IfM

UNIVERSITY OF CAMBRIDGE

Understanding China's manufacturing value chain

Opportunities for UK enterprises in China

Selected case studies in white goods, TFT-Liquid crystal display and pharmaceutical sectors

Acknowledgements

This study has received funding and support from the British Embassy, Foreign & Commonwealth Office, Science & Technology Unit through its Global Opportunities Fund. The fieldwork and support was crucial for our engagement with policy makers and industry associations. In many cases initial introductions to industry were also facilitated through FCO contacts. Our special thanks go to the FCO staff in Beijing, Shanghai, and Guangzhou and in particular Rapela Zaman, First Secretary, Science and Innovation, British Embassy, Beijing. Thanks also go to the representatives from the following organisations who have provided valuable information and insights on industry drivers and trends:

Industry associations, government and policy advisors

- State-owned Assets Supervision and Administration (SASAC)
- General Research Institute for Non-Ferrous Metals (GRINM)
- Development Research Centre of the State Council (DRC)
- Zhejiang University
- Guangdong University
- British Embassy, Beijing and Consulate Office, Guangzhou
- British Chamber of Commerce
- Institute of Industrial Economics
- Ministry of Science & Technology (MOST)
- Institute of World Economics and Politics

Industry

- Airbus China Ltd
- AUO (TFT-LCD)
- BOE (TFT-LCD)
- ExcelStor (Electronics)
- Flextronics (EMS)
- Fresenius Kabi (Pharma)
- Galanz (White Goods)
- Haier (White Goods)
- Hengdian Group (Magnets)
- Hon Hai (Electronics)
- Huawei (Telecoms)
- HYT (Telecoms/Electronics)
- Johnson Electrical (Electric motors)
- Kelong/Hisense (White Goods)
- Lenovo (Computers)
- MetersBonwe (Clothing)
- Midea (White Goods)
- Rolls Royce Int. Ltd (China)
- SAE Magnetics (Hard disc drives)
- Strix Ltd (Components/Home appliances)
- TCL (Consumer electronics)
- Unilever China (Consumer detergents)
- Xiangxue Pharmaceutical
- Yi Wu Trade (Consumer goods)
- Youngor (Textiles)
- Yue Yuen (Sports footwear)
- ZTE (Telecoms)

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First published in Great Britain 2008 by the University of Cambridge Institute for Manufacturing. www.ifm.eng.cam.ac.uk
ISBN: 978-1-902546-69-8

Contents

Foreword

China's manufacturing capabilities have developed rapidly over recent years and Chinese value chains have become increasingly sophisticated. They present opportunities for overseas companies to engage in China and Chinese companies to move overseas. This study seeks to review the impact of globalisation on Chinese industries from R&D through to production, service and disposal.

The project team used a structured approach to review the value chains in a number of key sectors and companies, building on the framework developed for the UK's recent review of science and innovation published by Lord Sainsbury in 2007. The team was made very welcome in a range of companies allowing new insights into their structure and evolution. For reasons of confidentiality detailed information about individual companies has been generalised but the insights and patterns remain clear.

The value chain structure of the report reveals multiple opportunities for engagement by Chinese companies with the global industrial system, as well as providing a way to understand the dynamics of increasingly influential Chinese businesses. The approach has already led to an active network of senior industrialists, policy advisers and academics and we hope that this growing community will be well-placed to understand patterns of global industrial structures through what is likely to be a turbulent period.

The team received tremendous support from staff at the FCO Science and Technology Unit and UKTI and greatly valued the opportunity to work in this most dynamic of manufacturing economies.

Mike Gregory
Head, Cambridge University Institute for Manufacturing

Executive summary

China's dominant position in mass production is well established. More recently the country has been seeking to extract greater benefits from its manufacturing sector by increasing its involvement in higher-end activities and across all elements of the manufacturing value chain. These developments present significant opportunities for UK businesses who can offer complementary capabilities and who are prepared to enter into partnerships with Chinese firms.

This study of manufacturing in China identifies opportunities for UK and Chinese companies to work together for mutual benefit. Case studies from three selected sectors identify key characteristics of China's manufacturing value chain, and the opportunities that may result from further international collaboration.

The study

The research is based on case studies with selected China-based companies including interviews with senior operations management on the development of their manufacturing value chains. The analysis has also been informed by discussions with senior Chinese policy makers and academics on trends and future priorities. The report presents the case studies within a sector-wide context to identify broader trends.

The case study analysis takes a comprehensive approach, covering all parts of the value chain, from R&D and design, through to after-sales service.

Regions investigated

The report is based on case studies from the Pearl River Delta, Yangtse River Delta and Pan-Bohai regions in 2007, and two investigative field trips to Beijing, Shanghai, Guangzhou and Chongqing conducted in early 2008.

Industrial sectors

The study focused on the following sectors:

White goods

Chinese manufacturers dominate the white goods sector, operating a mass–production operating model, although few operate internationally using their own brands. However, several Chinese companies, who entered the market barely a decade ago, have managed to migrate from outsourced, third-party factories to become independent contract manufacturers on a global scale. This migration has created opportunities for UK companies who can offer skills in such things as brand development, advanced production technologies, high-end component supply, and support with international strategy development.

TFT Liquid crystal display

The future trajectory of the sector remains uncertain, however initial indications are:

- Rapid technology evolution is likely to continue
- The next stage of internationalisation may witness value chain specialisation with technology development in Japan, mass production by Korean and Taiwanese companies, many based in China
- Chinese firms are focusing on growing their domestic market to secure a foothold in the sector
- New technologies emerging from the UK may challenge current industry structures with multiple evolution paths possible; collaboration with current mass producers is most likely to be based on current value chain strengths.

Pharmaceuticals

Exploitation of global value networks has seen:

- UK firms extend their R&D footprints into China (e.g. GSK, Astra Zeneca) having already transferred local generics production
- Emerging Chinese firms exploring development of R&D links in the UK e.g. Xiangxue's UK R&D university interactions
- The development of the Chinese downstream health care market by German firm Fresenius, using on-shore operations
- Export-oriented Chinese contract manufacturing service providers are now engaging with foreign resources to better equip their manufacturing systems, upgrade R&D capabilities and improve clinical support practice.

Key findings

The key findings of this report are:

- China is not only focused on low-end mass market manufacturing but has made serious investments in aerospace, shipbuilding, steel, IT and telecommunications
- Both government and foreign owned MNCs are now investing in aerospace, IT and Pharma R&D and manufacturing; expertise centres are expected to emerge in the near future
- Intellectual property protection remains a major concern for foreign manufacturers and Chinese flagship companies – exacerbated by intense competition amongst component manufacturers
- Chinese firms, often utilising modest entry positions in the value chain (e.g. beginning as a regional distributor) are rapidly entering adjacent more value-added positions; this dynamic capability allows rapid upgrading of skills and capabilities

- Many state-controlled enterprises have also grown dramatically with 14 major Chinese state industries present in the Fortune 500 list
- Many Chinese manufacturing firms readily invest in extensive upstream supply networks, either as part of highly concentrated inter-firm supply clusters or more vertically integrated models
- Emerging flagship companies and industries provide examples of innovation for others to follow. These developments coupled with heavy investments in key state industries, education and technology universities, are likely to mean that capabilities rise faster in China than in other developing economies
- The impressive growth of Chinese manufacturing has signified the transformation from a highly planned to a mixed economy. Its sustainability in environmental, social and political terms has been carefully and pragmatically managed – overcoming difficulties as they arise. Sustaining this growth going forward will present social, technological, environmental and political challenges
- Over the past 20 years key engines for growth have been the unique regional clusters in PRD, YRD and Pan-Bohai regions.

Implications for UK firms

Potential opportunities for UK firms span the manufacturing value-chain, where complementary capabilities can support future development. Specific areas that have emerged in our case studies include:

- Technology complementarities between UK and Chinese firms, with UK firms in particular providing 'primary innovation' research and Chinese contract manufacturing firms increasingly providing capabilities in 'secondary innovation'
- The emergence of expertise centres in R&D, production and service in China represent opportunities for UK companies to build collaborative partnerships where the local context plays a significant factor
- Brand development, increasingly a major focus of many contract manufactures, may benefit from UK expertise
- Intellectual property protection needs to be considered carefully with novel approaches used by foreign MNCs and flagship Chinese firms to protect technologies and brands
- There is scope to support Chinese internationalisation through a variety of mechanisms including the management of multi-domestic operations, and by supporting more effective mergers and acquisitions
- Rapid prototype development in China benefits from superior access to suppliers and production capabilities
- Low-cost component or product sourcing continues to be an option for UK firms who have thought through comprehensive make-buy strategy considerations
- Increased partnering and collaboration between UK and Chinese universities may provide opportunities for technology transfer and training
- The relatively immature services sector provides new opportunities for UK companies to engage with Chinese partners.

1 Introduction

Background

Regional focus of the study

Manufacturing focus

Report structure

Future work

Background

Manufacturing value chains – from R&D, design, production, distribution to services – are increasingly fragmented and globally distributed (e.g. design in the UK and manufacturing in China). This means companies active in different parts of the value chain must work together in order to extract as much value as possible from the whole value chain.

The UK is no stranger to outsourcing and China is no stranger to manufacturing. 'Made in China' is no longer a tag confined to cheap jeans and plastic toys. High-tech goods accounted for 35% of China's total manufacturing exports in 2005 and 60% in 2006, up from 16% in 1995.

Extracting benefits from this international division of labour can be of mutual benefit and is potentially a positive sum game for the UK. Working with strategic partners to understand and develop Chinese manufacturing performance can improve UK enterprises' ability to manufacture in China whilst presenting an opportunity to address issues such as quality assurance, technology transfer and intellectual property rights with relevant stakeholders.

Chinese private and public sector enterprises are also under pressure to raise their manufacturing and innovation game. Up-grading manufacturing production process technologies is necessary to achieve wider government goals including energy efficiency and efficient resource consumption. Chinese officials are also keen (as have been other manufacturing nations e.g. Ireland) to extract more benefits from value chain management.

Aims

This study has three broad aims, namely to:

- Build new stakeholder relations with Chinese officials (government and industry in Beijing, Shanghai, Guangzhou and Chongqing) that may help to catalyse follow-up activities (e.g. by engaging and raising awareness of key decision-makers on manufacturing and innovation-related issues such as quality assurance and protecting intellectual property)
- Build UK firms awareness of opportunities to exploit downstream benefits by engaging with the Chinese manufacturing sector (e.g. technology transfer, market access) and Chinese opportunities for UK inward investment in related areas (e.g. R&D)
- Increase UK enterprises' competitiveness through effective contract manufacturing in China.

Target outputs

A specific target output for the study was to strengthen the IfM's Chinese Manufacturing Network – building in policy makers and policy implementers to the existing academic and industrial mix. This report seeks to provide further current insights into China's Manufacturing Value Chain. Simple briefing sheets for UK industrialists and China based S&I and UKTI officers on contract manufacturing have also been developed. Finally, dissemination activities in the UK through industry-workshops, China industry forums and an International Symposium have enabled further communication of study findings.

Dissemination

Workshops and symposia supporting the dissemination of case study findings of China's manufacturing value chain have included the following:

- 'Making it in China' workshop, Cambridge, June 2008
- China Horizon: Integrating Value-Chains in a Global Economy – China's Manufacturing, 2008
- China symposia "Global manufacturing" Hangzhou in partnership with Zhejiang University. 2007
- International Manufacturing Symposium 'Global Value Chains' 2008.

This report provides supporting documentation for ongoing dissemination. Further information is available from the authors.

Regional focus of the study

This study summarises the outputs from studies in 2007 covering the Pearl River Delta (PRD), Yangtse River Delta (YRD) and Pan-Bohai regions, and investigative field trips to Beijing, Shanghai, Guangzhou, Chongqing conducted in 2008.

Manufacturing focus

The brief for the study focused on two types of manufacturing systems which offer different insights into value chain management. Firstly, contract manufacturing involving mass production and secondly, research-intensive sectors such as pharmaceuticals. Within the mass production category, the studies focus on mature sectors such as white goods, but also emerging value-chain models of high-clock speed sectors such as thin-film technology liquid-crystal displays. In the mature sectors the studies have focused on contract manufacturing and the emergence of well-developed, supply side industry 'cluster' effects. In pharmaceuticals, tight coupling between value chain stages and heavy expenditures on front-end R&D, present particular opportunities for UK engagement.

Contract manufacturing - mass production

Two very different sectors are studied within contract manufacturing, in which manufacturing models involve production for multiple OEMs:

- White goods manufacture: here China exhibits global dominance in production through global-scale contract manufacturing in this mature sector
- TFT Electronics: here high-end advanced electronics players in Korea, Taiwan and mainland China have invested heavily in production.

Research intensive - pharmaceutical

Separate consideration is given to:

- The challenges facing western MNCs and their role in manufacturing in China
- China-based pharma where indigenous players focused on generics manufacture and traditional medicines have emerged.

Report structure

The report is structured as follows:

- Section 2: Overview of Chinese Manufacturing
  A historical perspective on the evolution of China's manufacturing base.
- Section 3: Value-chain analysis of Chinese manufacturing
  A review of the main manufacturing trends across the main value-chain elements.
- Sections 4, 5 and 6: Sector reviews
  Observations of linkages between value-chain stages of selected firms in mass production-based sectors and research-intensive pharmaceuticals, identifying alternative business models and potential complementarities with UK firms.
- Section 7: Summary of findings and implications for the UK
  Opportunities and implications for UK manufacturing businesses emerging from the case study analysis.

Future work

The following are suggested for further exploitation of the resources developed and to broaden and extend this initial study:

- Extend case-studies to other sectors of UK interest
- Develop specific studies targeting the significant public sector companies loosely coordinated through the State-Owned Assets Supervision and Administration (SASAC) body
- Follow up specific 'implementation' projects with selected UK partner companies.

2 Overview of Chinese manufacturing

Introduction

Over the last two decades, the emergence of China as a dominant player in world manufacturing output has been well documented. From relative obscurity in the 1980s, China's Industrial output is now second only to the US (Manufacturing GVA), closely followed by Japan, Germany, Italy and the United Kingdom.

