Coordination, Collaboration and Integration for Supply Chain Management

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Abstract - Supply chain management (SCM) is defined as the integration of key business processes from end user through original suppliers providing products, services and information that add value for customers and other stakeholders. The customer is an integral part of the supply chain and the primary purpose of any supply chain is to satisfy customer needs in the process of generating the profit for itself. Supply chain activities begin with a customer order and end with a satisfied customer. There must be an easy access for coordination, collaboration and integration among the suppliers for effective Supply Chain Management. These elements are equally important for fluctuation of orders, inventory maintenance, replenishment lead times, transportation costs etc. Certain incentives are also permitted by the supply chain partners in order to avoid the distortions (unavoidable delays, over ordering etc.). Quality information can prevent manual mistakes in view of the elemental aspects.

Keywords*- Supply Chain Management, coordination, collaboration, integration, information.*

I. INTRODUCTION

Forrester has been the first to identify the phenomenon of oscillating and amplifying order behaviour upstream of supply chains and its effects on inventories, capacity utilization and other operational parameters. This Forrester effect has become known as the bullwhip effect and can be considered to be the best-known phenomenon of supply chain inefficiencies. The first time the bullwhip effect was evident in an industrial company in the supply chain of Procter & Gamble's diaper products. Though diaper sales were relatively stable, fluctuations of distributor orders were much higher and so were material orders of Procter & Gamble's suppliers (Lee 1997). After this discovery, the same effect has been observed in other supply chains as well and is still evident. The bullwhip effect is evidence of the consequences of uncoordinated decision making for which there must be easy access for coordination, collaboration and integration for an effective Supply Chain Management.

II. BULLWHIP EFFECT AND ORDER FLUCTUATIONS

The resulting order fluctuations have a variety of consequences for the supply chain. These fluctuations increase manufacturing costs, inventory costs, replenishment lead times, transportation costs, and labor costs for shipping and receiving. Additionally, the level of product availability decreases and relationships across supply chains are affected negatively (Andraski et. al. 1998).

The structure of a system is of great importance for explaining system behavior. This bullwhip effect is a consequence of this structure. Structure influences the behavior of a system to a great extent. More precisely, feedback structures and inherent delays unavoidably cause distortions that then become evident through oscillations in key system parameters, such as inventory levels or utilization rates. Based on a more detailed analysis of given industry supply chain structures. The four factors that cause the bullwhip effect are

(1) demand forecast updating, (2) order batching, (3) price fluctuation, and (4) the rationing and shotage game. These will be described briefly in the following:

a) **Demand forecast updating:** When performing demand forecasts, companies interpret historical order information and update them regularly. This order information from customers, however, does not directly reflect actual demand. This information is used to determine supply requirements as a function of historical demand information, service level policies, and lead times in order to satisfy future demand and safety stocks. The further upstream in the supply chain forecasts are conducted through the more their variability increases, because longer lead times require higher safety stocks under identical conditions, worsening the bullwhip effect.

b) **Order batching:** Two forms of order batching are identified by Lee, Padmanabhan, and Whang: periodic ordering and push ordering. Most frequently, periodic orders are used. Many such companies run their MRP systems or inventory status periodically and therefore, orders occur periodically as well. Additionally, fixed order costs, such as order processing costs and transportation costs, contribute to larger orders in order to reduce per unit order costs. Push ordering refers to behavioural order distortions. It occurs in cases of budget spending related end-of-year or end-of-period surges. It also contributes to erroneous demand signaling and therefore less reliable forecasts upstream in the supply chain.

c) **Price fluctuation:** Temporary price discounts, promotions, and payment term benefits offered by manufacturers to downstream supply chain members encourages forward buying behaviour. In order to benefit from these price reductions, companies buy larger amounts than immediately needed. Depending on inventory holding costs, this might be beneficial for really large amounts. In any case, for upstream supply chain members, it is impossible to derive real customer demand because of this forward buying behaviour. Higher direct costs might occur because of over-utilization of resources and resulting negative long-term consequences of varying capacity utilization.

d) **Rationing and shortage game:** If supply is limited due to a temporary surge in demand and orders are only partly filled due to this shortage, customers might react by overstating their real demands in order to receive a larger share of the limited supply. When demand returns to normal levels, orders are cancelled or, because of previous more-than- demanded deliveries, simply disappear. This is especially a problem when customers only anticipate a shortage and place multiple orders with multiple suppliers. Then, after the first order is fulfilled, all redundant orders are cancelled. The problem is that it is almost impossible for a manufacturer to tell real orders from fake ones. As Sterman remarked: “Even a perfect forecast will not prevent a manager who ignores the supply line from over ordering”.

