EBRD, 2012b). Apart from EU project co-financing loans, in Lithuania minor activity exist with further improvement of freight trains (have already started in period of 2003-2007) and small-scale industrial development loans.

Table 1. EIB financed projects in Estonia (in Euros) within transportation and energy sectors (period of 2008-2012). Source: EIB (2012)

Project	Sector	Signature	Amount
TALLINK RO-PAX II	Transport	18/12/09	90,000,000.00
MUUGA HARBOUR INTERMODAL FACILITIES	Transport	14/12/09	11,500,000.00
EU FUNDS CO-FINANCING 2007-2013 (EST)	Transport	25/05/09	115,500,000.00
PORT OF TALLINN EXPANSION	Transport	12/02/09	40,000,000.00
TALLINN MUNICIPAL INFRASTRUCTURE	Transport	19/11/08	31,955,000.00
TALLINK ROPAX	Transport	27/06/08	25,000,000.00
		Total:	313,955,000.00

Project	Sector	Signature	Amount
EESTI ENERGIA WINDPARKS	Energy	08/12/11	45,000,000.00
EESTI ENERGIA WTE	Energy	08/12/11	25,000,000.00
ESTLINK 2 TEN-E	Energy	18/11/10	75,000,000.00
EESTI ENERGIA POWER NETWORKS	Energy	25/05/09	150,000,000.00
		Total:	295,000,000.00

Table 2. EIB financed projects in Latvia (in Euros) within energy sector (period of 2008-2012). Source: EIB (2012)

Project	Sector	Signature	Amount
LATVENERGO CHP	Energy	02/10/09	100,000,000.00
LATVENERGO POWER DISTRIBUTION	Energy	24/10/08	100,000,000.00
		Total:	200,000,000.00

Table 3. EIB financed projects in Lithuania (in Euros) within transport and industry sectors (period of 2008-2012). Source: EIB (2012)

Project	Sector	Signature	Amount
CIE AUTOMOTIVE MULTITECHNOLOGY PARTS	Industry	23/12/09	3,000,000.00
WIENERBERGER PRODUCTION DEVELOPMENT	Industry	03/12/09	19,000,000.00
LITHUANIAN RAILWAYS II - LOCOMOTIVES	Transport	29/03/10	20,000,000.00
EU FUNDS CO-FINANCING 2007-2013 (LT)	Transport	13/03/09	226,400,000.00
		Total:	268,400,000.00

Estonian industrial and energy sector project portfolio looks more diverse and double to that of two other Baltic States (Table 1). In Transport sector improvements are targeted to the maritime sub-branch, which is natural, since Tallink Silja is one of the leading short sea shipping companies in Baltic Sea. Table 1 shows, how this operator modernized its fleet couple of years ago. Also improvement projects have been completed in Tallinn sea port (largest passenger sea port in Baltic States), and sea port's industrial terminal located in Muuga. Similar to Latvia, electric network and power generation is under renewal in Estonia. It is important to note that electricity distribution is not only improved within Estonia domestically, but also consist investment project of linking Estonian electricity network to Finland (submarine cable, ESTLINK 2 TEN-E). Notable is the role of wind energy, which has also been supported by EBRD (EBRD, 2012a). In overall solution for future energy needs, Estonia relies upon oil shale based energy production in the future too. It recently selected Alstom to supply power plant close to Narva (plant called as Auvere; Eesti Energia, 2012). It is unclear how finance of this power plant was case specifically organized (operational in 2015), however, should be noted that Eesti Energia gathered 300 mill. euros with bond sale from European investors in March 2011 (Eesti Energia, 2011).

In most recent information from EBRD (2012c), it is reported that they are committed in the funding of the new energy production capacity of Lithuania. This due to the closure of Ignalina Nuclear Power Plant (large-scale facility, which was closed in the end of 2009, major producer of electricity, even contributing to export). Based on EBRD (2012c) brochures, help in energy production is being implemented with the renewal of old gas turbines at Lietuvos Elektrine – sharing similarities with Latvia's gas investments.

5. EU Cohesion Funding

All three Baltic States became full members of European Union (EU) during May.2004. Until today only Estonia is also member of monetary union, Euro, while Latvia and Lithuania have still in use national currencies. EU membership has enabled all three countries to access important cohesion funds (in here incl. European Regional Development Fund, European Social Fund and Cohesion Fund), which are given for the development of economically less developed regions in Europe. For program period of 2007-2013 total sums were as follows (EU Regio, 2012): 3.4 bill. euros for Estonia, 4.6 bill. euros for Latvia and 6.8 bill. euros for Lithuania. In comparison, more or less similarly sized with Baltic States, Finland and Sweden received 1.7 bill. euros and 1.9 bill. euros respectively. So, due to economical situation, Baltic States attracted nearly eight times development funds as compared to neighbors in west or north. These large sums of development funds are not only intended for transportation infrastructure or manufacturing industry development, but are used to improve and protect environment, foster R&D and innovation as well as healthcare (e.g. EU Structural Assistance to Estonia, 2012). It could be assumed that one third or one fourth from total funds will be devoted to transportation infrastructure.

Baltic States were able to enter EU cohesion funds partly during program period of 2000-2006, as EU accession was completed in May.2004. However, funding in this period was rather limited. For transportation infrastructure following sums were granted (Steer Davies Gleave, 2010): 233 mill. euros for Estonia, 409 mill. euros for Latvia and 208 mill. euros for Lithuania. For the author other granted sums are unknown. Anyway, even if funding sums seem to be rather small, it should be remembered that for Baltic States these sums were still significant in years 2004-2006. Also it should be noted that program period was only three years long.