The fast growth in manufacturing output has benefited from the macroeconomic factors in the Chinese economy. Economic liberalisation polices post 1978 with the so called open door policy and its subsequent confirmation in 1992, have led to substantial and growing Foreign Direct Investment (estimated at US$83 billion in 2007).

At the operational level, taking a product category and value-chain perspective, Chinese manufacturers, the most successful of which are private owned enterprises, are competing favourably against their international counterparts. Despite factory operational practices that are often not as advanced as their international competitors and from our site visits clearly in the early stages of process maturity, Chinese manufacturers are competitive against many of their international rivals not only on cost, but also on other order winning parameters such as responsiveness and dependability.

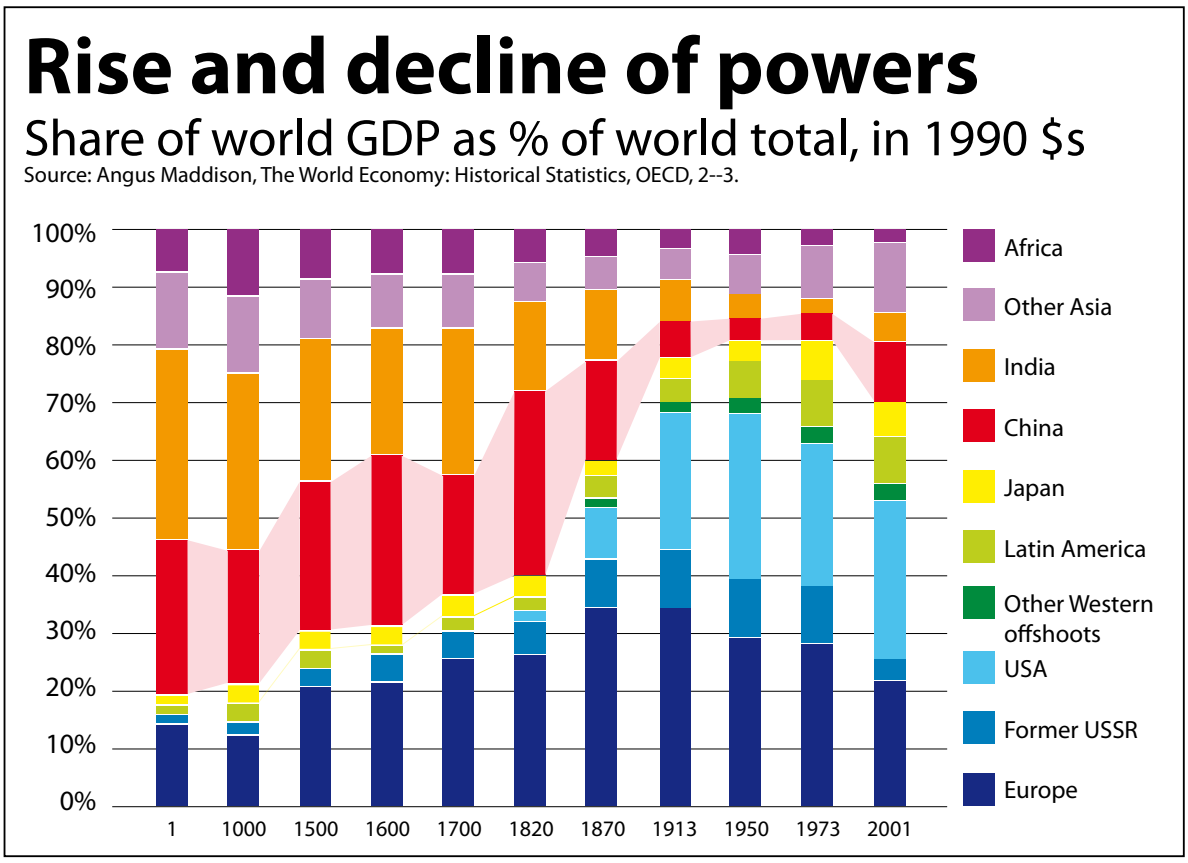
Previous work on Chinese manufacturing success has tended to concentrate on the macroeconomic factors, or at the firm level, on individual firm capabilities. Regional studies have tended to be cross-sector. There has been less systematic focus on the Chinese manufacturing system at the product category level, its supply network structures and characteristics, linkages and supporting relationships across the value-chain and the critical role 'upstream supply network clusters' may play in competitiveness.

This study looks at the manufacturing value chain from both a broad national perspective, but also at a product category level with supporting case studies, to demonstrate each product sector's recent evolution.

Economic overview

Before reviewing the recent past and the trends now emerging in global supply, it is worth noting that the Chinese economy has been a significant player in the world economy up and until the last century.

The chart below shows how China's share of world GDP, considered in a historical context, may be seen as a 'resurgence' rather than a new phenomena.



The Chinese economy is the fourth largest in the world when measured by nominal GDP. But the report on Global Purchasing Power Parities (GPPs) published by the IBRD in 2008 showed China in second place. Its share of world population in 2005 was 21.3%.

	GDP as a % share of global GDP 2005	
	PPP-based	Market exchange rates
United States	22.5	27.9
China	9.7	5.1
Japan	7.0	10.3
Germany	4.6	6.3
India	4.3	1.8
United Kingdom	3.5	5.1

Beginning in late 1978, the Chinese leadership has been moving from a Soviet-style, centrally-planned economy to a more market-oriented economy, although still within a rigid political framework under Party control. The reforms replaced collectivisation with privatisation of farmlands, increased the responsibility of local authorities and industry managers, allowed a wide variety of small-scale enterprises to flourish, and promoted foreign investment. Price controls were also relaxed. These changes resulted in mainland China's shift from a planned economy to a mixed economy. Estimates for 2007 GDP composition show manufacturing as the dominant sector with industry 48.6%, services 40.1% and agriculture 11.3%.[1]

In 1989, the government introduced legislation and regulations designed to encourage foreigners to invest in high-priority sectors and regions. A significant example of this is the 'Encouraged Industry Catalogue' which sets out the degree of foreign involvement allowed in various industry sectors. Opening up to the outside world remains central to China's development. Foreign-invested enterprises produce about 45% of mainland China's exports (note, though, that the majority of China's foreign investment comes from Hong Kong, Taiwan and Macau, two of which are under the administration of the PRC), and mainland China continues to attract large investment inflows.

Annual data	**2005[2]**
Population	1,303.7
GDP (US$ bn; MER)	2,688.8
GDP (US$ bn; PPP)	5,333.2
GDP per head (US$ bn; MER)	1,721
GDP per head (US$ bn; PPP)	4,091
Exchange rate (average) Rmb : US$	8.2
Historical averages (%)	**05-07[3]**
Population growth	0.6
Real GDP growth	11.3
Consumer Price Index	2.7
Current-account balance (% of GDP)	9.1

(MER) Market Exchange Rates
(PPP) Purchasing Power Parity

China's top exports 2007 ($ billion) Source: PRC General administration of customs, *China's customs statistics*

Commodity description	Volume	% of total
Electrical machinery and equipment	300.3	24.7
Power generation equipment	228.6	18.8
Apparel	108.7	8.9
Iron and steel	76.6	6.3
Optics and medical equipment	37.1	3.0
Furniture	35.9	2.9
Vehicles other than railway	31.8	2.6
Inorganic & organic chemicals	30.3	2.5
Toys and games	27.1	2.2
Plastics and articles thereof	26.4	2.2

China's top imports 2007 ($ billion) Source: PRC General administration of customs, *China's customs statistics*

Commodity description	Volume	% of total
Electrical machinery and equipment	256.8	26.9
Power generation equipment	124.2	13.0
Mineral fuel and oil	104.9	11.0
Optics and medical equipment	69.5	7.3
Ores, slag and ash	54.0	5.2
Plastics and articles thereof	45.3	4.7
Inorganic and organic chemicals	44.8	4.7
Iron and steel	31.1	3.3
Copper and articles thereof	27.2	2.8
Vehicles other than railway	22.1	2.3

[1] CIA World Factbook
[2] IBRD Global Purchasing Power Parities and Real Expenditures (published 2008)
[3] US China Business Council

Sustained growth over the last 20 years

The widely acclaimed progress of the Chinese economy over the last 20 years has been achieved on the base of significant successful growth of its manufacturing sector. During this period, China's manufacturing industry has experienced a major transition, as shown by the shift in exports from primary products to electronics and machinery. In contrast to state-owned enterprises (SOEs), private firms and joint ventures have thrived in China and have become the major forces of the country's export zones.

Historically, the development of the manufacturing sector in major world economies has followed three distinct phases. The first phase is dominated by national needs with low external input. The second phase builds on emerging domestic capabilities accompanied by external knowledge transfer to satisfy export demands. The third growth phase is dominated by structural changes driven by innovation and intense competition[1]. The Chinese manufacturing sector had been in the first phase until it adopted its open door policy in 1978 and is now in the process of transition from the second to the third growth phase.

As well as forming the world's most rapidly changing large economy, China can claim increasing presence and influence in the world. China sews more clothes and stitches more shoes and assembles more toys than any other nation. It has becomes the world's largest maker of consumer electronics, producing more TVs, DVD players, and cell phones than any other country. More recently, it has ascended the economics development ladder higher still, moving quickly and expertly into computer manufacturing and telecommunications equipment.

China's manufacturing industry has an evident regional dimension, especially in the Pearl River Delta (PRD) and Yangtze River Delta (YRD) in which different business models have been adopted. Foreign investments have different characteristics at different stages. Foreign investors, primarily small and medium-sized enterprises from Hong Kong, Macau and Taiwan, first moved into the PRD in the early days of reform and opening up. After years of 'exploratory ventures', large foreign firms and multinationals followed, leading to the formation of industrial clusters producing shoes, toys, bicycles and IT products in the region. These powerful industrial clusters in the PRD have been quickly 'cloned' in Suzhou, Kunshan and other cities in the YRD since the 1990s.

The economic growth taking place in the YRD is not occurring at the expense of the PRD, even though there is some overlap. In fact, the two complement each other and make for a bigger China market. Together, the two regions account for over 50% of FDI into China. PRD is a production base of downstream, light consumer goods, while the YRD is a leading producer of raw materials and intermediate goods. For example, while the PRD produces 70% of China's toy exports and 90% of its watch exports, the YRD manufactures over 60% of the country's integrated circuits. Both regions are huge markets with high levels of demand for industrial and consumer goods.

The GDP of the PRD is equivalent to that of Portugal. If Hong Kong and Macao are taken into account, the aggregate GDP of Greater PRD is greater than that of Switzerland, while the economic size of the YRD region is close to that of Sweden. Shanghai in the YRD and Guangzhou in the PRD continue to be major distribution centres. The two regions together accounted for 63% of the mainland's total exports by 2002.

In 2003, foreigners invested more in building businesses in China than they spent anywhere else in the world. China took the lead in FDI pulling in $53 billion compared to the US's $40 billion. Foreign companies have pumped up China's trade volume enough to make it the third-largest trading country in the world with $1,155 billion in 2004, behind the US and Germany but ahead of Japan.

China now sets the global benchmark for prices in many manufactured goods. Over much of the business world, the term 'China price' has become interchangeable with lowest price. According to the annual report of the Federal Reserve Bank of Dallas in 2003, personal computers fell by 28%, televisions by nearly 12%, cameras and toys by around 8%, while other electronics, clothing of all sorts, shoes and tableware also dropped in price. This deflationary trend has continued in more recent years.

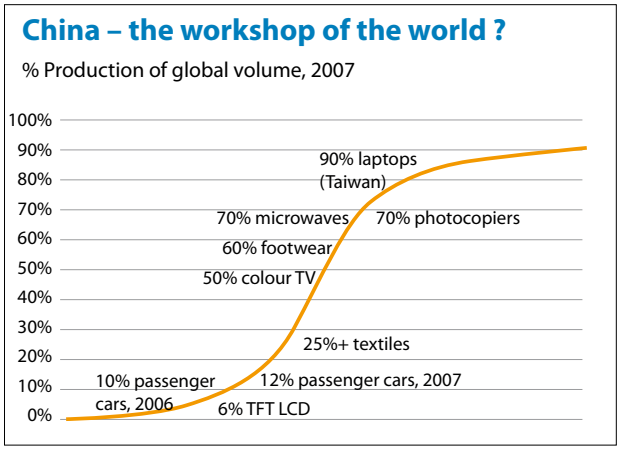
As an example, the world's largest retailer, Wal-Mart Stores Inc, reports its inventory of stock produced in China reached $18 billion in 2004, maintaining an annual growth rate of over 20% in recent years. Walmart shifted its overseas procurement centre from Hong Kong to Shenzhen in February 2002 to better serve its purchasing and exporting business. More than 5,000 Chinese enterprises have established steady supply alliances with Walmart based on good quality and low price. More than 70% of the commodities sold in Walmart are made in China.

China - the workshop of the world?

The schematic opposite demonstrates the global dominance, in production volume terms, of Chinese manufactured goods. Many of the case studies undertaken by the IfM as part of this study, and related work in 2007/8, have captured the evolution and growth of the leading product manufacturing firms which account for the major

[1] Navarri, 2005

part of the production volumes depicted in the schematic. They include case studies on BOE (TFT LCD), Huawei and ZTE (Telecoms), Youngor and Meters Bonwe (Textiles), TCL (Colour TVs), Yue Ywen (Footwear), Galanz and Midea (Microwaves), Hisense and Hair (Consumer Electronics), and Lenovo (Personal Computers).



The rapid development of supporting suppliers, who directly feed many of these industries, is equally impressive – as demonstrated in some of the case studies in this report. These suppliers also dominate global volumes in a number of areas, for example Magnets (Hengdian Group), and Electric Motors (Johnson Electric). More recent trends have seen contract manufacturers moving into design, developing more value-add services to add to their traditional contract production.

Whereas mass-production remains a vital component of China's manufacturing success, new labour laws present a challenge for contract manufacturers who also see margins being squeezed by commodity price inflation. The limited negotiating power of contract-manufacturers to increase their producer prices presents a major challenge to the low-cost (mature product) manufacturing sector. Recent policy initiatives include a focus on High Value Manufacturing strategies (discussed later in this report) to progressively add higher margin manufacturing businesses to the national mix.

