

Policies for managing operational complexity in the supply chain

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ABSTRACT

The operational complexity of supply chains can vary with the volatility of customer demands, reliability of material supply, predictability of internal performance, and the effectiveness of management and control policies in place. Based on insights from real-life case studies, this paper explores some practical policies available to organisations for managing the operational complexity of their system.

The complexity management policies adopted by organisations can be categorised into exporting operational complexity to some other organisation; charging for the service of coping with imported complexity; investing in precautionary systems that work to avoid complexity generation; or investing in sufficient resources to absorb complexity. These policies have implications on the operational complexity of the internal organisation and the external supply chain within which it operates.

INTRODUCTION

Manufacturing organisations transfer material and information within their internal business units. Internal material flows can include actual production flows and actual delivery flows. Similarly, internal information flows can include production schedules and dispatch schedules. Manufacturing organisations also transfer material and information externally with their suppliers and customers. The material flows at the interface include actual deliveries. The information flows at the interface can include forecasts, orders and confirmation documents.

For manufacturing organisations operating in competitive environments, responsiveness has become the differentiating factor where competitive pricing and quality are assured. Pressures to improve competitiveness through increased responsiveness cannot be met solely by isolated change within the boundaries of a single organisation, as an organisation's own business performance is directly impacted by the performance of its suppliers and customers. Instead, to be responsive to changing market conditions, organisations have to look to the responsiveness of their suppliers and customers. Recognition of this fact is leading to considerable changes in the way organisations manage their internal and interface systems.

In the light of these environmental and organisational changes, the resulting operational complexity experienced by the supply chain is explored in Section 0. The paper then discusses, in Section 0, some generic policies available to organisations for managing the operational complexity experienced within the supply chain system. Finally, the paper concludes with Section 0.

The findings reported in this paper are based on results of cases studies conducted across the customer-supplier systems of Unilever-ALPLA and BAE SYSTEMS-Graphic (Sivadasan, 2001; Sivadasan *et al.*, 2001, 2002b). These case studies form a part of the Supply Chain Complexity Project (Frizelle and Efstathiou, 1998), which develops and applies information-theoretic measures for investigating the complexity of information flows and material flows across and within supplier-customer systems.

SUPPLY CHAIN OPERATIONAL COMPLEXITY

The drive towards responsiveness involves monitoring and managing the uncertainty of information and material flows internally and at the interfaces. As the uncertainty of the information and material flows of the supplier-customer system increases, the system becomes operationally more complex to monitor and manage. Operational complexity can be defined as the uncertainty associated with the dynamic system (Frizelle and Woodcock, 1995; Frizelle, 1998; Sivadasan *et al.*, 2002a).

In a dynamic environment such as the supply chain, even basic supplier-customer systems with structurally simple information and material flow formations have a tendency to exhibit operational complexity. The operational complexity of supplier-customer systems is associated with the uncertainty of information and material flows within and across organisations (Sivadasan *et al.*, 1999b; Sivadasan *et al.*, 2002a). In essence it is associated with variations in quantity or time across expected and actual flows. From a more theoretical perspective, the operational complexity across the supplier-customer system can be defined as the amount of information required to describe the state of the system in terms of the quantity or time variations across the material flows and information flows that exist (Sivadasan, 2001).

The indicators of operational complexity can be observed within organisations on a daily basis in the form of ad hoc orders, unreliable deliveries, changes to what has been ordered, alterations to specifications and other unpredicted variations in information and material variation across supplier-customer interfaces (Sivadasan *et al.*, 1999a; Sivadasan *et al.*, 2000). Organisations that try to manage operational complexity often have to cope with schedule revisions and production changes (Huaccho Huatuco *et al.*, 2001).

For material flows, operational complexity increases as the variation between actual and expected activities in quantity or time become more uncertain. The problem investigated is the uncertainty of not knowing how much more, or less, of a product is delivered than scheduled and how much earlier, or later, it is delivered than scheduled. For example, across an interface, this would include how the Actual Delivery quantity or delivery time differs, for any product, from what is stated in the Delivery Schedule.

Similarly, across information flows, operational complexity refers to the uncertainty of variations in quantity or time that appear across successive documents. For example, across an interface, the delivery quantity or delivery time requests may differ, for any product, from the Forecast document to the Order document. The problem investigated here is the uncertainty of not knowing how much more, or less, of a product is required than previously specified and how much earlier, or later, it is required than previously informed.