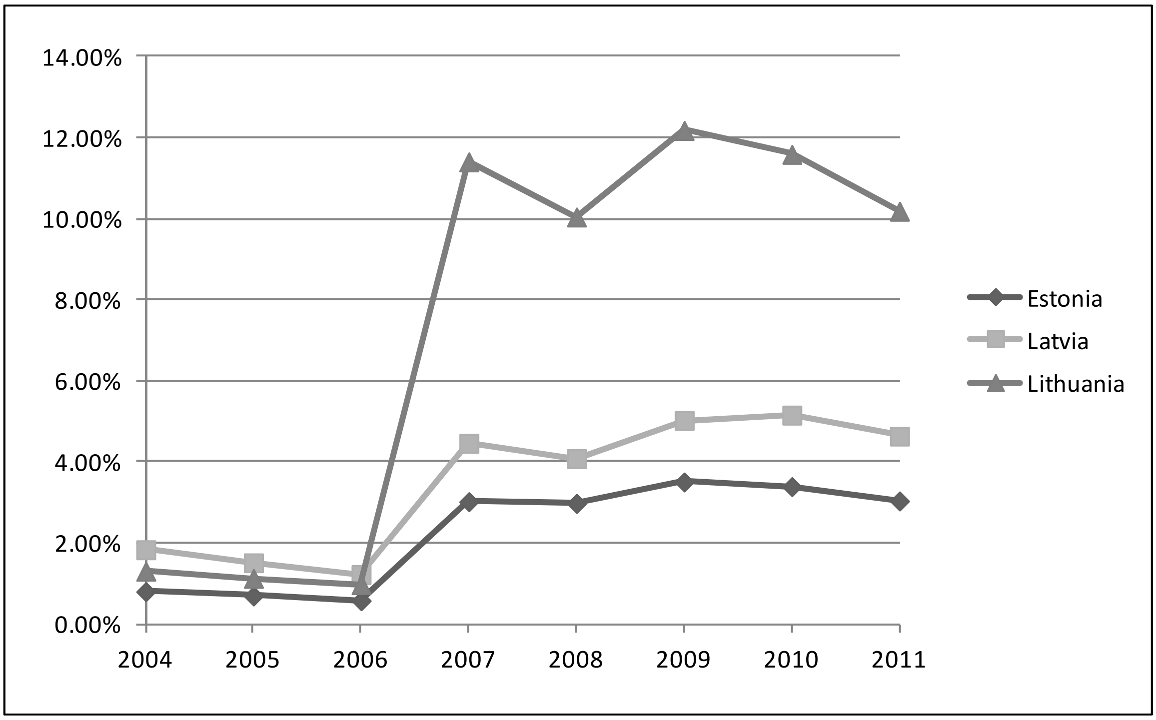

Figure 10. Share of EU Cohesion funds in Baltic States from GDP during years 2004-2011.

Importance of EU cohesion funds is illustrated in Figure 10 by estimating what is their share from respective year's GDP. In here we have distributed cohesion funds equally to program period, and for the years 2004-2006 is only devoted these known transportation infrastructure funds. At first glance it is inevitable that especially most recent program period has played key role in the economy development. It could be even argued that for Lithuania these funds play too large role, and dependence as well as economy overheating could be caused by these. It could also be argued that without this funding, all Baltic States would have suffered even more from credit crunch, and their recovery would have been much more fragile. Without a doubt these funds have played key role as an instrument to stimulate the economies.

6. Conclusions

As emerging economies, Baltic States have attracted significant amount of FDI after late 90's. However, this rapid growth of FDI stock showed leveling off development during year 2009 in Estonia and Latvia – in Lithuania year 2008 was showing decline. Based on our analysis, important and large scale loans were available in this moment, but were mostly used in years 2008-2009. Thereafter, three Baltic economies have showed rather cautious approach for making investments. However, in positive respect effect of credit crunch was short-term lived, and FDI has started again to increase in all countries. This growth has its limits, since very robust growth was caused earlier by domestic oriented sectors (finance, real estate, construction and retail), and growth from now onwards need to be attracted out of export oriented sectors (like manufacturing and transport).

As all three Baltic State economies are rather small ones in absolute terms, it is rather fortunate for them that they joined EU already during year 2004. From current EU cohesion funds Baltic countries (among other east and south European counterparts) receive relatively high sums. This enables them to renew e.g. transportation infrastructure in large-scale. Even if instrument could be seen as stimulating element, it should be connected more on attracting FDI inflows too. So, these infrastructure investments should enable higher amount of transit transports through Baltic States, and as well support inauguration of export based manufacturing industries. Of course, it is problematic in EU cohesion funding perspective to support these, but taking into account this perspective, together with population well-being, should not be impossible. However, measures should be integrated into most important area of economic development: Improving trade deficit in all three countries, and in particular Latvia and Lithuania. Current situation in these two mentioned countries resembles too much life before crisis, which does not lead to sustained growth.

For the further research, we would be interested to build a model (e.g. analytical or simulation), which would take into account different forms of capital inflows in economically less developed countries in Europe, and also estimate role of capital inflows into development of GDP. Most probably private and public sector attraction of funds plays key role. For the future development we would like to seek countries or regions, where these attracted funds have resulted on investments and renaissance of export based industries. Without this important link, fund inflows are just cause of yet another recession as business confidence erodes for one reason or the other. This again leads to massive unemployment, which is entirely undesired outcome in the current state of European economy.