Large scale distribution channels have also emerged in China such as YiWu's International Trade City, where some 10,000 small scale local manufacturers utilise the sophisticated infrastructure of what is marketed as the world's largest supermarket for trade buyers. Set up in 2004 and continuing to expand rapidly, over 50,000 selling 'booths' are housed in purpose built facilities supported by excellent local transport facilities (roads, airport), with integrated purchasing centres that facilitate transaction completion and eight of the world top logistics providers on-site to support container shipments. Banking facilities and hotels for international buyers are also available in the complex.

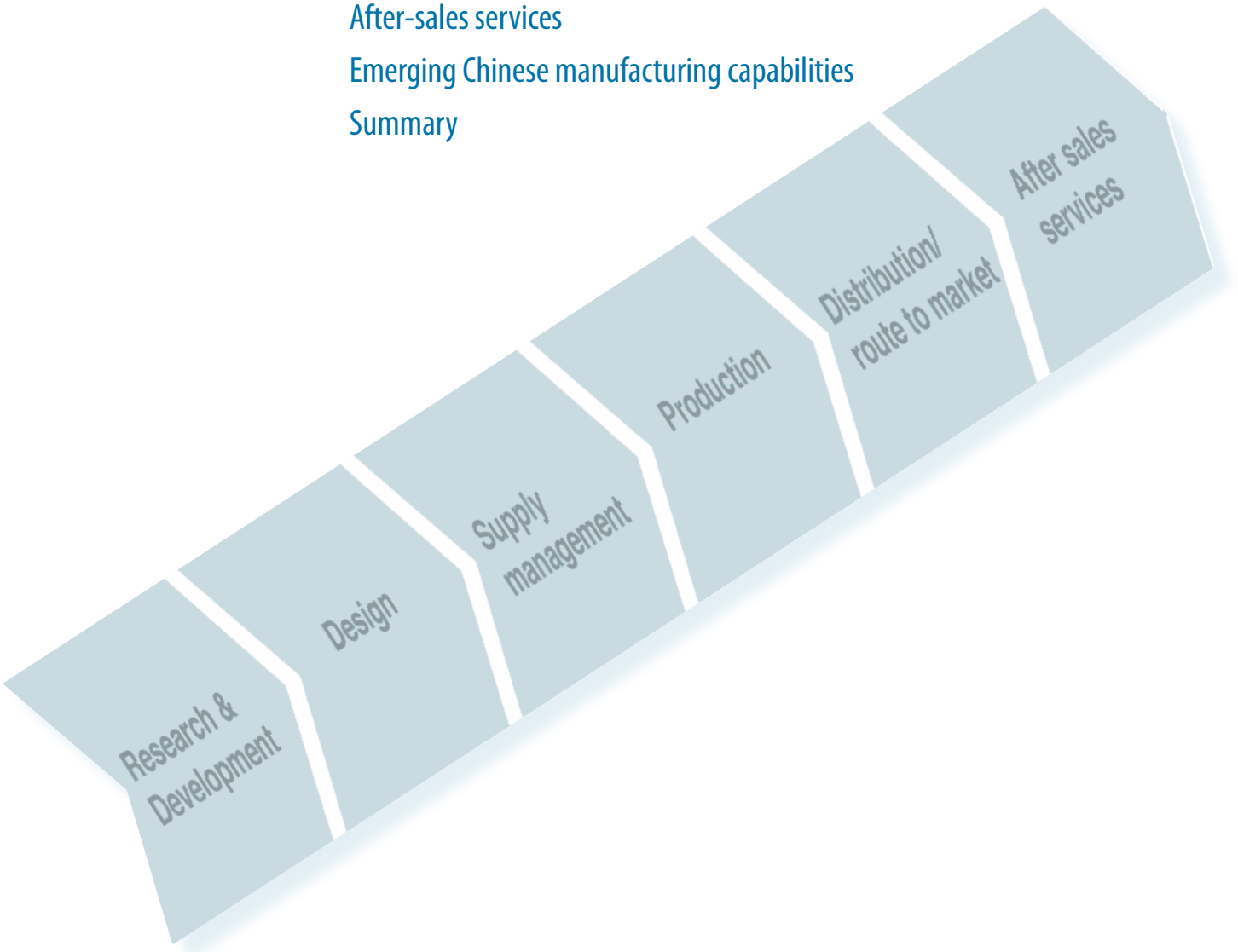
International trade

China has become a major trading power over the last 25 years, moving from almost negligible international trade to becoming, by 2006, the second largest exporter and third largest importer in the world. However, most of its imports support China's exports trade and this 'processing' trade obscures the limited consumption of international goods by Chinese consumers.

In the last 10 years there has been a dramatic change in export statistics, with China moving from 5% of global exports to 15%, whilst the US has gone down from 19% to 13%, and Japan from 14% to 9%. In the last three years alone, China's trade surplus has grown from being in balance to a surplus of £200 bn, representing some 10% of GDP.

The emergence of a developing economy as a major trading nation will present new challenges to global trade.

3 A value-chain overview of Chinese manufacturing capabilities



Introduction

Analysis of manufacturing capabilities has traditionally focused on production capabilities. More recently, many studies have extended their analyses to the supply networks within which production sits – capturing the complex interrelationships, information and material flows between the various players in the supply chain, both upstream suppliers and downstream distribution activities. In this study, the value chain concept is used to ensure that a broader systems perspective is taken; one that incorporates both R&D and after-sales-services into the analysis. Whilst this concept is not new, it's application as an analysis framework is used here to capture the main drivers and trends within each stage, and equally importantly the key linkages between stages of the value-chain, and the importance or otherwise of where they are located.

Research and development

The acquisition of overseas technologies is used to redress China's capability gaps in R&D and Design; there is a frustration however with what is perceived to be the guarded approach by the West to technology transfer in some areas (e.g. aerospace) through export regulation and controls in North America and the EU.

There is an active pursuit of 'secondary' innovation, focusing on incremental design enhancements rather than fundamental research, with indigenous innovation being encouraged. This is supported through rapid growth of the higher education institutions with major investments in universities.

Industrial research institutions are closely affiliated to key industries and are well established – though there continues to be some duplication and there is concern that the recent need to be largely self-reliant in funding may be reducing genuine research.

Nationally, specific programmes have been developed to encourage joint development of high potential ideas by entrepreneurs and scientists.

In response to high levels of imported industrial machinery, there is a policy focus on building capacity to manufacture heavy plant and machinery, including production equipment, with incentives for end-users to adopt locally manufactured prototype products. Interestingly, there are specific policies and incentives that encourage the adoption of locally manufactured industrial equipment.

Priority areas for government include aerospace, energy and defence where domestic demand is anticipated to remain strong.

National strategies (11th, 5-year plan) focus on the 'Enabling' and 'Hi-tech' programmes. The latter features technologies supporting green, digitised, modular and sustainable manufacturing in order to narrow the quality gap between Chinese and foreign products. This 'High Value Manufacturing' programme mirrors similar initiatives that might be expected from advanced manufacturing-based economies.

Design

Design capabilities are seen as a major weakness in many sectors in China. Some notable exceptions are emerging where the journey from imitation to innovation is well advanced. Hon-Hai[1] have focused on being the electronics contract manufacturer of choice having acquired and integrated traditional OEM design (and production) capabilities whilst explicitly not entering branded products. ZTE[2] excel in the speed with which they can manufacture to customer specification in telecoms using a highly responsive supplier base. Lenovo[3] have integrated IBM hardware design capabilities to complement their traditional strengths in desk-top and lap-top computer assembly and production.

Many OEMs have created 'universities' that aim to support product design (e.g. Hon Hai, where there is investment in high-end R&D and design). This development is actively encouraged by national and provincial governments. In many other cases however these expenditures are focused on applied research (design focused) rather than exploratory (fundamental) research areas.

Supply management

Basic component manufacturing capabilities are extensive providing dramatically lower input costs to OEMs. Component suppliers tend to cluster around OEMs often creating single industry clusters of major scale, and thereby providing significant cost savings. These clusters also promote fast component replenishment, kanban operations, with low intermediate inventory.

The Government actively promotes the ability of MNCs to do business in China. An example of this is the development of 'agents' who can provide local or imported

[1] Hon Hai is a global electronics manufacturing service provider based in Shenzen
[2] ZTE is a major international telecom equipment and service provider also based in Shenzen
[3] Lenovo recently acquired IBM's personal computer manufacturing business

components to OEMs; this development of the agent approach makes foreign manufacturing investment in China more attractive and practical. Importing high-value components is seen as an important step to secure and develop manufacturing in general.

Funding by provincial government to support the local development of tertiary suppliers has significant benefits to OEMs who are well served by co-located or closely located suppliers.

The single industry upstream supply-cluster, represented by a heavy concentration of related firms operating almost exclusively in a single product category, often within two hour by road, that is prevalent in many product categories, provides for rapid component and product replenishment without the need for sophisticated planning and management systems. This helps relatively immature supply networks to operate highly responsive operations often with risk-pooling, supplier partnering approaches.

Production

Extensive and largely modern production capabilities are now established across most mature industry product categories. There is still, however, an 'assembly focus' but there are moves towards the manufacture of complex components with some firms venturing into product design.

Many industries and firms are developing capabilities from 'assembly' to 'design-and-assembly' as part of an integrated contract manufacturer 'service'. Examples are emerging where this creates a competitive barrier to contract manufacturing and some firms are considering the separation of design and production operations. A good example here is HYT[1] where the potential conflict between contract manufacture role and own-brand manufacturer was seen as a barrier to growth.

Some industries are now finding that they dominate global markets with major growth being driven by domestic Chinese requirements e.g. ship building, steel, construction. These industries, which include some prominent state-owned enterprises, are investing in all elements of the value chain and becoming global leaders. In some sectors, gaps in capability are being identified (such as aerospace and energy) where growing domestic demand is not matched by manufacturing, technology and research capabilities. These are being prioritised for government support. Dependence on overseas energy and fuel sources is a growing concern.

Domestic consumer demand for manufactured goods is generally serviced by local industries where 'tailored customer specifications', often involving expediting supply time to between two and four weeks, allow local firms preferential position. Genuine competitive advantage of local players is however present in after-sales product repair and warranty-related services.

Distribution/route-to-market

Development of the retail trade appears unrestricted by government controls; but some concerns have been expressed about 'foreign control' on the daily-life of Chinese people.

Large international retail chains already have sophisticated procurement and logistics operations in several major cities. These represent global sourcing hubs for overseas markets; the scale of these operations are such that they are influencing international shipping capacity.

Dedicated industrial trade centres of unparalleled scale, focused exclusively on exports and international traders, have emerged, e.g. Yiwu International Trade City[2] . These make it easier for small scale manufacturers to serve international markets by sharing common marketing and distribution infrastructure.

Massive projects to improve capacity and efficiency in shipping ports, air cargo and road networks aim to sustain China's ability to continue its growth in the export of manufactured goods.

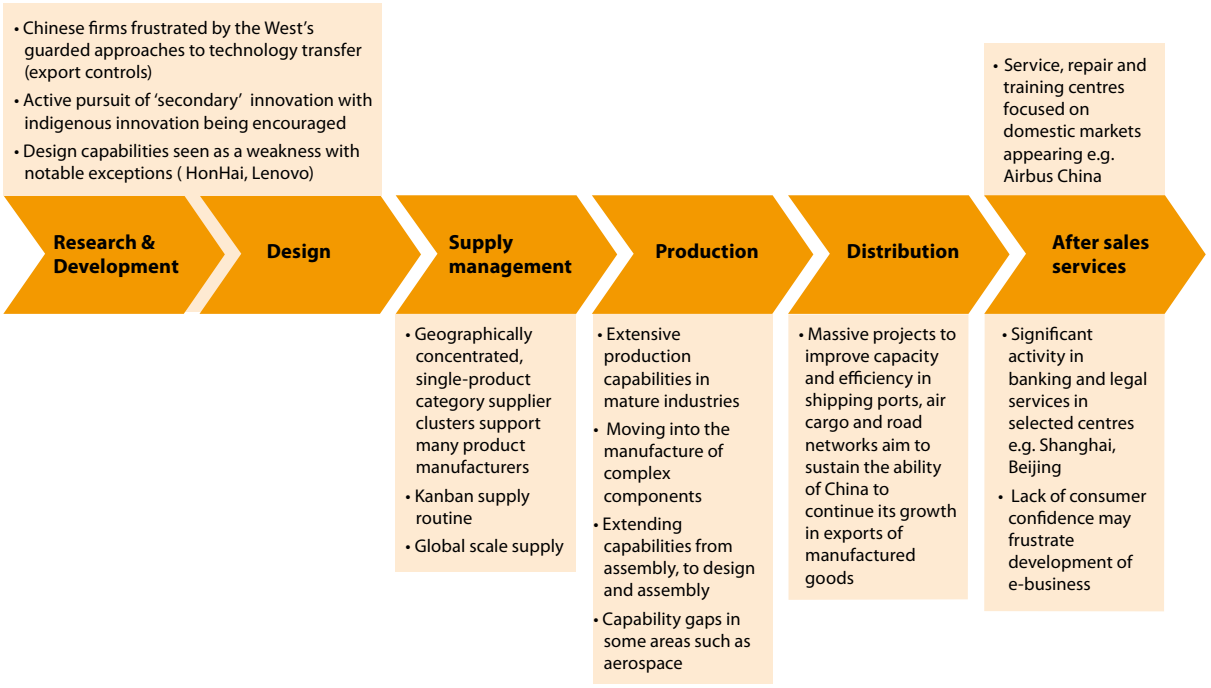
After-sales services

Several developments in relation to after-sales service are emerging but tend to be very sector specific. Service, repair and training centres are now being set up, focused on domestic markets, e.g. Airbus China. Training by foreign enterprises has helped their rapid development.