If one common denominator can be derived as counter-measure for the bullwhip effect, it would be coordination. Based on simulation results, the improvements gained from information integration and therefore information sharing and information exchange are relatively high (Towill 1997). Operational and economic factors, such as lead times and ordering costs, also play a role but the lack of coordination seems to explain most of the bullwhip effect. Though coordination can significantly reduce the bullwhip effect, it may not completely eliminate it. The magnitude of the bullwhip effect is highly dependent on the specific problem situation and therefore hard to pin down in general terms. The major causes and counter-measures, however, are well known and grounded on the foundations laid out by Forrester as well as Lee, Padmanabhan, and Whang. Counter-measures to weaken or even eliminate the bullwhip effect have been analyzed and suggested by several authors. They can be summarized as follows:

a) **Information sharing:** In order to avoid the problem of multiple demand forecasts based on indirect demand data, it is suggested that end consumer demand information be shared with upstream members of the supply chain. Still, differences in the forecasts might occur due to different forecasting methods and assumptions. The concept of Vendor Managed Inventory (VMI) builds on information sharing but goes one step further. With VMI, suppliers or manufacturers manage inventory directly at the customer’s site. Inventory information is shared in addition to demand information. Improvements in automation and information technology have been important for efficiently managing such a system. Operationally, shorter lead times reduce uncertainty. Consequently, safety stock inventory and capacity cushions can be reduced. Information sharing can also include capacity information sharing with downstream supply chain partners. Fundamentally, information sharing influences all causes for the bullwhip effect positively.

b) **Smaller order batches:** The effects of large order batches contribute not only to wrong demand signaling but also to increase in workload fluctuations which is not at all entertained in case of industries. Besides more frequent MRP runs and policy adjustments to avoid push ordering, operational improvements are important to keep per unit costs low even with small order batches. This can be achieved by transportation aggregation through third party logistics providers or arrangements with co-suppliers and by reduction of order processing costs through automation and ERP systems.

c) **Price stability:** Instead of providing irregular price discounts, an everyday low price policy can avoid forward buying or purchase postponement in anticipation of price discounts or promotions. Another alternative is to move from lot size-based discounts to volume-based quantity discounts.

d) **Reducing delays:** Material flow delays, information flow delays, and information distortion can be reduced by eliminating entire tiers from the supply chain or by time compression of the processes. Changing the supply chain structure is a difficult task. Therefore, time compression is the more common and more feasible approach for counterbalancing the bullwhip effect.

It is pointed out before that the bullwhip effect can be mainly attributed to a lack of coordinated decision making. This includes structural deficits with regard to coordinated decision making. In the context of SCM, the terms cooperation, collaboration, and integration appear frequently together with coordination. Therefore, the next section takes a closer look at those terms and examines how they correspond, interrelate, and most importantly, differ.

III. SUPPLY CHAIN MANAGEMENT COOPERATION, COORDINATION, COLLABORATION, AND INTEGRATION

Generally, coordination and coordinated decision making refers to separated entities that work together for decision alignment in order to improve overall performance. This has been a major issue of early economic theory that differentiated between the firm and its hierarchies and price mechanisms as forms of coordination. If separate companies coordinate, it is referred as combination or integration. In the context of industrial engineering research and in particular SCM research, the related terms cooperation, coordination, and collaboration are often used interchangeably without clearly distinguishing them from each other. This can cause confusion and ambiguity.

Cooperation is defined as acting or working together for a shared purpose, working or acting together toward a common end or purpose, being compliant, or as working with someone toward a common goal. In the context of SCM, Quiett (2002) has interpreted cooperation as “little more than toleration of each other.” While this view might be a bit drastic, the other definitions imply that cooperation emphasizes mainly the alignment towards a common goal and a shared purpose. The notion of “working together” in the context of cooperation does not suggest a close operational working relationship, but rather a positive attitude towards each other.