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Introducing Scenario Planning to manage Supply Chains in an uncertain environment

Christian Daum, Raphael Moser, Johannes Book, Gisela Lanza
Karlsruhe Institute of Technology, wbk Institute of Production Science,
Campus Süd, Kaiserstraße 12, 76131 Karlsruhe, Germany,
ChristianDaum@ymail.com
Raphael.Moser@kit.edu
Johannes.Book@kit.edu
Gisela.Lanza@kit.edu

Don Fleet
University of Cambridge, Institute for Manufacturing,
Alan Reece Building, 17 Charles Babbage Road, Cambridge, CB3 0FS, UK,
def25@cam.ac.uk

Abstract

To keep their competitive edge companies seek to exploit the best available resources. As a result most companies' Supply Chains are highly interrelated and spread all over the world. This global set-up and the surrounding highly dynamic environment increase the level of uncertainty within a company's Supply Chain. In such an environment, anticipating future trends and being able to adapt quickly to changes has become an imperative. For this purpose Scenario Planning has been introduced and advanced since decades. Nevertheless, the academic literature about the application of Scenario Planning in a Supply Chain context is still very limited. Scenario Planning is understood to be the composition of developing future states and deriving strategy based on these future states. Hence a logical first step to narrow the academic gap is to assess Scenario Development techniques and their suitability to create scenarios for a Scenario Planning exercise within a Supply Chain context.

Keywords: Supply Chain, Scenario Planning, Scenario Development, Future Studies, Uncertainty

1. Introduction

In 2010 the former chairman and CEO of Caterpillar Jim Owens stated about Caterpillar's industry:

> "*The competitor that's best at managing the Supply Chain is probably going to be the most successful competitor over time. It's a condition of success.*" (Malik *et al.*, 2011)

This quote highlights Caterpillar's dependency on its Supply Chain performance and indicates a change in nowadays business strategy, as Supply Chain management was not always considered to be vital for the overall business competitiveness (Singh, 2009a). To understand the change in perspective of Supply Chain management its development since the 1980s is reflected briefly.

In the mid-1980s Henzler and Rall recognised the increasing globalisation of manufacturing companies and demonstrated that changes in national markets and the opportunity to achieve scale effects were pushing companies to increase their global presence (Henzler and Rall, 1986; Dhingra, 1991; Kumar and Gregory, 2007).

In the following years the internationalisation of companies was mainly facilitated by the breakdown of the east-west-divide, which caused a decline of national boarders as well as deregulation, privatisation and liberalisation of national markets (Mills and Blossfeld, 2003). The consequence of the liberalisation of markets was a strong rise in international competition. In order to sustain competitiveness companies sought to use the new opportunities and began to spread their sites around the world (Mills and Blossfeld, 2003). In their effort to increase efficiency and effectiveness, companies within a Supply Chain increased their level of cooperation and co-creation, which led to highly intertwined Supply Chain partners (Christopher, 2000; Singh, 2004).

Additionally to the shifts in national policies, a fast technological change took place supporting the dispersion of multinational companies. It also led to shorter product-life cycles and faster changing customer requirements and thereby increased the volatility of markets (Singh, 2004; Norrman and Jansson, 2004).

After years of rapid political and technological changes, today's companies find themselves being a part of a highly intertwined and complex Supply Chain with customers and competitors in various markets, facing a highly dynamic and unpredictable future (Christopher, 2000; Singh, 2004; Mills and Blossfeld, 2003).

In such an environment, anticipating future trends and being able to adapt quickly to changes has become an imperative (Chermack *et al.*, 2001; Singh, 2009b; Varum and Melo, 2010). Nevertheless, many companies have not yet developed the required capabilities to address the high level of complexity and uncertainty (Malik *et al.*, 2011).

This might be due to the fact that many strategists are deriving business strategy based on a singular view of the future, which has been developed by extrapolating historical data. This traditional strategic planning approach is too limited to provide the required insights for strategists to spot possible threats or opportunities and create strategies to use them (Wack, 1985a; Singh, 2009a).

In contrast, Scenario Planning approaches suggest to create strategies by drawing out multiple, alternative future scenarios, which has shown to be a useful mean to improve decision making in an uncertain and turbulent environment (Chermack *et al.*, 2001; Bradfield *et al.*, 2005). Nevertheless, the academic literature about the application of Scenario Planning in a Supply Chain context is still very limited.

2. Background

2.1 History and development

One of the first Scenario Planning implementations took place in the 1940s, when Herman Kahn and his team conducted research about new types of weapons, and developed strategies for the United States Department of Defence. After world war two the RAND (Research and Development) Corporation was founded, where Kahn developed a technique called 'future-now thinking'. The aim of 'future-now thinking' was to generate reports of a possible future state by combining simulation models and the Delphi technique to improve decision making (Chermack *et al.*, 2001; Bradfield *et al.*, 2005).

Kahn's work on the consequences of a 'nuclear war by miscalculation' had a major impact on American's military leaders. By 'thinking about the unthinkable' he became the first to developed scenarios to find alternatives to annihilation and surrender as a result of nuclear war. With publishing his results in his book 'On Thermonuclear War' in 1960, the popularity of Scenario Planning quickly rose (Bradfield *et al.*, 2005).

With some colleagues from RAND Kahn founded the Hudson Institute in 1961 where they extended the scope of 'thinking about the unthinkable' from military planning to the fields of social forecasting and public policy (Van der Heijden, 1996; Chermack *et al.*, 2001). In cooperation with the Royal Dutch Shell company they began constructing scenarios for the year 2000. This Scenario Planning exercise helped Shell to predict a steep increase in oil

prices and allowed them to react quickly when prices rose rapidly after the Yom Kippur war in 1973 (Chermack *et al.*, 2001).
Inspired by the success of Kahn's book, two RAND employees, Theodore Gordon and Olaf Helmer, founded the Institute of the Future. Together with members of the Stanford Research Institute's (SRI) 'Future Group' and the California Institute of Technology they advanced the Scenario Planning methodology (Ringland, 1998; Van der Heijden, 1996). The developed methodologies at the SRI and Royal Dutch Shell are part of the 'Intuitive Logics' school of Scenario Planning (Huss and Honton, 1987a).
Besides their work for the Institute of the Future, Gordon and Helmer continued working for RAND. They argued that future events cannot be seen in isolation, since events with a high impact are likely to affect the probability and consequences of other events. To tackle this problem Gordon and Helmer developed a probability driven approach to account for the interrelated nature of events. This school of future planning is called 'Cross-Impact analysis' (Bradfield *et al.*, 2005).
Another rather quantitative approach to Scenario Planning is the Trend-Impact analysis. It was pioneered in the American based Future Group in the 1970s. Their approach was based on the assumption that there is no surprise-free future (Bradfield *et al.*, 2005) as the traditional forecasting method suggests. Extrapolating historical data and providing one single future ignores the possible occurrence and impact of trend-changing events. The Future Group's model integrated this idea into traditional forecasting, and is thereby able to illustrate how the trajectory of baseline trends might be impacted by occurring event (Bradfield *et al.*, 2005).