Many MNCs that operate using the power-by-the hour concept have operations in China (e.g. Rolls Royce) where local presence is a necessary part of their business model. It is likely that these operations will increasingly expand the scope of their activities as local capabilities develop. The growth within China of industrial 'supermarkets', targeting international volume buyers (e.g. Yiwu), offers

[1] HYT manufactures cell phones for industry use, largely in the field of security management
[2] YiWu International Trade City specialises in industrial scale 'retail' exports of consumer household items that are locally produced

Value chain highlights – China



sophisticated services to support transaction management and to facilitate the shipping of containers overseas.

IT centres have emerged (e.g. Beijing, Dalian, Shanghai) providing IT outsourcing and back-office integration capabilities. China's software outsourcing market has grown rapidly from 2002-2006, increasing between 30-50% annually, with key markets being Japan and Korea. China remains a small IT outsourcing player globally, with around 3% of global market share lagging well behind India (41%), Ireland (19%), Canada (9%) and Israel (5%). However, with current growth rates and infrastructure development some project a global market share of nearer 9% by 2011.

Other service activities observed

Significant activity in banking and legal services in selected centres in Shanghai and Beijing are emerging. However, lack of consumer confidence in the immature banking systems may frustrate the development of e-business, despite the rapid development in markets and consumerism in general.

Industrial trade centres, set up to assist international volume buyers in dealing with the myriad small regional manufacturers, have also developed sophisticated services that cover the full range of support, from transaction management through to delivery. However, despite China's growing trade surplus, overall its trade in services is in deficit and is a target for future development.

Emerging Chinese manufacturing capabilities

The schematic above highlights the main observations in relation to China's manufacturing landscape. Using a value-chain framework demonstrates the strength of production and the inbound material/component supply base and the weaknesses generally found in upstream innovation and downstream service activities.

A particularly interesting observation from our case studies is that Chinese firms, often utilising modest entry positions in the value chain (e.g. beginning as a regional distributor), are rapidly able to enter adjacent higher value-added positions.

The evolution path from 'distributor' to assembly 'production', to vertical integration into specialised 'tier 1' supply base activities and/or design, often takes place within a relatively short time frame. This dynamic capability allows rapid upgrading of skills and capabilities, although the evolution path, as illustrated in our sector reviews, indicates that multiple business models are being followed.

The national strategy going forward targets 'upgrading' of capabilities. This is widely discussed as a strategy but has still to take shape, other than in the areas of high value manufacturing discussed earlier.

Moving up the value chain

HYT, one of the largest suppliers of 2-way radios, provides a typical example of the path followed by many Chinese companies (see case study opposite). HYT has risen up the value chain from its original role as a contract manufacturer, by moving into design, and then manufacture, of its own-branded products.

Summary

The sustained growth of the Chinese economy is largely driven by the impressive performance of its manufacturing sector.

Key observations include:

- A strong infrastructure and supplier base (including OEM contract manufacture of finished goods) provides significant competitive advantage in traditional industries. Chinese industries are world leaders in volume terms across many sectors including high-tech sectors such as Telecoms
- In selected industries, the market dominance of Chinese firms is resulting in them now leading next generation manufacturing technologies e.g. steel, telecoms, ship-building, and to a lesser degree in mature markets, e.g. domestic appliances, textiles, leather
- Many state-controlled enterprises have also grown dramatically, with 14 major Chinese state industries present in the Fortune 500 list. These are loosely supervised by a co-ordinating body (SASAC) which provides direction on investment and liberalisation policies
- National strategies (11th 5-year plan) focus on two main programmes in order to narrow the gap between Chinese and international products: Enabling and Hi-tech programme initiatives with the latter focused on technologies supporting green, digitised, modular, and reliable/sustainable manufacturing
- National policy makers are questioning the benefits of low-value manufacturing and switching attention to higher-end manufacturing e.g. IT, pharma, aerospace (despite previous failed attempts) with clear policies to invest in fundamental research capability and building absorptive capacity, e.g. "We need to export millions of TV sets in order to buy one Boeing," – Lu Zheng, Director Institute of Economics and an architect of the 11th Five year plan
- Current industry absorptive capacity remains low but emerging flagship companies and industries may provide models for moving from 'imitator' (reverse engineering focus) to 'innovator' (leading-edge applied technology). These developments, coupled with heavy investments in key state industries, education and technology universities, are likely to develop Chinese capabilities faster than in other developing economies.
- The impressive growth of Chinese manufacturing has signified the transformation from a highly planned to a mixed economy. Its sustainability in environmental, social and political terms has been carefully and pragmatically managed, overcoming difficulties as they arise. Sustaining this growth going forward will present social, technological, environmental and political challenges – with a generation now having only experienced 10% or more annual GDP growth.
- The benefits of international trade are now seen in financial terms, with unprecedented trade surpluses in the last few years for a developing economy. It is interesting to note, however, that it is not uncommon for Chinese commentators to view their international partners as the main beneficiaries of China's manufacturing development.

CASE STUDY

HYT (SHENZHEN, CHINA)

- HYT, founded in 1993, is the largest supplier of professional two-ways radios in China, and is among the global industry leaders in this niche market.
- HYT's trunking systems cover 20 provinces and municipalities throughout China.
- Founded by young entrepreneur, with no technology background, or high school education. Two-way radio business began as a dealership, continued through to production and launched own-brand in 2000.
- Since its founding HYT has grown into a premier developer, producer, manufacturer and marketer of wireless communications and systems engineering with around $50m sales in 2006.

R&D/design

- Research and Development Centre for professional two-way radio technology established in 2004 at HYT's main office in Shenzhen, China.
- Its R&D centre is the largest in China for professional two-way radio technology.
- Can compete in R&D internationally by adopting 'open system' standards.
- Availability of highly experienced engineers in China, who have worked in MNCs allows rapid development of critical mass; some 400 engineers working on NPD.

Production/supply management

- Fast growth from humble origins following a typical Chinese high-tech growth path (like Lenovo): trading ► Chinese domestic market ► production ► R&D ► brand name development ► internationalisation.
- Utilises its contract manufacturing service model to engage with international markets.
- Component procurement from Dongguan PRD with parts available in 1-2 hours.
- Local suppliers enable JIT replenishment and low inventory stocks: 1 day components; 4 hours packaging.

Distribution/service

- Company's distribution channels are very strong building on its heritage as a main dealer for Motorola with some 250 sales offices/agents; a competitive advantage typical of many indigenous companies.
- The handsets and analogue trunked systems are the preferred systems of the Chinese police force.
- The company has good marketing feedback system for new products. After sales service feeds back to the very early stage of NPD. Many products are tailored for niche market demands, such as mining.

Major issues

- As the telecoms market becomes more and more saturated, Chinese giant mobile phone companies like Huawei and ZTE may exploit their technology in niche markets such as two-way radios. This would present a major challenge for HYT in both production and technology.
- HYT is considering the separation of brand-name owned business (R&D) and contract manufacturing service operations (Production) to avoid conflicts of interest with competitors and potential customers. This will provide more flexibility for brand name development but also attract more OEM competitor brands to take advantages of current production resources.
- Technology breakthrough is becoming more critical and difficult, with key global players like Motorola, developing their own standards and restricting technology transfer. HYT is adopting a quick follower strategy as a survival capability.

4 Sector review: white goods

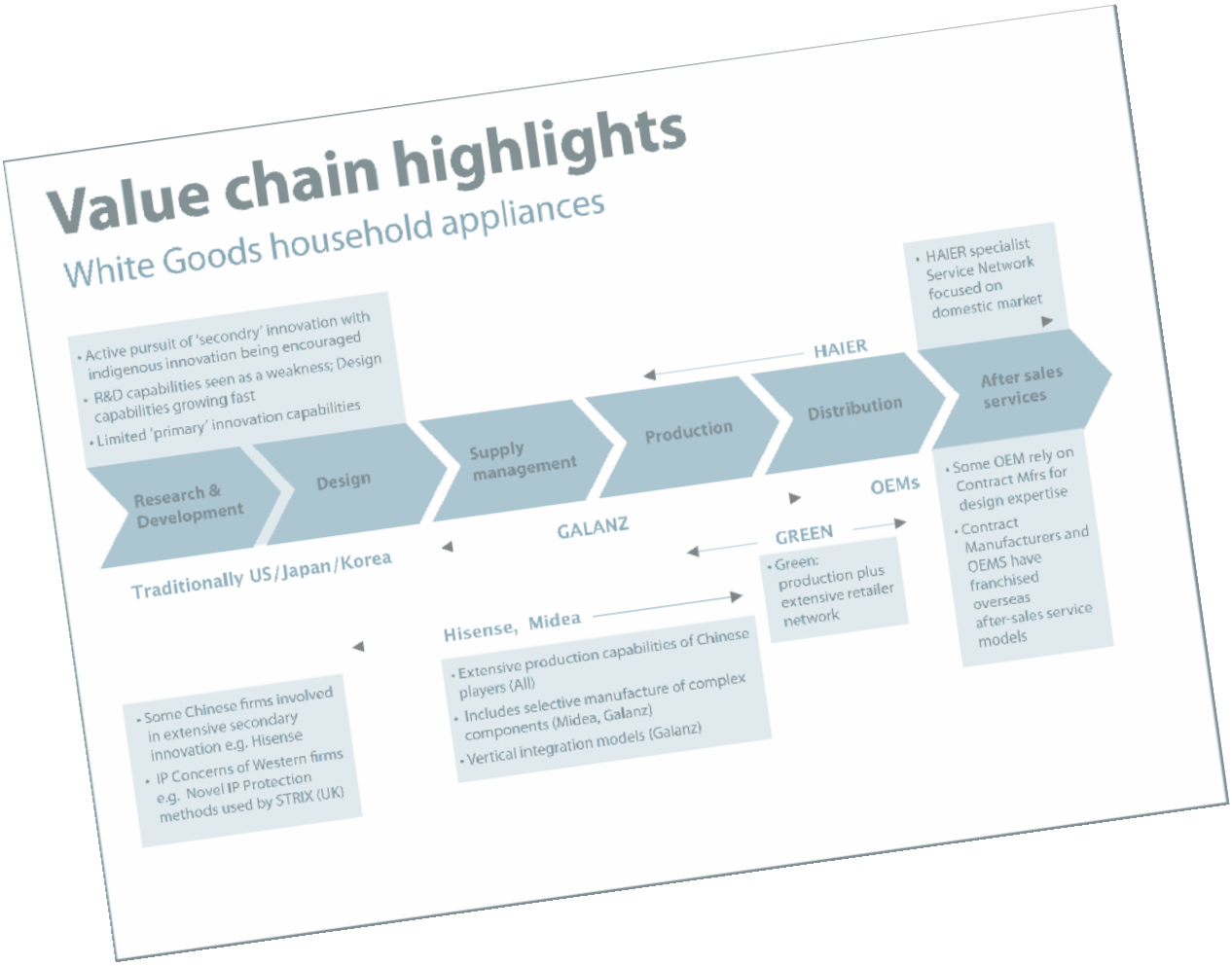
Overview of China's white goods sector

Case study companies visited

Value chain highlights

Emerging models and future trajectories

Potential UK-China complementarities



Overview of China's white goods sector

In production terms, Chinese manufacturers dominate the white goods household appliance sector. China is now the world's largest manufacturer with over 50% of its production for overseas markets.

Although there are still few Chinese players operating internationally using their own brands, there are several contract manufacturers who are extremely active in international supply in a number of mass production product categories – refrigerators, washing machines, microwaves, air-conditioners, domestic cooling-fans etc – where they have progressively moved into design and extensive secondary innovation. Hisense, for example, develop multiple product variants each year that exhibit innovative design. Many of these manufacturers have entered the market barely a decade or so ago but have migrated from outsourced third-party factory, to independent contract manufacturer, to design lead and own brand development (domestic market) within this period.

Internationally, the high levels of exports of contract manufacturers typically involve large consignment orders for overseas based OEMs and retail chains, and mainly mass-market product ranges that compete largely on cost. For a particular product category, these operations are often heavily clustered in a particular town or city. Microwave oven production, for example, is dominated by the manufacturers Galanz and Midea, who between them represent some two-thirds of global production volumes, and are both based in Shunde. Their supplier base is located within a two-hour road transport network, facilitating rapid response and low cost. Our case studies demonstrate that a highly geographically concentrated, single product category 'supply-cluster' is typical for many product categories in China.

Despite the white goods sector being relatively mature in technology terms, the domestic market has grown rapidly by some 60% between 1995 and 2005 and continues to grow at a healthy rate of 8% per year, driven by rapid urbanisation. Price competition is however fierce, both in domestic terms and the consignment-based international contract production, where single-digit margins have been routinely accepted by manufacturers who seek volume dominance. However, producing firms are becoming keen to establish independent footholds in overseas markets to improve margins.

Secondary innovation (rather than any fundamental R&D) by some manufacturers is now emerging. Examples include Hisense, Midea and Haier, with new designs that are increasingly producer-branded. This development is in line with domestic consumers who are becoming increasingly brand-aware.

Case study companies visited

The following white goods firms were reviewed. Each represents different strengths, driven by their particular business models and value-chain footprint.

- **Strix** UK component manufacturer; China/UK operations supply OEM and Chinese contract manufacturers
- **Galanz** Vertically-integrated manufacturing – recent moves into significant retail activities
- **Haier** Manufacturing based; own-brand development with an extensive service network arm in China
- **Hisense** Manufacturing based; major focus moving into secondary innovation and novel product design
- **Green** Manufacturer with extensive electrical retail network
- **Midea** International consignment orders for OEMs, now active in own brand and product development
- **OEMs** Technology-led heritage; now mainly relying on outsourced contract manufacturing and design.

CASE STUDY

STRIX LTD

- A UK-based company and a world leader in kettle control component manufacturing (dominant global market share) "Our wide range of kettle controls, cordless interfaces, thermostats and water boiling elements are used more than a billion times each day in domestic appliances around the world".
- Its factory network includes three production sites: two in the UK and one in Guangzhou, China.
- Exploration of new business models that build sales through supporting component product branding 'Strix technology inside' and working with contract manufacturers to improve their manufacturing operations.