Coordination refers to a more direct, active cooperation. It is defined as “the act of making arrangements for a purpose,” the “harmony of various elements,” “harmonious adjustment or interaction,” and making separate things working together. Compared to cooperation, coordination indicates an interactive, joint decision making process, where separate entities influence each others’ decisions more directly. Besides horizontal coordination, i.e. coordination within a supply chain tier, and vertical coordination, i.e. coordination across supply chain tiers, for example between supplier and customer, coordination can also be distinguished from mechanism of coordination. The fundamental mechanisms are markets and hierarchies. Market structures refer mainly to incentive-driven coordination between separate, legally independent companies whereas hierarchical structures indicate either a high unilateral dependency or that companies are not legally independent or equity is shared. High degrees of coordination are subject to antitrust actions because they are believed to impede competition and reduce welfare.

Collaboration is defined as working together or with someone else for a special purpose or simply as working with someone. In the last instance, collaboration is simply defined as a synonym for working together. The other two definitions point out common objectives and efforts. Whereas coordination is mainly conducted by sending the right signals or sharing the right information and the same policies, collaboration indicates a joint, interactive process that results in joint decisions and activities. By that, it also indicates a higher degree of joint implementation and can be thought of as a teamwork effort. According to this interpretation, coordination alone excludes joint implementation and operational efforts.

IV. THE SCM FRAMEWORK

Within the SCM framework, the core SCM model is labeled SCM cooperation. It is seen as a strategic directive that subsumes coordination and collaboration. The distinction between these two is necessary in order to distinguish different types of cooperation that are relevant to SCM. Cooperation can be divided into intra-company cooperation, bilateral cooperation, and multilateral cooperation, depending on the scope of the cooperation under consideration.

In terms of cooperative intensity, collaboration can be seen as more intensive than coordination because most of the time it subsumes all characteristics of coordination as well. Therefore, in a hierarchy of different levels of cooperation, collaboration would be positioned above coordination. This does not mean coordination is less important or relevant; it is just not as intensive.

Coordination aims at achieving global optimization within a defined supply chain network. Interactive, joint collaborative efforts aim to exploit hidden potential and consequently expand the optimization potential, i.e. it shifts the efficient performance frontier upwards. The three types of coordination in terms of level of involvement, in ascending order: (1) simple information exchange, (2) formulated information sharing, and (3) modeled collaboration.

Simple information exchange is straightforward in its meaning. It refers to information exchange without additional interpretation or rules. In formulated information sharing, such policies as restocking policies are shared together with operational information. In modeled collaboration, operational models are also shared, together with capabilities, factory load, inventories, and orders (Shaw 2000). This understanding can be directly linked to the three levels of collaboration which are data exchange, cooperative collaboration and cognitive collaboration. These views, however, indicate a more extensive information sharing scheme on the highest level instead of a close team-work-like working relationship.

As suggested in the context of the bullwhip effect, supply chain profitability as a whole can only be maximized when all stages are coordinated(Chopra, Meindl). Consequently, this must lead to concerted decisions. The significance of coordination has been confirmed by a study conducted by Thonemann among manufacturing companies. There, supply chain coordination has been identified as the top success factor by manufacturing companies. It is inferred that a supply chain is fully coordinated when all decisions are aligned to accomplish global system objectives. Information sharing is of central importance for coordination which allows for coordinated forecasts and forecasts based on richer information.

Thus, a lack of coordination occurs when decision makers have incomplete information or incentives that are not compatible with system-wide objectives.

As also shown in the context of the bullwhip effect, even full information availability does not guarantee optimal supply chain performance. Nevertheless, full information availability can have a significant, positive impact on supply chain performance. But the problem of conflicting objective functions may remain and cause forecasts to be distorted (Swaminathan and Tayur).