Whilst Kahn was developing scenarios for military use, Gaston Berger a French philosopher proposed a different methodology for developing scenarios. He called his process of long-term planning La Prospective (prospective thinking). The aim of La Prospective was to establish a framework to develop positive images of the future. These images should serve as visions for policy makers and France itself. Although, Berger died in 1960 his work was continued by Bertrand de Jouvenel for the national economic plan in France. Since the 1970s, Michael Godet began to develop mostly computer supported methods to improve the procedure and outcome of La Prospective (Bradfield *et al.*, 2005).

2.2 Scenario Planning – Definition

As shown in the previous section, Scenario Planning has evolved over time and in different geographical regions. As a consequence the terms 'Scenario' and 'Scenario Planning' have been defined in many different ways. To demonstrate the variety of definitions the most recognised are presented in the following.

The term 'Scenario' has his origin in the movie and theatre production where it was used as alternative expression for a script (Schwartz, 1991). In the context of future studies, Kahn was one of the first to define the term. He stated that scenarios *"are hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision-points"* (Eden and Ackermann, 1998). Peter Schwartz, head of the Scenario Planning department at Royal Dutch Shell in the early 1980s, popularised the Scenario Planning approach by publishing 'The Art of the Long View' in 1991. He perceives scenarios as *"a tool for ordering one's perceptions about alternative future environment in which one's decision might be played out"* or alternatively *"a set of organised ways for us to dream effectively about the future"* (Schwartz, 1991). In 'Competitive Advantage', Michael Porter defined scenarios as *"an internally consistent view of what the future might turn out to be"* and stressed that scenarios are *"not a forecast, but one possible future outcome"* (Porter, 1985).

A more general definition has been provided by Peter Bishop *et al.* who defined scenarios as every description of an alternative future. Therefore, scenarios can be seen as *"the archetypical product of future studies"* (Bishop *et al.*, 2007).

Scenario Planning again has been defined in various ways. Gill Ringland and Kees van der Heijden argue that Scenario Planning is a structured approach to strategic business planning for handling the uncertainty of the future (Ringland, 1998; Van der Heijden, 1996). However, Schoemaker takes a different point of view and highlights that Scenario Planning is *"a disciplined methodology for imagining possible futures in which organizational decisions may be played out"* (Schoemaker, 1995).

To clarify the understanding of Scenario Planning within the context of this research, Scenario Planning in this paper is understood to be *"Developing strategies for managing an uncertain world based on the structured creation of alternative future descriptions."* It is important to underline that Scenario Planning does not just include scenario creation, but also includes the identification and analysis of possible actions.

2.3 Success Factors for Scenario Planning

Although Scenario Planning has been introduced by many as a logical and structured approach, its success depends on a variety of small factors and is therefore perceived as an art (Schwartz, 1991; Van der Heijden, 1996; Godet, 2000). To assist inexperienced practitioners and researchers in their Scenario Planning exercise, Van der Heijden has highlighted five criteria essential for successful Scenario Planning, many of which are supported by other practitioners and researchers (Van der Heijden, 1996):

- A minimum of two scenarios have to be developed to mirror uncertainty (Wack, 1985b; Van der Heijden, 1996)
- The scenarios have to be plausible (Schwartz, 1991; Schoemaker, 1993; Van der Heijden, 1996)
- The scenarios have to be internally consistent (Schoemaker, 1993; Van der Heijden, 1996)
- The scenarios must be relevant to the user's deepest concerns (Van der Heijden, 1996; Chermack *et al.*, 2001)
- The scenarios must challenge the current paradigms and change manager's mindset (Wack, 1985a; Schwartz, 1991; Van der Heijden, 1996)

These five criteria are vital for a successful application of Scenario Planning and should therefore be of consideration (Van der Heijden, 1996).

3. Objective and Methodology

Scenario Planning has previously been defined as *"Developing strategies for managing an uncertain world based on the structured creation of alternative future descriptions."* Hence, it is the composition of developing future states and deriving strategy based on it. 'Scenario Development' instead is understood to be the scenario creation process. To be more precise, 'Scenario Development' exclusively focuses on developing a future state and does not include the decision making process.

Hence a logical first step to narrow the academic gap within the Scenario Planning literature is to assess Scenario Development techniques and their suitability to create useful scenarios for a Scenario Planning exercise within a Supply Chain context.