R&D/design

- Company's HQ and R&D centre are based in Ronaldsway, UK.
- Product and process innovations are essential to maintain edge over competition which includes many 'reverse engineering' copyists.
- In the early 1980s, Strix developed new concepts such as immersed element technology and cordless interface technology.

Production/supply management

- Two UK factories in Port Erin and Ramsey. Ramsey factory specialises in plastic injection moulding and component pressing.
- In the 1990s, Strix won serial export and manufacturing awards through operational excellence.
- More recently its move into China, globalising its operations and getting close to product manufacturers, mainly contract manufacturers, has been key to growth. Coordination with downstream partners provides potential foundations for further success.
- Fast growth in China building from early entry (sales office in 1989):
  - 2001: assembly operations established using a third party to produce plastic mouldings
  - 2003: ISO 9000, 14000, 18000 accreditation
  - 2007: 510 people, two shifts for assembly and three shifts in moulding.

Distribution and service

- Plays a bridging role between contract manufacturers and UK OEMs (e.g. Philips, Tefal, Rowenta, Morphy Richards, Russell Hobbs, Kenwood, Bosch Siemens, Braun and Bodum).
- Promotes "Strix Inside" concept (Intel model) in the contract manufacturing network.

Major issues

- Intense cut-throat competition in China with 150 contract manufacturing companies in this sector; likely to be rationalised to "less than 50 in the next five years".
- Unique business model to protect IP and increase sales in China:
  - Using existing production control and quality management competences to support Strix contract manufacturers (kettle production) to improve production capabilities;
  - Sending engineers to Chinese contract manufacturers to solve production problems and use Strix components.
- Strix's strategy to deal with copyists in China: ensure collaborators have quality mass production capabilities, fostering and promoting them whilst ensuring 'Strix Technology' inside.
- Working with the Chinese government at various levels to protect their IP (design and patents) – requires a dedicated in-house team to follow-up!

CASE STUDY

HAIER

- Haier, founded in 1984, is now the No.1 domestic electrical appliance manufacturer in China, with annual sales of US$14bn in 2005. It is one of China's flagship manufacturing companies.
- It's operations include some 96 product lines including refrigerators, freezers, air-conditioners, washing machines, microwave ovens, TV sets, etc.
- In terms of turnover, Haier is now ranked 4th amongst global white goods manufacturers, behind Whirlpool, Electrolux and Bosch-Siemens, and is the largest for refrigerators.

R&D/design

- Haier is an innovative Chinese company. Its strengths are in product design and new product development, adopting new technologies and identifying new international markets.
- Its R&D centres are dispersed in many countries. In China, it has strong research teams working in electronics, control, new materials and aspects of nano-technologies.

Production/supply management

- Strong manufacturing internationalisation philosophy: Haier's manufacturing internationalisation started in 1996, when its first overseas joint venture factory was launched in Indonesia. From 1996 to 1999, several wholly-owned factories were established in Southeast Asia (Philippines, Malaysia, etc.) and the Middle East (Jordan).
- In March 2000, Haier's US complex in South Carolina, with annual production capacity of 200,000 units (one shift operation) entered into production.
- In June 2001, Haier purchased an Italian factory with similar production capacity to its US complex.
- Its international production network plays an increasingly important role in Haier's value chain optimisation: product R&D, brand-name development, production of wide range of products, and the development of a global distribution network.
- Very vertically integrated company – from R&D, production, distribution, after sales services (installation and maintenance), including brand-name promotion and marketing – developing a complete brand-product-supply integration strategy.
- Expansion of white goods concept, expansion of company size targets Fortune 500 group of companies – reflecting Chinese governments' ambitions to create global scale Chinese MNCs.

Distribution/service

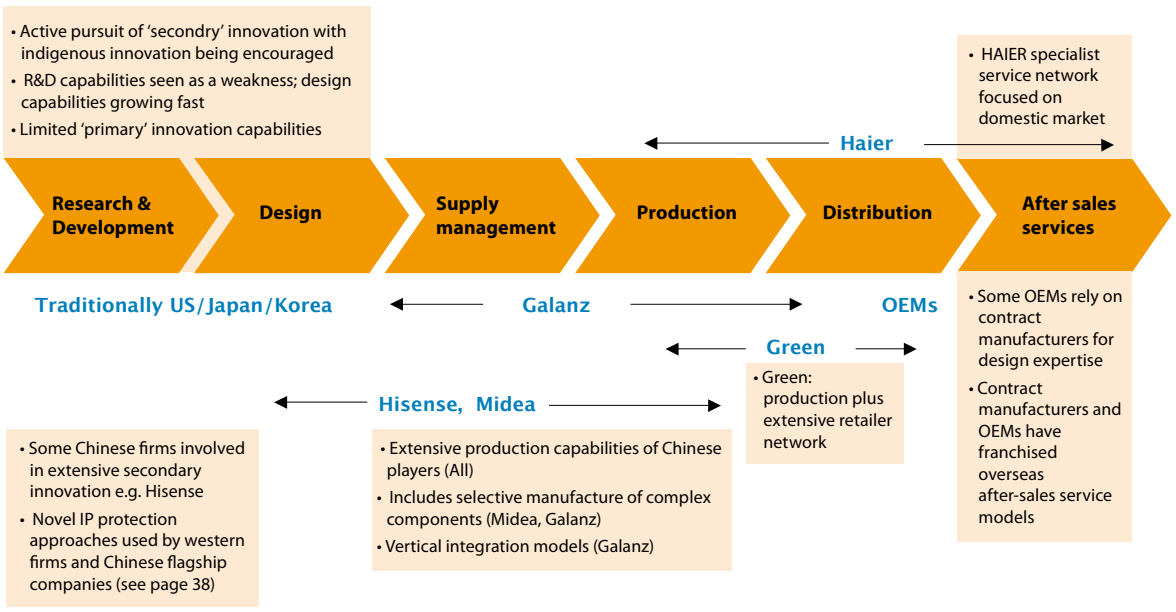
- Strong distribution channel in China through various types of networks.
- Haier has developed its service team and logistics network in order to enhance distribution and connections with its end customers. The strategy is very well received by Chinese consumers but may be less effective in the USA.
- Haier uses its logistics network to provide 3rd party logistics services to other companies.

Major issues

- One of Haier's major challenges is how to optimise its global operations, including design organisation, manufacturing network and training of resources – this is a typical 'internationalisation issue' faced by many large Chinese organisations.
- The company has become a national flagship of new China, gaining government sponsorship for its continued penetration of overseas markets.

Value chain highlights

White goods household appliances



Value chain highlights

Many of these global scale contract manufacturers have evolved from humble beginnings as local regional distributors or small-scale, third-party contract manufacturers. Demonstrating dynamic capabilities which enable them to move rapidly into adjacent value-chain activities, these firms display a variety of value-chain footprints and alternative approaches to value capture and internationalisation.

The schematic above positions the firms in our study along the value-chain, identifying their primary areas of focus and key strengths. It identifies potential gaps in their capabilities which may represent opportunities for external support or partnering arrangements of some kind. A more detailed analysis of selected firms is included in the case examples.

The rapid spread across multiple stages of the value chain appears to be driven by a number of factors. Profitability is a major issue for many of these manufacturers and their evolution is in part driven by a need to gain independent access to both innovation and markets. While indigenous innovation is a key national policy, few firms are making serious investments in this area. Those that are, may be regarded as focusing on secondary innovations in design – an R&D strategy rather than full blown research. This represents a key opportunity for UK firms to provide primary research at component level and product levels.

A second key dimension is internationalisation strategies where the dependence on OEMs and retailers from advanced economies is a frustration, with relationships barely beyond contractual, cost-based negotiations. Market access and after-sales services are by their nature distributed activities that present partnering opportunities or perhaps potential merger and acquisition activity.

Most evident in our review was that in this technology-mature sector, a sole focus on contract production leaves Chinese companies in a highly vulnerable position. This is only sustainable if it can be justified through process technology development leading to competitive advantages in cost and quality. In general, the lack of automation in production, and the high labour turnover at shop-floor levels (often around 50%), may represent some opportunity for introducing improved production technologies.

Emerging models and future trajectories

The development of multiple positions in the value chain by Chinese contract manufacturers, and the different business models that they represent, suggests that the move-away from production-only manufacturing to a more traditional footprint will emerge with:

- a more balanced presence across R&D, supply and distribution channels
- a rapid development of own-brands, with perhaps some consolidation in the future, as perhaps not all will be able to afford ongoing market support
- internationalisation strategies involving partnerships with overseas specialist retailers involving partnership rather than contractual product supply
- a requirement for some manufacturers to improve quality yet further through production technologies in order to compete with high-end products in advanced economies
- labour-law changes impacting PRD region, that provide workers (previously classified as 'casuals') with new employment rights, may require a re-think on the use of temporary casual labour and the greater adoption of automation in production
- material price-inflation forcing a re-examination of the pricing strategies of many manufacturers
- indigenous innovation currently practiced by a few players and focused on secondary innovation will determine which players are able to compete internationally.

The fierce price competition in the sector points toward some future rationalisation with the unprofitable positions of some manufacturers leading to their rapid decline and perhaps future demise. Nationally, the country is well positioned to maintain its dominance, helped by a booming domestic market and the importance of after sales services in some product categories.

Potential UK-China complementarities

The report has identified specific opportunities for the UK-China collaborations. These include supporting:

- the development of the internationalisation process through a more partnered approach with technology providers (product and process), retailers and service centres
- brand development
- primary innovation in terms of next generation products
- the introduction of more advanced production technologies to improve quality yet further
- high-end component supply, in terms of technology and/or products
- firms with their strategy development and value-chain analysis.

The value-chain models of the various case study companies appear to diverge from their traditional contract production heritage, with each representing different areas of strength. Potential for support in areas outside each firm's main focus is thus becoming more company specific, perhaps best demonstrated in the value-chain schematic shown earlier. These 'gaps' in the value chain of Chinese firms, whether as a result of strategic decisions or capability gaps, represent potential opportunities for partnering.