OPERATIONAL COMPLEXITY MANAGEMENT POLICIES

An organisation's attitude towards complexity management is key in the type of management strategy adopted and implementation policy pursued. The complexity management policies adopted by organisations can fall into four categories as indicated by Figure 1, from which organisations have a choice of one or more of the following:

1. export operational complexity to some other organisation;
2. charge for the service of coping with imported complexity;
3. invest in precautionary systems that work to avoid complexity generation; or
4. invest in sufficient resources to absorb complexity.

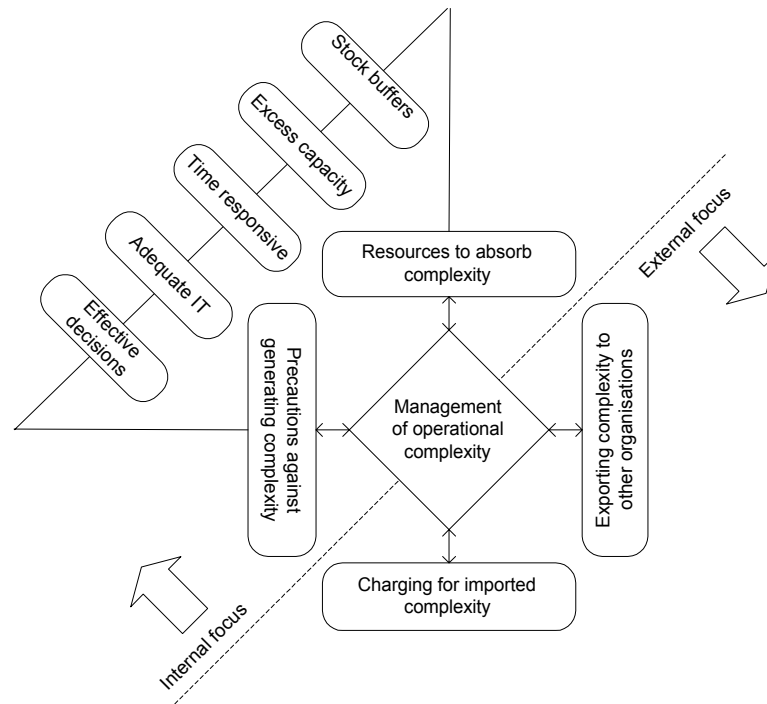


Figure 1: Operational complexity managing policies

Details of exporting complexity as a means of coping with operational complexity are discussed in Section 0. The details of charging for imported complexity are discussed in Section 0. The policies of investing in resources to absorb complexity and precautions against generating complexity are discussed in Section 0.

EXPORTING COMPLEXITY

One way in which organisations try to cope with operational complexity is by transferring it to their suppliers and customers. This phenomenon can be described in terms of exporting complexity. Thus, for example, organisations that alter their supplier delivery schedules due to changes in their internal production schedule can export complexity to their suppliers. Similarly, organisations that fail to deliver the required products at the expected time and in the requested quantity can export complexity to their customers. The justification for adopting the term is that such events generate additional information that needs to be transmitted to and managed by the importing organisations.

The extent to which organisations export complexity at the supplier-customer interface can be due to several factors including:

1. poor ability and insufficient resources internally to control and contain complexity;
2. necessity of exporting complexity that has been imported from some other organisation;
3. imposition and control of the direction of complexity transfer by organisations with greater bargaining power; and
4. internal culture of a ‘them and us’ divide in the supply relationship.

However, exporting complexity is not necessarily an effective response to dealing with supply chain issues, as these actions can have repercussions on the entire supply chain with direct implications for immediate partners. Suppliers can incur high operating costs where customer induced variations across Forecasts and Orders are internally accommodated. Suppliers can also export complexity to customers through the transfer of material by unreliable deliveries (in time or quantity) and sub-standard product quality.

Customers can incur high revenue losses if supplier failures lead to plant stoppage. Unfortunately, the majority of the smaller and less powerful organisations may have neither the infrastructure nor the resources to absorb the additional variations and uncertainties transmitted to them, from suppliers or customers.

CHARGING FOR IMPORTED COMPLEXITY

Suppliers can incur high precautionary costs in administering policies to buffer against imported customer complexity. These precautionary costs can include costs associated with building up inventories, investing in extra capacity, acquiring more powerful information management systems and training personnel to cope with a greater degree of decision flexibility. Ultimately, increased operating costs of the supplier would be passed on to the customers, where the supplier does not have the means to deal with them internally.

Customers can also incur high costs where complexity is exported to them. Complexity exported to customers, from suppliers, in the form of early deliveries, has costs associated with managing and monitoring the stock. Late or poor quality deliveries can at best delay internal production and at worst bring the customer's production to a halt. Precautionary measures taken by customers include cases where they may hold Goods-In inventory or operate a dual- or multi-sourcing policy, where a choice of supply provides an opportunity for the complexity generated by one supplier to be absorbed by the flexibility of another supplier. These also carry costs.