To achieve this objective the process has been divided into 4 steps:

1. Define suitable categories of Scenario Development techniques to cluster the existing ones
2. Derive requirements for Scenario Development techniques for the application within a Supply Chains context
3. The introduced Scenario Development categories will be analysed based on the identified requirements to assess their usability
4. The analysis will be discussed and the suitable Scenario Development categories will be elected

4. Categories of Scenario Development techniques

Over more than half a century of modern-day Scenario Planning, numerous researchers and practitioners have developed an enormous number of Scenario Development approaches. They can differ in process, product, starting point, nature (quantitative or qualitative), perspective (from present to future or vice versa) and level of assistants from IT support (Bishop *et al.*, 2007). To review most of them in detail would exceed the boundary of this research. Addressing this vast variety, Bishop *et al*. have been proposing a classification of Scenario Development techniques. In their review of the state of Scenario Development, they defined eight general categories of Scenario Development techniques, namely: Judgement, Baseline/expected, Elaboration of fixed scenarios, Event sequences, Backcasting, Dimensions of uncertainty, Cross-impact analysis and Modelling (Bishop *et al.*, 2007).
To the best of our knowledge there is no other established categorisation of Scenario Development techniques. There are indeed different approaches to categorise Scenario Planning methodologies (see Huss and Honton, 1987a; Bradfield *et al.*, 2005). However, both categorisations miss to include multiple Scenario Development techniques (compare Bishop *et al.*, 2007). As a consequence the categorisation of Scenario Development techniques proposed by Bishop *et al*. will be used to assess the usability of Scenario Development techniques for Scenario Planning within a Supply Chain context.
In order to create a common understanding the eight categories will be described in the following.

4.1 Scenario Development techniques

4.1.1 Judgement

Judgement describes all techniques which are primarily based on the opinion of individuals or groups about the future. This form of predicting the future can be supported by various means. Some argue that meditative techniques should be used to boost creative thinking about the future while others suggest setting up a role play to simulate how main actors might behave (Bishop *et al.*, 2007). One of the few structured approaches was proposed and successfully used by Coates (2000).
His technique is subdivided into five steps:

1. Define domain and time frame for the Scenario Development exercise
2. Identify describing conditions and variables
3. Generate four to six scenario themes which describe possible future states and significantly concern the domain (e.g. Rapid growth of emerging countries; Global stagnation; etc.)
4. Assign different values to each condition and variable depending on the theme
5. Write scenario

Since Judgement techniques are solely based on people's opinion, their results are strongly dependent on the knowledge, expertise and creativity of each participant. Due to their simple design, Judgement techniques are easy to execute and might lead to novel insights. Nevertheless, the subjective nature of such techniques might reduce the credibility of the scenarios (Bishop *et al.*, 2007).

4.1.2 Baseline/expected

The aim of every baseline/expected Scenario Development technique is to exactly determine the most likely future state. In its simplest form, baseline scenarios are created by extrapolating existing trends in a qualitative or quantitative way. At the University of Hawaii one baseline technique has been developed. This technique begins with individually assessing three almost undisputable trends, followed by a qualitative cross-impact analysis. Finally one scenario is drawn out based on the results of step one and two.
Baseline scenarios are criticised because they suggest certainty, although they will rarely fulfil in reality. Nevertheless, they can serve as useful starting position for developing alternative future scenarios. Furthermore, presenting a baseline scenario is not likely to meet resistance in the audience, since it will not conflict with anyone's mind-set (Bishop *et al.*, 2007).

4.1.3 Elaboration of fixed scenarios

As the title of the category indicates, techniques in this cluster start by providing fixed scenarios or fixed scenario titles. The user's task is to elaborate the fundamental idea behind the scenario. By doing so, the implications of each scenario might be revealed, which could lead to a better understanding of possible future developments (Bishop *et al.*, 2007).
One technique within this category is Incasting. Incasting starts by presenting rather extreme scenarios to the participants. These scenarios can be stories about a high-tech future, a green future, and so on. After providing the participants with these scenarios they are asked to describe how certain field might be shaped in each specific scenario. By doing so, multiple future scenarios are drawn (Bishop *et al.*, 2007).
A slightly different approach to Scenario Development was introduced by the Stanford Research Institute. Instead of providing extreme stories of alternative futures, they suggested that only the fictive titles of scenarios should be provided. The participants are then asked to complete a matrix similar to the one shown in Table 1 (Bishop *et al.*, 2007).

	Technology	Economic	Oil price	Labour cost	...
Expected future					
Worst case					
Best case					
...					

Table 1 - SRI: Elaboration of fixed scenarios

The arrangement of each scenario can be seen in every row, while the possible variation of a certain dimension can be seen in the corresponding column (Bishop *et al.*, 2007).

Conducting an 'elaboration of fixed scenarios' technique, is an easy way to create very detailed scenarios. However, there are two major drawbacks. First, the inherent logic of the provided scenario might not be of concern to the user and second, the level of assessment of uncertainty strongly depends on the given dimensions by which participants have to characterise the provided scenario (Bishop *et al.*, 2007).

4.1.4 Event sequence

The idea of all techniques in the category ‘event sequence’ is that the future is shaped by the successive occurrence of events. The Scenario Development therefore starts by defining an event. The event can be seen as a decision point dividing the future depending on its occurrence or non-occurrences. An event can also have multiple outcomes, in which case the number of branches increases (Bishop *et al.*, 2007).

If probabilities are assigned to each trend the resulting graph is a ‘probability tree’. Probability trees are commonly used in risk management to assess the likelihood of multiple risks happening simultaneously. Sociovision advances the idea of probability trees by bunching together similar event sequences. The events happening in each bunch of event sequences are then used to describe a future scenario (Bishop *et al.*, 2007).