5 Sector review: TFT-Liquid crystal display

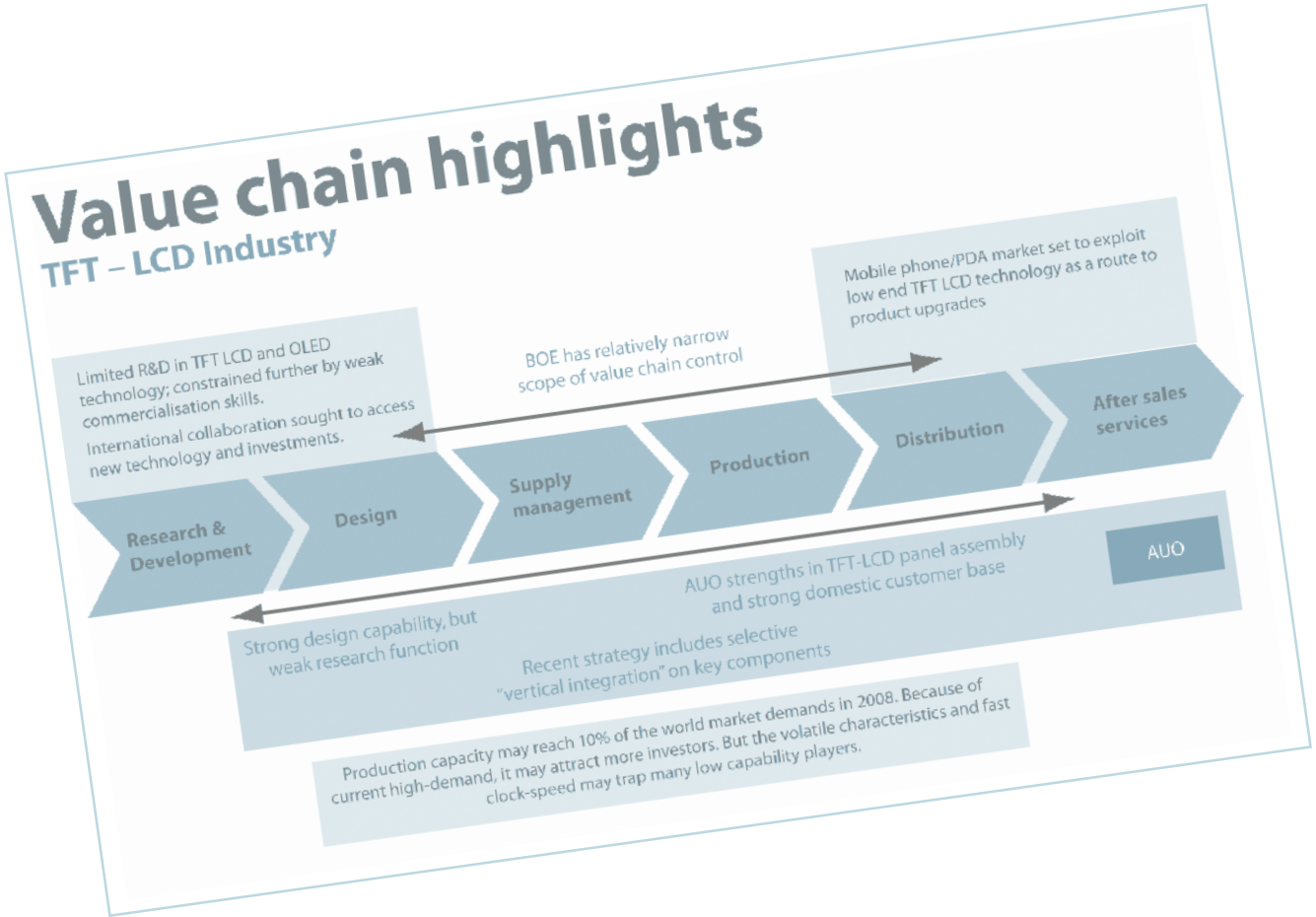
Overview of TFT-LCD

Case study companies visiteds

Value chain highlights

Emerging models and future trajectories

Potential UK-China complementarities

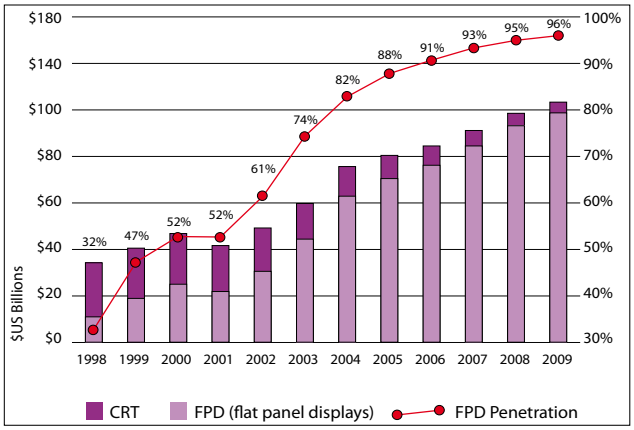


Overview of TFT-LCD

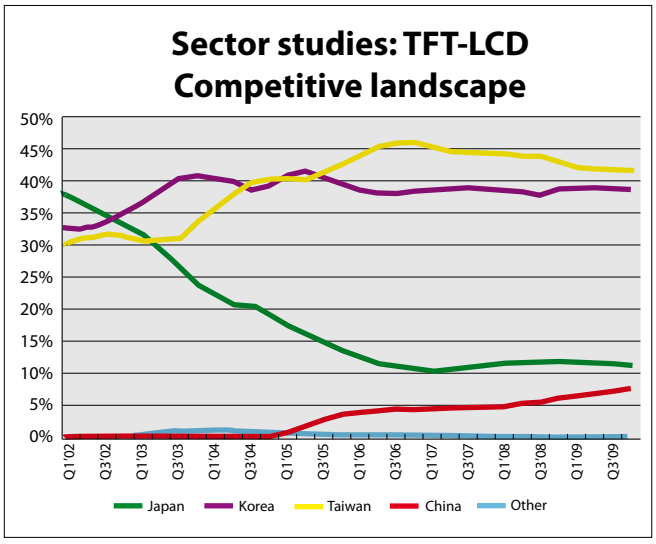
Thin-film transistor liquid crystal displays (TFT-LCDs) are a variant of liquid crystal displays (LCD) using thin film transistor (TFT) technology to improve image quality. Although liquid crystals were discovered by the Austrian botanist Fredreich Rheinizer in 1888, the technology's first real commercial use came in watch displays in 1970 in the US. Since then, there have been major improvements in technology and production processes. The TFT LCD panel has been coloured and the screen has been significantly enlarged. However, the television industry has only adopted the technology in the last five years. Amongst flat panel displays, TFT-LCD is the largest sector with sales expected to reach $78 billion in 2007.

Since 2004 the revenue from TFT-LCD sales has overtaken traditional CRT (cathode ray tube) sales and it has become the largest electronics sector globally (taking over the combined volumes of DRAM and Foundry sales). In 2009 world revenues are anticipated to exceed $90 billion in revenue, illustrated in the chart top right.

China's rather late engagement in this industry was driven by the need to migrate quickly from CRT technology to TFT LCD technology in television manufacture, where it has become the dominant platform. Chinese manufacturing companies, as seen in the graph on the right, are still in the early (incubation) phase of industry activity. There are now a few indigenous players joining the more established Taiwanese and Korean companies who have had production plants for some time in China. It will be very interesting to observe how these Chinese manufacturing companies engage with, and gain growth in, the industry dominated by Taiwan and Korean based companies.



TFT-LCD (flat panel displays) replacing CRT displays – now the largest sector in the electronics industry



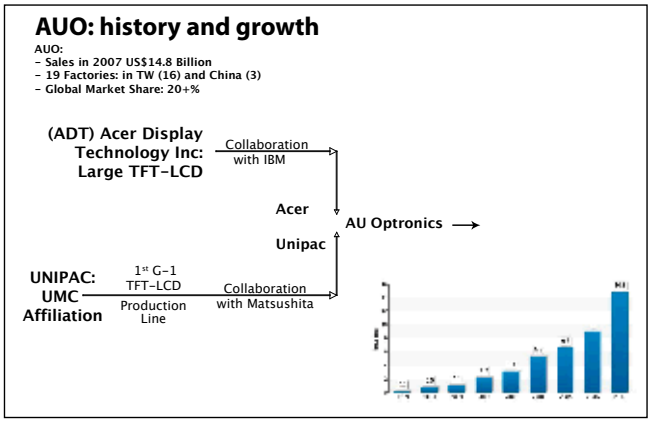
Key manufacturing players in TFT LCD industry (Source: Display Search, 2007)

Case study companies visited

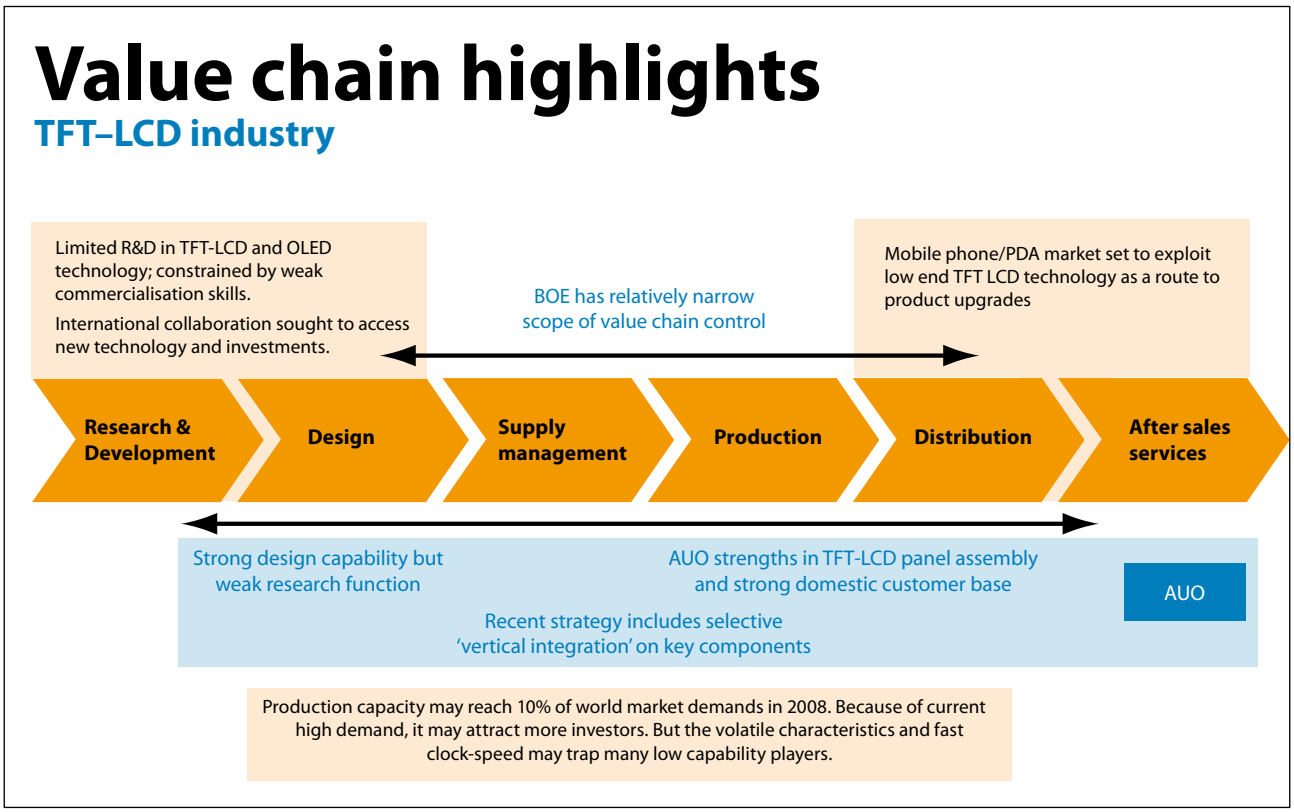
Our manufacturing value chain review included two case study firms from this sector:

AUO Taiwan's TFT LCD Manufacturing company. AUO, with sales $14.8 billion in 2007, is the largest TFT LCD company in the world. It has 16 factories in Taiwan and three factories in China. Its rapid rise and evolution is shown in the schematic on the right.

BOE Beijing Orient Electronics is a Chinese state-owned TFT LCD manufacturing company. It acquired Korean Hydis in January 2003. After several years managing the integration of the firms with both production capabilities spanning both countries, and integrating worldwide market demands, BOE is emerging as a strategic player in China with the latest 5th generation production line and new product development capabilities.



AUO development in the last 16 years



Value chain highlights

The schematic above sets out some of the main highlights of this product sector.

Emerging models and future trajectory

The review of TFT LCD industry demonstrates the rapid evolution of emerging ,high clock speed industries. The technology was invented in Europe, commercialised in the USA, technology transferred to Japan and then extended to mass production by Japanese, Korean and Taiwanese companies. Now Chinese firms are focusing on growing their domestic business.

Japanese companies have collaborated strategically with Taiwanese companies, perhaps to balance the power held by Korean firms in the development of this technology. Taiwanese companies have played a production-based role; Japanese firms have withdrawn from mass production and enhanced their high-end technology, preferring to co-develop mass production with Taiwanese firms. This kind of collaboration model and partner selection strategy may be the future model for development.

Potential UK-China complementarities

The UK electronics industry has recently developed potential breakthrough technologies in new types of semiconductor and display platforms. These technology interventions may lead to the emergence of new industry trajectories. However, the track record of the UK in capturing significant value across the value chain is mixed. A possible evolution path may involve Chinese or Taiwanese contract manufacturers as new strategic partners. There are complementarities between UK (both upstream R&D strengths and end-user markets) and Far East (downstream production) companies. At this early stage, it remains unclear how UK technology companies may develop their production capabilities and routes to market and how they might collaborate with downstream component and contract manufacturers. Equally complex is projecting how the migration between these very different product technologies and product life-cycles will evolve.

CASE STUDY

BOE

BOE (Beijing Orient Electronics Technology) is a Chinese state-owned TFT LCD manufacturing company, formed in 1993, and now the largest indigenous firm in China. The company history can be traced back to the 1950s to a Chinese company producing various electronic CRT products in Beijing. It has accumulated technology, production experience and human resources for some time and started its exploration in the TFT LCD arena in 1995. It collaborated with Hydis to produce mobile products STN-LCD in 2001. BOE acquired Korean Hydis in January 2003. After several years struggling to digest the fast-changing technologies and integrate production capabilities and markets, BOE emerged as a strategic player in China with its new 5th generation production line and new product development capabilities. In August of 2003, BOE acquired 26.36% shares of TPV Technology Group and became TPV's largest shareholder. After TPV acquired Philips Display Division in 1995, BOE became one of the largest display manufacturing production companies in China.

R&D/design

- BOE has rich product families based on its long term technology accumulation, including TFT-LCD for both IT/TVs (larger size) and mobile products (smaller size), various kinds of display technology and related products, LED and CCFL products, and CRT and VFD.
- It has wide research interests including OLED technology and total solution system integration.
- Currently BOE has developed more than 250 patents covering many core technology elements in the TFT-LCD industry.

Production/supply management

- BOE's operational disciplines are reflected in its four principal operational performance indicators: (1) maximise productivity of individual panels; (2) finished good inventory time to be < 1 day; (3) maximise cash turnover; (4) build rapid response teams.
- BOE has six production bases in China, with 10,000 employees.
- Its Beijing production base has the 5th Generation Production Line with 85,000 pieces per month capacity; its Chengdu production base has the 4.5 Generation Production Line with 30,000 piece per month capacity.
- BOE has relatively strong technology transfer capability and M&A integration capability after several international deals.
- However, unlike Taiwanese TFT-LCD manufacturers, BOE hasn't moved into up-stream key component areas and its core components are heavily dependent on suppliers. Its up-stream supply source dependency may be a strategic weakness.

Distribution/service

- Because BOE owns TPV, it has a stable client-base to ensure stable demand for its TFT-LCD production.
- It also has a wide range of customers including Samsung, LG, Dell, HP, Levono, and AOC/TPV, together reaching 70% of its production volume with another 20% supplied to the HiSense Group.
- Some core IP/IC drivers are co-developed between BOE and strategic alliance partners.

Major issues

- The industry is undergoing very rapid change. BOE has just reached profitability after long term losses. A key challenge will be its ability to cope with technology demands in terms of complexity and fast moving innovation. Its state-ownership behaviour heritage will need to develop further if it is to manage change.
- Demand is volatile, calling for operations to be more responsive and innovative.
- Compared with global players like AUO, CMO, LPL, and Sharp, BOE remains a very small player. How can it achieve fast growth during this industry growth phase? How can it survive if the industry takes a down turn?
- Future technology requires every player in the industry to have strong production planning. BOE's R&D capability is still quite limited. The company needs more strategic planning for the future.

CASE STUDY

AUO

AUO is a Taiwanese TFT LCD manufacturing company. Number 1 in global sales terms (sales of $14.8 billion) with more than 20% of the global market in 2007. It has 16 factories in Taiwan and three factories in China.

The company was formed in 2000 from two Taiwan display technology firms: UNIPAC formed by UMC in 1990, a Taiwanese semiconductor foundry, focusing on small/medium size TFT-LCD panels; and Acer Display Technology, focusing on computer screens. After the Asian financial crisis in 1997, both companies received strong support from Japanese companies via technology transfer, which directly contributed to their future development.

R&D/design

- The main product technology and basic scientific research are still heavily dependent on Japanese companies. After the Asian financial crisis, it appears Japanese companies faced serious challenges from Korean companies in terms of production costs. Taiwan firms became strategic, low-cost, production-based partners. Japanese and Taiwanese TFT-LCD industries have formed a complementary alliance across the value chain.
- AUO has a strong product portfolio, with wide coverage in mainstream product lines as well as strong economies of scale.
- AUO has very strong production technology capabilities, providing consistent product quality but also quick response to market changes.
- The firm has quickly developed its capability from a pure production facility to providing co-operative design with its downstream clients.