Complementary to the counter-measures identified by Lee, Padmanabhan, and Whang in the context of the bullwhip-effect, Chopra and Meindl have considered five categories of obstacles to coordination. These comprise factors that lead to local optimization, an increase in information delay, distortion, and variability within the supply chain. These categories are:

a) **Incentive obstacles:** These are obstacles that are caused by wrong incentives provided to supply chain members in order to influence their decisions to support global optimization instead of pareto-efficient solutions.

b) **Information processing obstacles:** They consist of orders based on forecasts instead of customer demand, and a lack of information sharing.

c) **Operational obstacles:** Lot requirements, rationing and shortage gaming, and large replenishment lead times can be summarized as operational obstacles. The effect of lead times was pointed out which can result in the halving of forecast errors.

d) **Pricing obstacles:** Lot sizes based on quantity discounts and price fluctuations contribute largely to the variability within supply chains.

e) **Behavioral obstacles:** Policies and management practices, such as frequency of MRP runs, limited company perspective and local optimization characterize this category.

Centralization, known as risk pooling, referred to as a horizontal coordination mechanism. Risk pooling reduces demand variability if demand is aggregated across locations. It is a means by which safety stock and average inventory can be reduced in a system. Of course, some costs might increase, such as transportation costs or customer lead time and therefore this has to be weighed against the benefits. Square root rule is a system for inventory can be reduced proportionally to the square root of the number of stock locations before and after centralization, under certain assumptions.

Researchers have summarized the major strategies and coordination mechanism.

a) **Price coordination using quantity discounts:** System optimization is sought through the alignment of a manufacturer's pricing structure with a customer's purchasing incentives under a variety of conditions, such as capacity restrictions and different information availability.

b) **Non-price coordination:** This includes mechanisms such as service territories, quantity forcing, and service differentiation.

c) **Buy-back and returns policy:** Such strategies aim to increase stocking incentives for customers, especially for perishable products.

d) **Quantity flexibility:** Contracts including flexible quantities such as a guaranteed amount of minimum purchases by a buyer and maximum amount of products made available through a supplier – aim at sharing the risks of forecast deviations.

e) **Allocation rules:** Due to scarce capacity resources, customers might distort their orders, which in turn lead to supply chain inefficiencies. Under certain conditions, a supply chain is better off not providing truthful information about actual order requirements but also note that this might change if conditions change, such as marginal cost for capacity or marginal customer costs.

In collaboration, two or more entities work together, share resources, and seek to achieve collective goals. It depends on the ability to trust each other and to appreciate one another's knowledge and emphasizes the building of meaningful relationships. Practice leaders report benefits such as inventory reductions, lower operating costs, and potentially profit gains through coordination and collaboration. Basch has stated that collaboration with channel partners is the most effective strategy for manufacturers. Still, many companies are unwilling or unable to share sensitive data that could be beneficial for both parties. They protect information in order to sustain a advantageous position. This behavior can be interpreted as a lack of trust. Therefore, trust is considered to be the most critical element of collaboration. It can be a great enabler but also a powerful barrier for collaboration.

The last ingredient of the core SCM model, indeed that component of SCM cooperation, which supplements coordination and collaboration, is integration. Many authors writing about integration seem to enhance its meaning beyond the one intended in the SCM framework developed. This might be due to linguistic reasons, but it is important to clarify those differences.

Integration is perceived differently. Coordination and collaboration includes the interaction and collaboration notions described as part of their understanding of integration. In contrast, integration should be considered separately with a distinct meaning. This is also more in line with the following definition of the act of integrating: "To make into a whole by bringing all parts together; unify." According to this, unification of once separate parts is implied. In the overall SCM context, this may only be desired in some areas, in particular in the material and information flows along supply chain processes. Diversity in contrast to homogeneity may be beneficial especially in collaborative efforts, as defined above. Therefore, integration refers mainly to a seamless material and information flow of all members within a supply chain with the objective to maximize competitive advantage.

V. CONCLUSION

Information is of crucial importance in SCM cooperation because it is present in all three elements of the core SCM model. It can be seen as the "glue" that holds together business structures, processes, and entire supply chains. Some even see information as an independent production factor, in addition to the traditional production factors of material, capital, and human capital. A distinction can be drawn between the volume of information and the richness of information exchanged. In the case of coordination, the amount of information exchanged is generally larger, whereas the information exchanged in collaborative relationships is richer. Richness is characterized by the dimensions bandwidth, customization, and interactivity. Interactivity determines whether a monologue or a dialogue type of information exchange is conducted in a particular situation where coordination, collaboration and integration are justified in order to stand in the present competitive world.

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