Another interesting way of building event based scenarios is called ‘divergence mapping’. Divergence mapping successfully integrates the idea of a morphological analysis into an event sequence technique. Divergence mapping can be used to develop various plausible future states and is divided into three steps (Bishop *et al.*, 2007):

1. Brainstorm events of concern to the decision experience
2. Draw a fan-like structure and place the events on the fan, depending on the expected time of occurrence.
3. Connect events which are likely to occur together

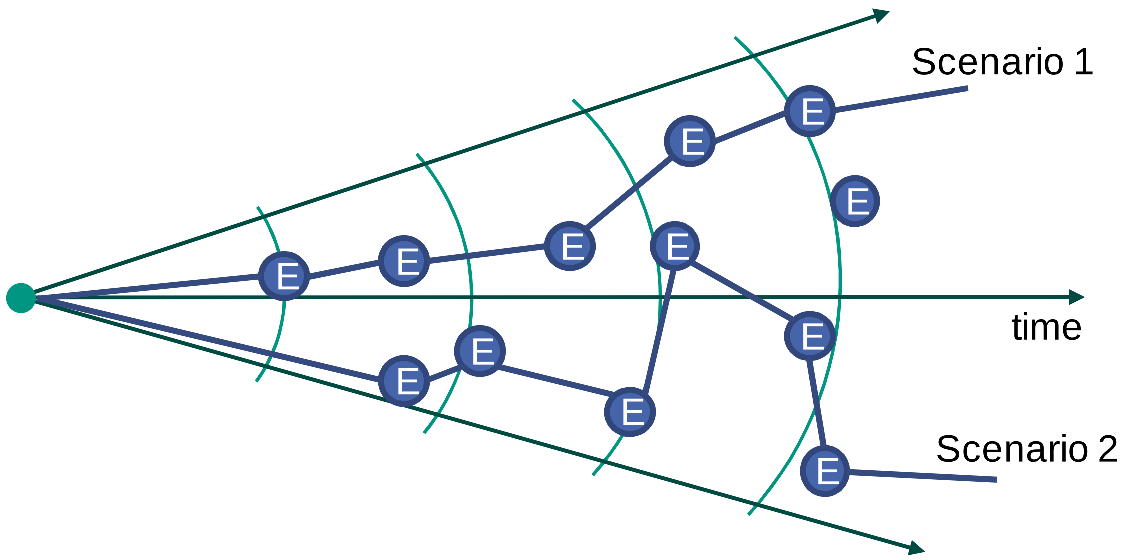

Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**1 - Event sequence

By applying divergence mapping, a variety of plausible future scenarios can be created (see Figure 1).

Creating multiple future scenarios by conducting an event sequence technique is a rather simple task and can be done without an extensive preparation. However, the assumption that events occur in a fixed order is highly doubtful (Bishop *et al.*, 2007).

4.1.5 Backcasting

Backcasting can be understood as the opposite of forecasting, as it starts with a defined future state or vision and works its way back to the present. The nature of the envisioned future state can be chosen freely. It can for example have a highly unrealistic, a catastrophic or plausible character. While working backwards from the future to the present the participants of a Backcasting session are asked to imagine milestones, events and happenings which need to occur for the future state to fulfil (Bishop *et al.*, 2007).

One popular Backcasting technique has been developed by NASA to identify technical innovations. Based on the current state-of-the-art in aerospace engineering, an entirely infeasible mission is drawn out. Engineers are then asked to decompose the mission into required components. These components again are decomposed and so on. By doing so, short-term milestones for R&D can be identified which might one day enable NASA to accomplish the ‘infeasible’ mission (Bishop *et al.*, 2007).
IBM developed a related approach which differs in two points: First, the starting point is not one future scenario instead multiple scenarios serve as such. Based on these future states the experts of the field are asked to mark required breakthroughs. The second difference to the NASA approach is the purpose. Instead of trying to identify near term milestones for R&D, the IBM approach tries to identify signposts which can be used to monitor future development and develop a contingency plan to reduce respond time in case of an occurrence of a breakthrough.

Since the development of scenarios starts from a future state and autonomous from the present, developers and scientists are less likely to be hold back by their rational mind, which might bias their imagination and creativity (see Bishop *et al.*, 2007).

4.1.6 Dimension of Uncertainty

The main purpose of Scenario Development is to prepare decision makers for an uncertain future by prophesying possible future states and illustrating hidden consequences. Doing so has been shown to broaden decision makers’ horizon for options which they would have otherwise dismissed, which in turn leads to an improved decision-making (Schwartz, 1991).

To achieve the desired benefit of Scenario Planning, techniques in this category directly address uncertainty by using uncertain trends or variables to create the inherent logic of scenarios (Bishop *et al.*, 2007).
Schwartz approach to Scenario Planning is to analyse the system and its environment, rank trends and drivers by uncertainty and impact and use the highest ranking factors as basis for the scenario creation (1991). Therefore, Schwartz's Scenario Planning approach can be classified as a ‘dimension of uncertainty’ technique.

The same argument counts for the morphological analysis introduced in La Prospective as dimensions of uncertainty are integrated as columns of a morphological space (Godet, 2004).

The major advantage of this category is the direct integration of uncertainty into the scenario developing process. Nevertheless, to successfully apply these techniques knowledgeable and experienced experts are needed to stretch out plausible and consistent scenarios.

4.1.7 Cross-impact analysis

The basic thought justifying the existence of cross-impact analysis techniques is that trends and events have a mutual impact, which must be addressed when creating future scenarios. Various different approaches to cross-impact analysis can be found in the academic literature.

The following six steps can be found in most scenario developing techniques using a cross-impact analysis (Huss and Honton, 1987a; Huss and Honton, 1987b):

1. Define the scope of analysis
2. Aggregate and analyse variables, trends and events which impact the field of study
3. Assign a priori probabilities of the occurrence of impacting factors
4. Quantitatively assess the mutual influence of trends, events, and variables
5. Run a simulation or a deterministic model to determine scenarios and their probability
6. Use results of step five and draw out multiple future scenarios

Both quantitative and qualitative factors can be incorporated into a cross-impact analysis. Hence, cross-impact analysis is a very flexible approach, which allows to integrate basically every trend, event or variable. Cross-impact analysis requires computer support for simulation or for running a deterministic model. This might lead to the perception that the results are based on an objective source, although the estimation of probabilities and assessment of relation is done by individuals or groups and is therefore of subjective nature (Godet *et al.* 2004).