Production/supply management

- Production capability is a key strength of Taiwanese manufacturing companies due to their discipline, commitment, and systematic approach to continuous improvement.
- Taiwanese companies are dynamic players in the pursuit of high-value manufacturing and in capturing economies of scale. AUO has strategically invested in key components of TFT-LCD panels after building a high volume base.
- Up-stream control is not traditional vertical integration. AUO's investments in the component businesses in TFT-LCD are maintained as independent companies with full autonomy and entrepreneurial power in growth and competition; a business model developed by many Taiwanese companies.
- Chinese production plays a critical role in mass production in order to fully exploit Chinese manufacturing potential.

Distribution/service

- AUO has strong linkages with many other computer and television OEMs. As it is mainly a contract-manufacturing service provider, it has no brand conflict, which gives it many more opportunities to expand volume and concentrate on production.
- Its engineering service has been strategically developed by working with the OEMs and providing proactive design services.
- AUO has a strong position from which to access key computer and television producers in China.

Major issues

- AUO's main supply chain operations are still heavily concentrated in Taiwan and mainland China. Because of its global business expansion and recent environmental concerns, the company is considering dispersal of its value chain further into Europe and other regions. This is a new operational challenge.
- Product R&D may need to be enhanced and will involve strategic repositioning concerning which technology areas to engage with and the competitive implications.

6 Sector review: China's pharmaceutical industry

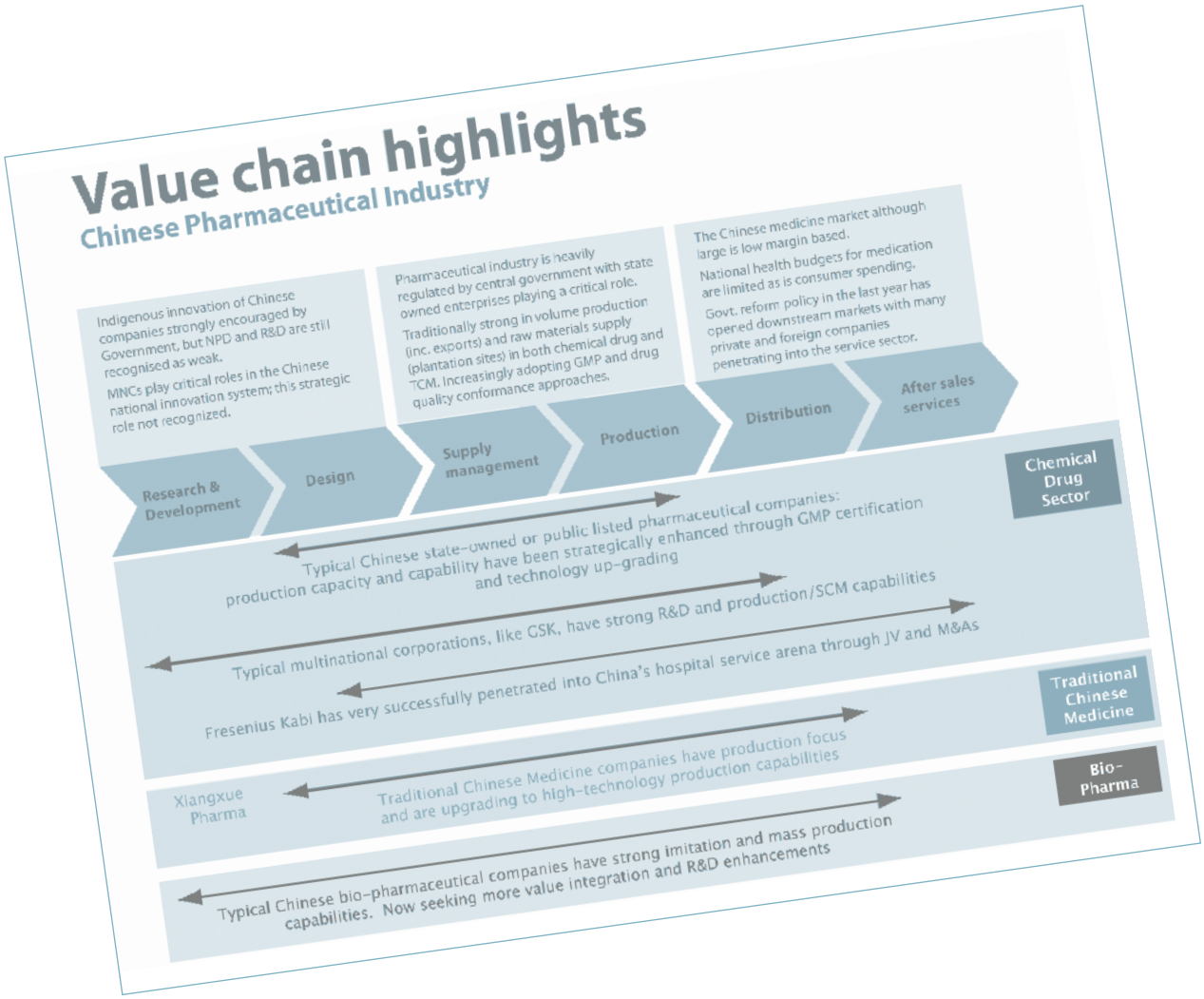
Overview of pharmaceutical industry

Case study companies visited

Value chain highlights

Emerging models and future trajectory

Potential UK-China complementarities



Overview

The Chinese pharmaceutical industry has an atypical product portfolio. Besides chemical and bio products, traditional Chinese medicines (TCMs) play a very important role in the national health system and contribute one quarter of total turnover in the industry. In 2007, the pharmaceutical industry turnover increased to 670 billion RMB, up more than 20% from 2006, and comprising about 2.7% of Chinese GDP. The three main product areas, chemical drugs, TCM and bio-pharmaceutical, account for 59.9%, 30.8% and 9.3% respectively. Chemical drug materials and medical equipment/machinery make up 48.9% and 25.4% of industry exports respectively.

The three product portfolios have very distinctive characteristics and their value chains and the key players in the industry are very different. The chemical drug sector has the strongest capability in terms of production capacity, technology inputs, company size, and impact on the national health system of China. It has 2,208 companies, almost half of the total enterprises in the industry. The chemical drug sector has been strongly influenced by both state-owned enterprises and foreign direct investment, but there is little in the way of interaction and integration between the two.

Undoubtedly, Chinese state-owned enterprises have strong downstream mass production and distribution power in the value chain, but their R&D capability is very weak and they have very low new drug development budgets and skills. On the other hand, the multinational corporations (MNCs) have strong new drug development capabilities and have developed significant R&D centres in China (see example of GSK R&D Centre in Pudong, right), and high quality production capacities, but have achieved relatively weak penetration of the Chinese market because of their high prices for prescription drugs and weak distribution channels into mass-markets. However, some focused MNCs, such as Fresenius-Kabi from Germany that have produced for hospitals, have gained huge success by developing tailored Chinese product and service packages.

Although the Chinese government still calls for a balanced policy encompassing both chemical (western traditional medicine) and Chinese traditional medicines, the Chinese elite and growing middle classes have increasing doubts about the TCMs in terms of their scientific basis and their effectiveness in targetting specific diseases. This trend is in contrast with the current worldwide interest in natural herb exploration and exploitation for new drug development. In order to upgrade TCM and provide more choice for patients, TCM companies have developed new technologies to enhance scientific approaches in TCM development and have sought to identify more accurate active ingredients in order to increase product effectiveness. For example, a Guangzhou-based TCM pharmaceutical company, Xiangxue, has explored setting up research links with a UK university pharmacology department, in order to complement its R&D resources and perhaps support brand building (see case study page 36).

Although a relative new comer to the sector, China has huge ambitions concerning bio-pharmaceuticals. In the last twenty years, the country has produced at least 579 bio-pharmaceutical companies and developed many bio-clusters in cities such as Beijing, Shanghai, Hangzhou, Chengdu, Wuhan and Guangzhou. In this sector, besides novel new product development (NPD) by Chinese bio-pharmaceutical companies, import-replacement strategies have been widely adopted. As a result, Chinese bio-pharmaceutical companies' business performance metrics are generally very healthy and their growth rates are also fast. Novel and high risk NPD collaboration between universities and companies are encouraged but sophisticated mechanisms to form networks for longer term cooperation are still lacking.

Bio-clustering is usually developed by either central or local governments. Many start-up companies are still demanding heavy governmental subsidies or various types of tangible support. Eagerness and enthusiasm for international collaboration are widely observed in the sector, especially in start-ups, in order to adopt new

GSK to invest US$100 million for R&D in China

- British pharmaceutical company GlaxoSmithKline (GSK) plans to inject US$100 million into a neuroscience research centre in China by the end of next year. This centre will play a crucial role in the development of global drug research.

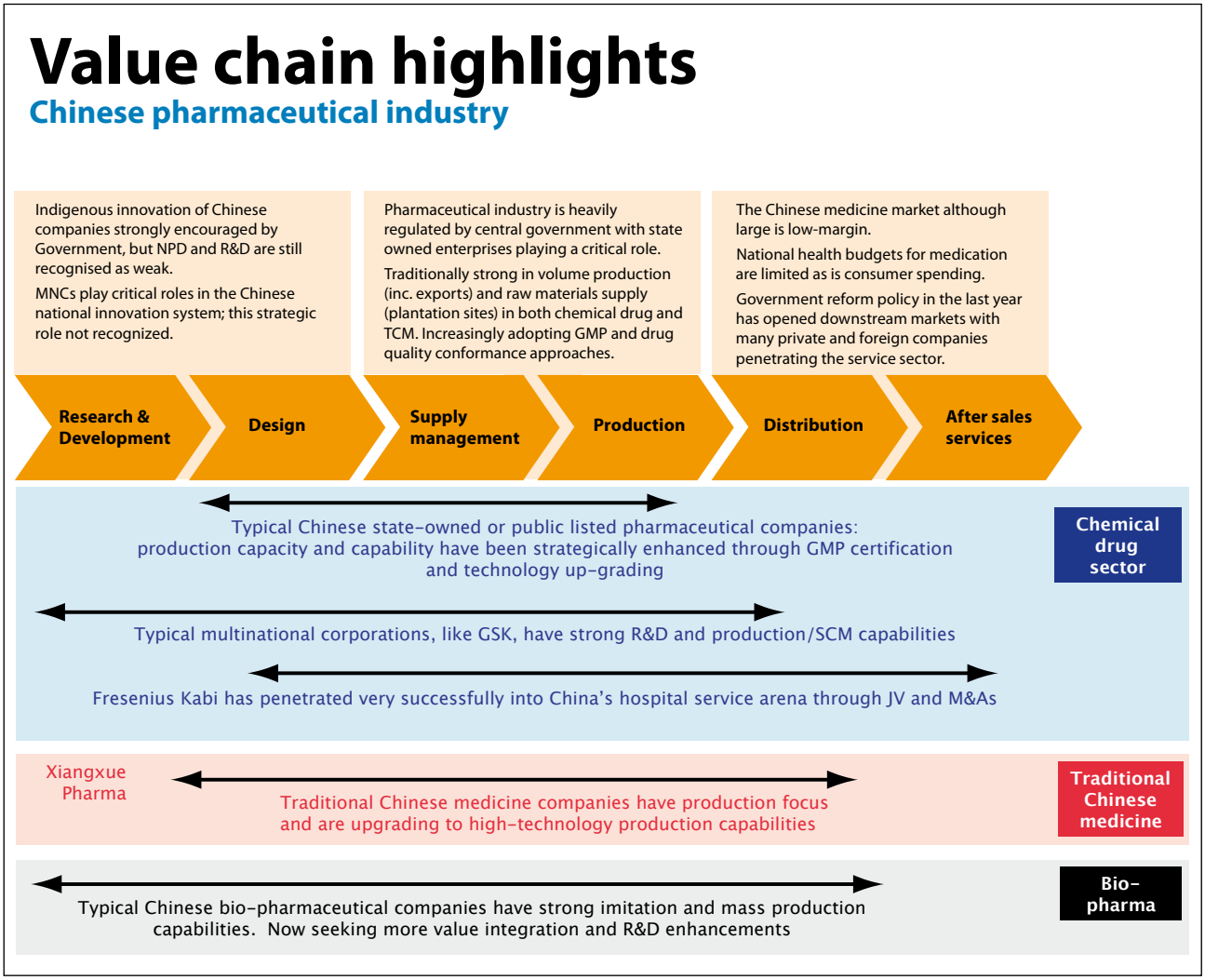
  Moncef Slaoui, the director of GSK's R&D department, claimed that the company will be establishing a research and development centre in Shanghai and will be responsible for researching into drugs for neuro-degenerative diseases, such as Alzheimer's disease, Parkinson's disease, and multiple sclerosis (MS).

  This investment marks the willingness of a large western pharmaceutical company to enter China, in order to tap into its rapid development of science, rather than only focusing on low cost manufacturing, clinical trials and growing sales of medicines.

  Currently, GSK has a research and development centre in Shanghai's Pudong, but the centre will be relocated to make way for the new centre. The new centre plans to recruit 1,000 scientists within the next 6 years.

  Neuroscience is one of the four therapy fields in Slaoui's plans.

  Dec. 13, 2007 (From China Knowledge)



technology and business development skills.

Case study companies visited

Fresenius Kabi headquartered in Germany, is the leader in infusion therapy and clinical nutrition in Europe and in the most important countries of Latin America and Asia Pacific. It has about 17,000 employees worldwide and achieved sales of 2,030 million Euro in 2007. The company has 45 manufacturing facilities spread across Europe, North America, Latin America, Asia-Pacific and Africa. Fresenius set up its first JV in Beijing in 1994, and then in 1999, acquired Sino-Swed Pharmaceutical Corp (which had been in China since 1982). Fresenius Kabi has become one of the largest MNCs in the Chinese pharmaceutical industry.

Xiangxue is a Zhuangzhou-based TCM pharmaceutical company. Its products cover a wide range of TCM families. Xiangxue is improving its production capability by achieving GMP standards and coordinating its whole supply chain. Its R&D is focused on identifying and purifying active ingredients in TCM. In 2007, it explored setting up R&D links with a leading university pharmacology department. Although, at present, this has not matured into any significant joint research work it recognises the potential value of international research collaborations. It has a strong interest in collaborating with UK scientists researching traditional Chinese medicine. The company recognises that TCM currently lacks hard scientific proof but believes it has great potential in terms of further theoretical development and future commercial performance.