Organisations that manage imported complexity can charge the exporting organisations. This is beneficial to the non-exporting, exporting, and importing organisations within the chain. Identifying and specifically charging the exporting organisations will mean that non-exporting organisations will not be unfairly penalised as in the case where the costs of complexity are spread evenly between all organisations. In the case where exporting organisations pay for the complexity that they transfer, they can in return demand and expect a more predictable standard of service. In this case, armed with a quantification of the problem and provided with adequate resources, the importing organisations can focus on meeting the specific needs of the exporters.

It is proposed that charges for managing imported complexity can be set through premium rates or penalty rates.

1. Premium rates would provide supply chain partners with an option of paying a premium to cover for their complexity exporting behaviour. Premium rates would primarily act to charge customers who export demand complexity, through variations in demand. This may include premium rates for accepting late changes to the delivery requests or for delivering products on a fast turn-around basis as observed from the BAE SYSTEMS-Graphic case study (Sivadasan, 2001).
2. Penalty charges would act to penalise supply chain partners who export supply complexity, through variations in supply. This would mainly take the form of penalty charges for failure to meet material delivery promises, such as quantity, timeliness and quality. Often contractual agreements contain clauses detailing the penalty charges.

The premium rate charges are likely to be made by suppliers for adhering to the unpredictable and urgent change requirements made by customers. The penalty charges are likely to be made by customers for having to adjust to the unpredictable delivery characteristics of suppliers.

RESOURCES TO ABSORB COMPLEXITY AND PRECAUTIONS AGAINST GENERATING COMPLEXITY

The resources available to organisations determine their ability to absorb (or reduce) complexity internally and their capacity to take precautions against generating complexity. With respect to Figure 1 the five resources of stock, capacity, time, IT systems and decision making are considered and detailed below. These resources have different costs and benefits attached to them.

1. **Stock holding:** Many organisations continue to manage large levels of finished goods stock. This is often in response to operational complexity. Holding huge amounts of inventory can be a costly way to manage complexity. Moreover, large buffer stocks do not necessarily facilitate better management of complexity. Often the opposite can be true, as high inventory levels can often obscure the real complexity within the system. The complexity of stock is not necessarily linked to the size of the stock, but instead on the uncertainty associated with the variations in the stock.
2. **Scheduling with excess capacity:** An alternative to building up stock mountains is to allow some spare production capacity to be scheduled into the system to accommodate any uncertainty within the system. The use of excess capacity is often considered wasteful, as production resources may stand idle for most of the time.
3. **Operating with time buffers:** Planning time buffers into the logistics, production and scheduling system also accommodates uncertainties. The competitive advantages presented by time compression (Mason-Jones and Towill, 1999; Towill, 1996) have persuaded many organisations to do just this, but at the cost of being more prone to variations.
4. **Investing in Information Technology:** Supply chain IT systems, such as extended enterprise resource planning tools (ERP), have the potential to facilitate tighter inter-firm links through facilitating increased information sharing. From a practitioner perspective, the use of IT systems should lead to reduced information complexity and associated costs. However, investment in IT does not automatically lead to a reduction in cost or in information complexity. The main drawbacks of present information systems include fragmentation and incompatibility of different systems, invisibility of data accuracy, poor co-ordination with shop floor manufacturing processes and issues regarding the security of data.
5. **Nurturing effective decision-making:** This is perhaps the most critical of all resource advantages available to organisations. Effective decision-making within the control and scheduling functions helps organisations to manage complexity (Calinescu *et al.*, 2001). Even with a given set of resources, poor decision-making can contribute to complexity generation.

The first three complexity management policies of stock holding, scheduling with excess capacity and operating with time buffers, ultimately have a trade-off attached to them. Where organisations strive for leanness by cutting back on stock, working to full capacity and pursuing time compression policies there is often a conflict with agility. In response to this conflict, organisations often resort to heavy investment in IT systems to manage complexity. The shortcoming of IT systems are often met by an increased reliance on decision-making systems.

CONCLUSIONS

The management of complexity associated with the supply chain is important for manufacturing organisations as internal efficiency and profitability of organisations are

influenced by the operational complexity that exists within the system. The management policies adopted by organisations have implications for the operational complexity of the supply chain system.

In order to create an efficient supply interface the transfer of operational complexity from one organisation to another should be effectively controlled. For this, it is important that companies can identify and understand operational complexity-inducing activities and actions. Furthermore, organisations need to be aware of the implications of transferring operational complexity across the supplier-customer interface and the trade-offs that exist across the various operational complexity management policies.

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