4.1.8 Modelling

Techniques in this category base their scenario development on the output of computerised images of the field of study, so called system models. System models are widely used for baseline forecasts. To create multiple alternative future scenarios the baseline forecast is altered by changing variables or integrating trend changing events into analysis. Two popular modelling techniques are the Trend-impact analysis and the Sensitivity analysis (Bishop *et al.*, 2007).

Sensitivity analysis alters the baseline forecast by changing one of the three parts in a system model (Bishop *et al.*, 2007):

1. The values of exogenous variables
2. The parameters which define the effect of the variables
3. The variables

Exogenous variables are the input values of the model. In an economic model interest rates or tax rates are an example for exogenous variables. The parameters are the coefficient by which an independent variable affects a dependent variable. Staying with the economic system model: If Z is the GDP of a country, X the interest rate and Y the tax rate, a system model could be $Z=aX+bY$; Hence, changing the parameters 'a' or 'b' effects the strength of the impact of interest rate or tax rate on the GDP. The variables of a system model are the last possibility to examine the sensitivity to changes in set up of system models. One could simply exclude the tax rate from the economic system model and argue that the GDP is only dependent on the interest rate, and thereby vary the output of the system model (Bishop *et al.*, 2007).

Another popular modelling technique is the Trend-impact analysis. The basic idea behind the Trend-impact analysis is that a historical extrapolated trend will change his trajectory, if certain events occur. A basic Trend-impact analysis includes the following steps:

1. Define trend and trend-affecting events
2. Examine probability and impact of event
3. Run computer model

The computer model will then compute the new trajectory of the investigated trend depending on the assigned probability and impact of the occurring events (Bishop *et al.*, 2007).

Both presented modelling techniques can produce multiple useful scenarios of the future. Nevertheless, the quality of an individual forecast is strongly dependent on the quality of the model and the historical data (Bishop *et al.*, 2007).

4.2 Deriving requirements

To specify the requirements for Scenario Development techniques in the given context, the characteristics of today's Supply Chains and its environment are highlighted. In addition to these context specific needs, general Scenario Planning success factors are provided to complement the list of requirements.

In chapter 2.3 success factors for Scenario Planning have been pointed out. It has been mentioned that to be truly effective, multiple scenarios have to be developed, in a plausible, internally consistent, relevant and challenging manner.

Also, it has been mentioned, that the focus of Supply Chain management is changing. Instead of exclusively optimising its own Supply Chain operations, companies increasingly cooperate and co-create to achieve a sustainable competitive advantage against competing Supply Chains. As a consequence of this development Supply Chain entities are increasingly intertwined (Christopher, 2000; Singh, 2004).

To further improve their competitive edge, companies seek to exploit the best available resources and try to benefit from rapidly growing emerging economies. As a result, most Supply Chains are globally dispersed (Srai, 2007).

Additionally to the transformation of design and management of Supply Chains, its environment changed as well. Fast technological advancements led to a wide variety of product configuration and increase the customer's desire for customised products. As a consequence of the fast changing customer demand, product life cycles are becoming shorter. The combined appearance of high variety and reduced life cycles further raises the level of demand uncertainty (Fisher, 1997; Singh, 2004; Norrmann and Jansson, 2004).

When reflecting the given environmental and business characteristics, it becomes clear that an appropriate Scenario Development technique needs to be able to address uncertainty and to allow a high level of complexity.

Consequently, a Scenario Development technique in a Supply Chain context, should...

- address uncertainty,
- allow complexity,

and be able to create

- plausible,
- internally consistent,
- challenging,
- and relevant

scenarios.

4.3 Analysis of Future Studies

Before assessing the usability of each Scenario Development technique, the measures will be described in detail to avoid confusion (see Table 2).

Requirement	Description / Question
Addresses uncertainty	Level of support to 'think about the unthinkable'
Allows complexity	Ability of technique to integrate a high variety of variables
Plausibility	Does technique lead to plausible scenarios?
Internal consistence	Does technique lead consistent scenarios?
Challenging character	Does technique lead to challenging scenarios?
Relevant	Does technique lead to relevant scenarios?
Possible number of scenarios	How many scenarios can be created?

Table 2 - Measures for assessment

Based on these requirements all eight Scenario Development categories are analysed. The results of the analysis can be seen in Table 3.

	Addresses uncertainty	Allows complexity	Plausibility	Internal consistence	Challenging character	Relevant	Possible number
Judgement	*Moderately* Little guidelines provided; Outcome strongly dependent on individual	*Yes* Only limited by the imagination of participants	*Dependent* on source, presentation and storyline of scenarios	*Dependent* on the storyline of scenarios	*Dependent* on the storyline of scenarios	*Yes* Thorough analysis of domain	infinite
Baseline / expected	*No* Aim is to identify the most likely future scenario	*No* Very limited number of variables possible	*Yes* Baseline scenario presents the most likely case	*Yes* Extrapolates an excising trend	*No* Expected scenario without surprises	*Dependent* on relevance of extrapolated trend	1
Elaboration of fixed scenarios	*Moderately* Dependent on provided scenario themes or titles and dimension of analysis	*Yes* No limitation of descriptive variables	*Dependent* on the input by participants and inherent logic	Dependent on the input by participants	*Dependent* on the input by participants and starting point	*Dependent* on the relevance of starting point	infinite
Event sequence	*Moderately* Based only on critical events; Assumes a fixed chronological order of events	*No* Limited to future events; Very little flexibility, due to sequential order	*Dependent* on chosen events and order of events in a sequence	*Dependent* on chosen events and order of events in a sequence	*Dependent* on chosen events and order of events in a sequence	*Yes* Only events relevant to issue are included in analysis	limited
Backcasting	*No* Target is only to look for the next milestone on the way back to present	*Yes* Working back from future to present is not limited	*Dependent* on starting point of the Scenario Development exercise	*Dependent* on identified milestones on the way back from future to present	*Dependent* on starting point	*Dependent* on relevance of starting point	infinite