Some discussions were held with GSK and Astra Zeneca. These covered specific topics only – namely their investments in on-shore production facilities (GSK) and recently announced R&D Laboratories (AZ).

Value chain highlights

Key trends in the pharma value-chain, identified in the case studies, are shown in the schematic above.

Emerging models and future trajectory

A global value network is emerging in the industry: GSK's Chinese and Xiangxue's UK R&D links and Fresenius's Chinese health care industry engagement demonstrate exploitation of global value networks. Collaboration, integration and value-chain positioning become critical management decisions in this increasingly globalised industry.

The strategic 'make-or-buy' decision has become an essential capability for survival and growth. It has moved beyond the traditional outsourcing or off-shoring decisions of components and equipment. Understanding the network, coordinating multiple suppliers and understanding how best to integrate them, are challenging both managers and scholars.

Chinese firms have started to internationalise their value chains. Export and contract manufacturing services have been traditional Chinese manufacturing strengths. More recently, Chinese manufacturing companies have started to engage with foreign resources to equip their manufacturing systems, upgrade R&D capabilities and improve clinical support practice.

Potential UK-China complementarities

The value-chain schematic on the previous page identifies several complementarities between the UK and China. This potential is not fully exploited because of the industry's restrictive regulatory framework, the poor reputation and bad name of state-owned enterprises, and a lack of understanding of emerging Chinese university research and China's national innovation system.

Chinese state-owned enterprises have evolved over the last thirty years, especially in the more market-oriented and competitive environments in the coastal regions. Most central and provincial government-controlled, state-owned enterprises have been floated on domestic or international stock markets, encouraging them to modernise. Industry consolidation has been dramatic in the last few years, but there is scope to improve performance through further rationalisation. This rationalisation, into fewer more capable firms, offers the potential for collaboration between UK and Chinese national flagship companies.

In the NPD arena, more and more opportunities are emerging from the pipeline engagement with Chinese partners who were believed to be too weak and to lack basic training in the systematic and scientific approaches to drug development. Of course, more training and guidance are still needed for effective collaboration. From a cost reduction perspective, there is strong pressure to enhance collaboration and to further exploit Chinese capabilities.

There is still a need to convince the Chinese government and the public that MNCs and their R&D centres are part of the Chinese national innovation system and can make a significant contribution to China's indigenous innovation capabilities. Chinese scientists working in overseas-based MNCs are increasingly encouraged to work and exchange ideas with their local university colleagues.

CASE STUDY

FRESENIUS KABI (GERMANY)

- Fresenius Kabi, headquartered in Germany, is the leader in infusion therapy and clinical nutrition in Europe and in significant countries in Latin America and Asia Pacific. It has about 17,000 employees worldwide and achieved sales of 7 billion Euro in 2007. The company has 45 manufacturing facilities spread across Europe, North America, Latin America, Asia-Pacific and Africa.
- Fresenius set up its first JV in Beijing in 1994 and increased its market share in 2005 by moving into the health care service business. Beijing Fresenius Kabi is a wholly owned foreign enterprise (WOFE).
- In 1999, it acquired Sino-Swed Pharmaceutical Corp (which had been in China since 1982).
- Fresenius Kabi has become one of the largest MNCs in China's pharmaceutical industry.

R&D/design

- R&D work is mainly located and organised in Germany and is heavily focused on infusion therapy and nutrition care service in and out of hospital. The company develops comprehensive product families compatible with the core service.
- Products and technologies are shared across its global network.
- Chinese product development is mainly conducted in China through marketing and engineering teams who tailor it to the Chinese hospital markets.

Production/supply management

- The company was the first one to promote Good Manufacturing Practice (GMP) in the Chinese Pharmaceutical industry.
- Chinese local development plays a critical role in local raw material and component sourcing.
- The company controls an extended value chain, from key device production to nutrition care services for hospital patients and outpatients.

Distribution/service

- The company's uses various distribution channels across China. It has a presence in teaching and demonstration hospitals in the principal cities. It advises medical students in the use of company products. These approaches help it to attract other hospitals into its supply and service network.
- It has used M&A as a means of developing new business, e.g. the acquisition of a clinical nutrition business in China from SSPC, helped it to move into Chinese hospital services.

Major issues

- Managing Chinese JV partners, especially in state owned enterprises, is still the key challenge for the company. Differences of approach concerning partner motivation, incentives, responsiveness and accountability, may have impacted the company's growth rate in China.
- How best to exploit China's increasing capability in engineering and research is a major issue. The company is considering an expansion of its development work in China.
- The company is considering the use of its Chinese manufacturing base as a potential regional sourcing hub for all Far East countries. However, the reliability and reputation of the Chinese pharmaceutical industry is still weak in more developed countries such as Japan and the four 'Asian tigers' of Hong Kong, South Korea, Singapore and Taiwan. The logistics and practicalities of regional supply also need to be evaluated.

CASE STUDY

XIANGXUE PHARMACEUTICAL

Xiangxue is a Guangzhou-based traditional Chinese medicine (TCM) pharmaceutical company. Its products cover a wide range of TCM families especially anti-virus syrup.

The company was developed in the 1950s as a township (collectively owned), small traditional Chinese medicine company. It was almost bankrupted in 1997, then bought by a local successful businessman, and re-named as Xiangxue Pharmaceutical Corporation. Under his leadership, the small company has grown rapidly and is diversifying from the traditional Chinese medicine domain into new high technology areas.

Its products have been up-graded and strategically diversified into more than 80 categories within four strategic families, from TCM and healthy food to bio-medical engineering, TCM plantation and education. In 2005 Forbes recognised it as one of the top 100 companies with growing potential in China.

R&D/design

The managers are introducing western approaches to the development of TCM. They are pursuing greater understanding of the science underpinning traditional Chinese medicines, including how the medication is applied, and raising the general image of TCMs.

The company is improving production capability by introducing Good Manufacturing Practice standards and by improving the coordination of its whole supply chain. It is also focusing its R&D on identifying and purifying the active ingredients of TCMs. It has a strong interest in collaborating with UK scientists to research traditional Chinese medicine, and explored development of R&D links with a UK university pharmacology department in 2007. It recognises that TCM lacks hard scientific evidence and theoretical foundations but believes it has great commercial potential.

Production/supply management

- GMP certification was pursued very soon after the ownership change in order to ensure TCM conformance to industry standards in terms of both hygiene and efficiency.
- The company develops and manufactures its own pre-batch materials to ensure high quality production.
- It has introduced advanced manufacturing technologies with fully automated production lines in its clean rooms, and advanced planning systems supported by enterprise resource planning tools. These production processes have strengthened its IP protection – a particular challenge with TCMs.

Distribution/service

- The company's marketing strategy is very aggressive and different from most TCM companies. It sponsors the Zhenzhen Football Club and uses the media to promote its healthy medicines and foods.
- It undertakes Traditional Chinese Medication education to raise the status of TCMs.
- It is developing distribution channels to penetrate into Chinese rural markets with affordable TCMs, using over-the-counter channels as the main route but backing this up by using rural hospital systems.
- It has divided Chinese medicine markets into six regional markets and strategically targeted southern (home) and eastern Chinese markets. It has used its limited resources effectively, successfully penetrating these markets and growing its core business.

7 Summary of findings and implications for UK enterprises

Summary of findings

The sustained growth of the Chinese economy is driven by the impressive performance of its manufacturing sector. Key highlights include:

- A strong infrastructure and supplier base (including OEM contract manufacture of finished goods) provides significant competitive advantage in traditional industries. Chinese firms are world leaders in volume terms across many sectors including high-tech sectors such as aerospace, shipbuilding, steel, IT and telecommunications.
- In selected industries the market dominance of Chinese firms has resulted in them leading next generation manufacturing technologies e.g. steel, telecoms, ship-building and, to a lesser degree, in mature markets, e.g. domestic appliances, textiles and leather. Many Chinese manufacturing firms readily invest in extensive upstream supply networks either as part of highly concentrated inter-firm supply clusters or more vertically integrated models.
- Chinese firms, often utilising modest entry positions in the value chain (e.g. beginning as a regional distributor) are rapidly entering adjacent, more value-added positions; this allows rapid upgrading of skills and capabilities.
- Many state-controlled enterprises have also grown dramatically with 14 major Chinese state industries present in the Fortune 500 list. These are loosely supervised by a co-ordinating body (SASAC) which provides direction on investment and liberalisation policies.
- National strategies (11th 5-year plan) for manufacturing focus on 'enabling' and 'hi-tech' programme initiatives in order to narrow the gap with international products. They emphasise technologies that support green, digitised, modular and reliable/sustainable manufacturing. National policy makers are questioning the benefits of low-value manufacturing and are switching attention to higher-end manufacturing, e.g. IT, pharma and aerospace (despite failed previous attempts) with clear policies to invest in fundamental research capability and build absorptive capacity. Government and foreign-owned MNCs are now investing in aerospace, IT and pharma – both in R&D and in manufacturing. Expertise centres are expected to emerge over the coming years.
- Current industry absorptive capacity remains low but emerging flagship companies and industries may provide models for moving from 'imitator' (reverse engineering focus) to 'innovator' (leading-edge technology). These developments, coupled with heavy investments in key state industries, education and technology universities, mean Chinese capabilities are likely to develop faster than in other developing economies.
- The impressive growth of Chinese manufacturing signifies the transformation from a highly planned to a mixed economy. Its sustainability in environmental, social and political terms has been carefully and pragmatically managed – overcoming difficulties as they arise. Sustaining this growth in the future will present social, technological, environmental and political challenges. A whole generation has only experienced GDP growth of 10% or more.
- Over the past 20 years key engines for growth have been the unique regional clusters in PRD, YRD and Pan-Bohai regions.
- Intellectual property protection remains a major concern for foreign manufacturers and Chinese flagship companies – exacerbated by intense competition amongst component manufacturers.

Novel IP protection approaches

- Foreign-owned MNCs and flagship Chinese companies are protecting their IP with a number of novel approaches:
  - effective use of IP laws (increasing legal protection for patents/utility models)
  - enforcement best practices using public authorities (dedicated in-house teams) and institutional bodies (use of sector cluster associations e.g. OTIS)
  - fragmentation of parts procurement (e.g. Li & Fung)
  - component and process accreditation/branding and selling of related services (e.g. Strix)
  - product allocation/licensing (centralised procurement agents)
  - business models that discourage imitation (e.g. ARM).

Implications for UK Companies

Potential opportunities for UK firms span the value-chain, where complementary capabilities can support future development of UK and China enterprises. Specific areas that have emerged in our case studies are:

- Technology complementarities between UK and Chinese firms are present in most sectors, with the UK providing R&D capability and product technology support (e.g. primary innovation research) and China increasingly providing capabilities in 'secondary innovation'. Many opportunities are sector specific e.g. extending clinical trials in pharma to China, potential breakthrough technologies in panel display, component technology support in household appliances etc.
- The emergence of China-based expertise centres in R&D (e.g. selective drug development and testing), production (e.g. consumer electronics and white goods) and service (e.g. aerospace) represent opportunities for UK companies to build collaborative partnerships where the local context is a significant factor, for

example strong domestic market, access to production technologies, and/or local equipment servicing.

- Brand development, a major focus of many contract manufacturers, may benefit from UK expertise where sophisticated brand development captures particular product characteristics, backed up by relevant component, formulation or production technology.
- Intellectual Property protection needs to be considered carefully with novel approaches used by foreign MNCs and flagship Chinese firms to protect technologies and brands (see box opposite).
- Scope to advise on a variety of Chinese internationalisation issues, including the management of multi-domestic operations, effective mergers and acquisitions and other cross-border partnering approaches.
- Chinese rapid prototype development facilities, which benefit from superior access to suppliers and production capabilities, present opportunities for UK firms to speed up new product development.
- Low-cost component or product sourcing from China continues to be a way for UK firms to achieve cost competitiveness provided they have undertaken a comprehensive make-buy strategy.
- Increased partnering and collaboration between UK and Chinese universities may provide opportunities for technology transfer and training. In addition to specific technology-based projects, developing advanced strategic and operational management capabilities to support more effective new product development, technology management and supply chain management, within internationally-dispersed operations, are likely areas of interest for transnational corporations.
- The relatively immature services sector is set to grow across manufacturing (maintenance and upgrade), logistics (transport), retail and support services (banking, legal etc). These provide new opportunities for companies to engage with Chinese partners.

Future work

The study has identified key trends in a selected set of product sectors. A number of sector studies key to manufacturing have not been covered, such as automotive, aerospace, the digital sector and equipment manufacturers. These sectors have been identified as key elements of China's high value manufacturing (HVM) strategy, where selective UK involvement may be of strategic interest.

Sustainable manufacturing, covering issues of energy supply, raw material sourcing and climate change, were also identified as key issues for future HVM and supply network design strategies, and may warrant a focused research project.

Finally, there is poor understanding of the state-owned-enterprises which have undergone major transformation in recent years. Initial interactions with SASAC suggest strong interest in developing tools and processes to better promote and manage indigenous innovation across all elements of the value chain. A focused study of these enterprises, perhaps through SASAC (spanning multiple firms within a sector, and multiple sectors), may identify new insights and opportunities for collaboration at both company and industry levels. These huge turnover enterprises are likely to present opportunities of significant scale.

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The IfM

The Institute for Manufacturing (IfM) provides a unique environment for the creation of new ideas and approaches for modern industrial practice. Part of the University of Cambridge's Department of Engineering, it brings together expertise in management, economics and technology to address the full spectrum of industrial issues.

The IfM has over 230 people working across a range of specialist areas, integrating research and education with practical application in industry. A team of industrial practitioners help companies of all sizes to apply research-based improvement techniques via a programme of consultancy and education services. This work brings benefits to both parties. Industry receives practical solutions based on the latest applied research; the IfM gains live feedback to help set the agenda for new research and an income stream to assist in funding future research activities.

The Centre for International Manufacturing

The Centre for International Manufacturing is one of several research centres within the IfM. It 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.

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