	Addresses uncertainty	Allows complexity	Plausibility	Internal consistence	Challenging character	Relevant	Possible number
Dimensions of Uncertainty	*Yes* Directly integrates uncertainty as logic of the scenario; Broad analysis of influencing factors	*Yes* All kinds of variables such as trends, key drivers and other dimensions of uncertainty can be integrated into analysis	*Dependent* on the selected scenario logic; Dependent on the scenario's story line	*Dependent* on the selected scenario logic	*Yes* Confronts participants with uncertainties and is likely to challenge mind-sets	*Yes* Strong focus on issue	infinite
Cross-impact analysis	*Yes* Thorough analysis of influencing variables, trends or events	*Yes* Both quantitative and qualitative variables can integrated in analysis	*Dependent* on the quality of the input	Yes Mathematical model corrects input errors and clusters variables which are likely to occur together	*Dependent* on input variables	*Yes* Variables are chosen only if they are influencing the issue	limited
Modelling	*Moderately* Little need to consider unexpected happenings	*Limited* Rather small number of variables; Variables have to be quantifiable	*Dependent* on the quality of the model and input	*Yes* Only few/little changes of extrapolated excising trend	*No* Models are an image of reality and based on extrapolated trends, hence little surprising	*Dependent* on the relevance of model or extrapolated trend	infinite

Table 3 - Analysis of Future Study categories

4.4 Selection and Discussion

The level of fulfilment of each requirement by each Scenario Planning category was measured and clustered into three groups. These groups are ‘full fulfilment of requirement’ (green), ‘degree of fulfilment strongly dependent on execution’ (yellow), and ‘not fulfilled’ (red) (see Table 4).

	Addresses uncertainty	Allows complexity	Plausibility	Internal consistence	Challenging character	Relevant	Possible Number
Judgement							
Baseline / expected							
Elaboration of fixed scenarios							
Event sequence							
Back-casting							
Dimensions of Uncertainty							
Cross-impact analysis							
Modelling							

Table 4 - Results of analysis

As all eight requirements are vital for a Scenario Development exercise in a Supply Chain context four out of all eight categories are dismissed. These four categories are ‘Baseline / expected’, ‘Event sequence’, ‘Backcasting’ and ‘Modelling’.

Nevertheless, the categories 'Judgement', 'Elaboration of fixed scenarios', 'Dimensions of Uncertainty' and 'Cross-impact analysis' provide various techniques to create suitable scenarios for a Scenario Planning exercise within a Supply Chain context. To deepen the understanding of these four categories, their advantages and disadvantages will be discussed in the following.

Judgement
Judgement has some obvious advantages, which are the simple design, high level of flexibility and simple execution. Due to its flexibility nearly all issues can be addressed by a Judgement technique. Also the relevance of scenarios is ensured, as thoroughly analysing the issue is an emphasised process step. The major drawback is the high level of dependence on the participant’s abilities.

Elaboration of fixed scenarios
Elaboration of fixed scenarios is a rather simple technique to execute and does not limit the number of variables under investigation. The success of the elaboration of fixed scenarios is strongly dependent on the provided scenarios or scenario themes and the creativity of the participants.

Dimensions of Uncertainty
Techniques in this category are best suited for an uncertain environment, as uncertainty is directly integrated as the logic of scenarios. Furthermore, a wide scope of influencing factors is analysed. The challenging character is guaranteed, as participants are directly confronted with uncertain future conditions. The relevance of resulting scenarios is ensured by the strong focus on the issue, while internal consistence and plausibility are dependent on the scenario's logic and story line.

Cross-impact analysis
A cross-impact analysis is suitable for a highly uncertain environment and a complex arrangement, as influencing variables are not limited and thoroughly analysed. Internal consistence is achieved as mathematical models correct input errors and cluster variables which are likely to occur together. The initial analysis in the first step of the process strongly emphasises the focus on influencing issues which guarantees relevance. On the other hand, plausibility and the challenging character are still dependent on the nature and quality of input variables.

5. Limitations and further research

The results presented in the previous chapter are based on a thorough literature review. A different and potentially better approach to compare the different future studies and examine their usability for Scenario Planning in a Supply Chain context would have been to apply the different techniques and compare their individual process as well as their results. Nevertheless, the results of this work can be used to focus future research on a selection of Scenario Development techniques. Furthermore, the results of this research are likely to support practitioners and academics when choosing an appropriate Scenario Development technique as advantages and disadvantages of each category have been provided.

From our point of view Scenario Planning within a Supply Chain context could be a very beneficial tool, if it is applied correctly. Therefore future research within this area should mainly focus on two issues. First, conducting Scenario Planning within the field of Supply Chain management to analyse and improve processes. Second, the four Scenario Development categories should be investigated to ease the selection process as application of different techniques requires a different level of resources and capabilities.

6. Conclusion

Companies nowadays find themselves in a globalised world with customers, competitors and business partners in multiple markets facing a highly dynamic and unpredictable future. In such an environment, it has become an imperative for companies to be able to quickly adapt to environmental changes and to anticipate future trends. Scenario Planning has been shown to be a useful mean to create strategies and improve decision-making in such an uncertain and turbulent environment. Consequently, it is important to broaden the body of knowledge on Scenario Planning within a Supply Chain context.

To start this process this research has focused on identifying Scenario Development techniques suitable for Scenario Planning within a Supply Chain context. As a result four categories of Scenario Development techniques have been identified. These categories are:

Judgement, Elaboration of fixed scenarios, Dimensions of Uncertainty and Cross-impact analysis.

Each of these four categories contain techniques which address uncertainty, allow complexity, and be able to create plausible, internally consistent, challenging, and relevant future scenarios and can therefore be applied to support a Scenario Planning process within a Supply Chain context.

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