Supply Chain Management: theory and practices

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1. Introduction

Fierce competition in today's global markets, the introduction of products with short life cycles, and the heightened expectations of customers have forced business enterprises to invest in, and focus attention on, the relationships with customers and suppliers (Simchi-Levi et al., 2000). Supply Chain Management (SCM) has become part of the senior management agenda since the 1990s. Executives are becoming aware that the successful coordination, integration and management of key business processes across members of the supply chain will determine the ultimate success of the single enterprise (Van der Vorst, 2000). According to Christopher (1998) businesses no longer compete as solely autonomous entities, but rather as supply chains. The increased interest in SCM has been spurred by developments in Information and Communication Technology (ICT) that enable the frequent exchange of huge amounts of information for coordination purposes. Consequently, there is a need and an opportunity for a joint approach of chain partners towards the establishment of more effective and efficient supply chains.

This chapter presents an overview of the background, theory and current practices of SCM in primarily industrial supply chains that produce, trade and distribute merchandise. First, we explore the concept 'supply chain' and discuss its hiccups and potential improvements. Section 3 discusses the key decisions and benefits of SCM. Section 4 presents an overview of current practices in SCM. We end this chapter with some concluding remarks.

2. What is a supply chain?

2.1. Definition of a supply chain

In this chapter we take a process view, which means we look at a supply chain as a sequence of (decision making and execution) processes and (material, information and money) flows that aim to meet final customer requirements and take place within and between different supply chain stages. The supply chain not only includes the manufacturer and its suppliers, but also (depending on the logistics flows) transporters, warehouses, retailers, and consumers themselves. It includes, but is not limited to, new product development, marketing, operations, distribution, finance, and customer service (Chopra and Meindl, 2001). Figure 1 depicts a generic supply chain within the context of the total supply chain network. Each firm belongs to at least one supply chain: i.e. it usually has multiple suppliers and customers.

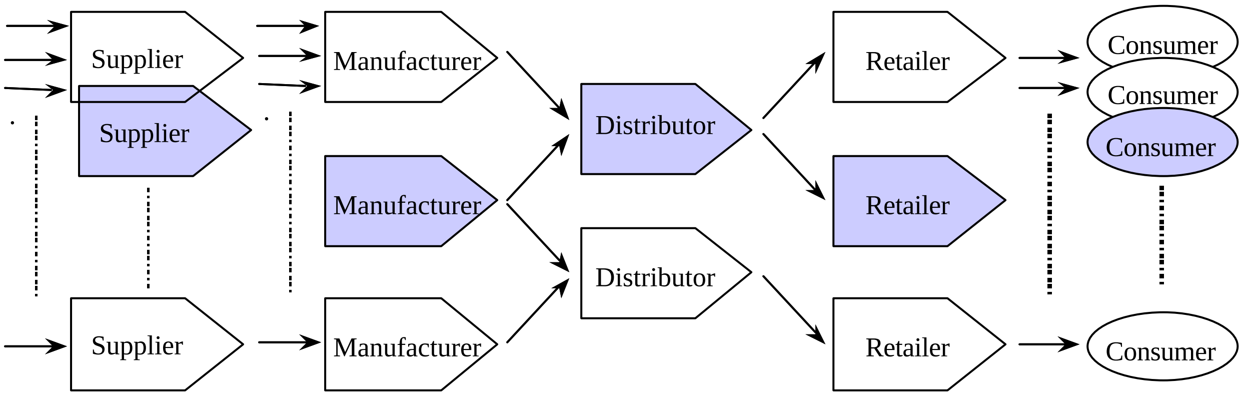

Figure 1. Schematic diagram of a supply chain (shaded) within the total supply chain network.

The traditional view on a supply chain is the *cycle view* (Chopra and Meindl, 2001). In this view the processes in a supply chain are divided into a series of cycles, each performed at the interface between two successive stages of a supply chain. This means that each cycle is decoupled from other cycles via an inventory so it can function independently, optimise its own processes and is not hindered by 'problems' in other cycles. For example, a cycle that replenishes retailer inventories by delivering products from the manufacturers end-product inventory and a cycle that takes care of replenishing the manufacturers inventory by producing new end-products. A cycle view of the supply chain clearly defines the processes involved and the owners of each process (hence roles and responsibilities). Although this might seem a satisfactory situation, the next section will discuss some negative effects from a supply chain perspective.

Box 1. Example of a food supply chain
Albert Heijn (AH), one of the leading retailers in the Netherlands, has to provide over 650 stores with the right products at the right time depending on the needs of the customers. Each of these stores receives daily deliveries from a national (for non-fresh products) and from one of the four regional distribution centres (for fresh products). On average each store carries about 15.000 different kinds of articles. Therefore, a large number of manufacturers is required to replenish inventory levels at the distribution centres. And again, each manufacturer has many suppliers who deliver key components for the manufacturing process. Often, the transport is arranged via a third-party logistic service provider.

2.2. Hiccups in the traditional supply chain: the bullwhip effect

The Beer Distribution Game is a management game developed at MIT's Sloan School of Management in the USA (Forrester, 1961) to give managers and students insight in the consequences of managerial actions in successive stages of a supply chain. It provides an exceptional means of illustrating the impact of a supply chain view on supply chain performance and it is often referred to in SCM literature as the starting point of supply chain research.

The Beer Distribution Game is a role-playing game in which the participants have to minimise costs by managing inventory levels in a production-distribution chain. The game consists of four supply chain stages: retailer, wholesaler, distributor and producer (Figure 2). Each sector has its own small buffer stock to protect it against random fluctuations in final consumption. All a sector has to do is to fill the orders it receives from its direct customer, and then decide how much it wants to order from its supplier. The game is designed so that each sector has good local information but severely limited global (chain) information about inventory levels and orders. This means that only the retailer knows real end customer demand. It takes two weeks to mail an order and two weeks to ship the requested amount of beer from one sector to the next. It is not possible to cancel orders. Stock out costs (associated with the possibility of losing customers) are twice as high as inventory carrying costs. The objective of the game is to minimise the total sum of costs of all sectors in the beer supply chain.

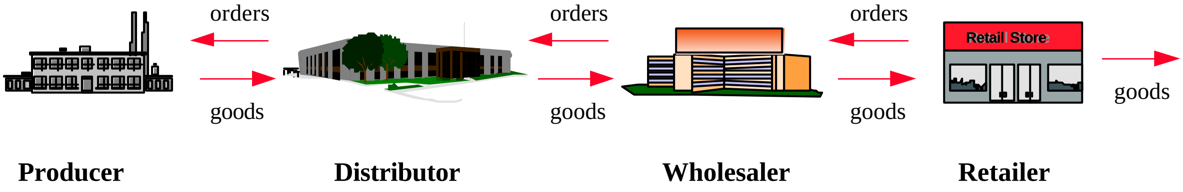

Figure 2. The beer supply chain.

The results of this game after 50 weeks of play are remarkable. Although consumer demand is only doubled once in week 5, huge order fluctuations and oscillations take place in the SC. Usually when playing the game, the producer receives demand patterns with 900% amplification compared to end consumer demand fluctuations (see Figure 3). Furthermore, huge stock outs occur at the retailer. When this game is played with different people (students or managers) but the same structure, similar results are produced. Even though the participants act very differently as individuals in ordering inventory, the overall (qualitative) patterns of behaviour are still the same: oscillation and amplification of order patterns and a phase lag in reaction time resulting in bad delivery performances and high costs. The further upstream the supply chain, the larger the variation in demand.

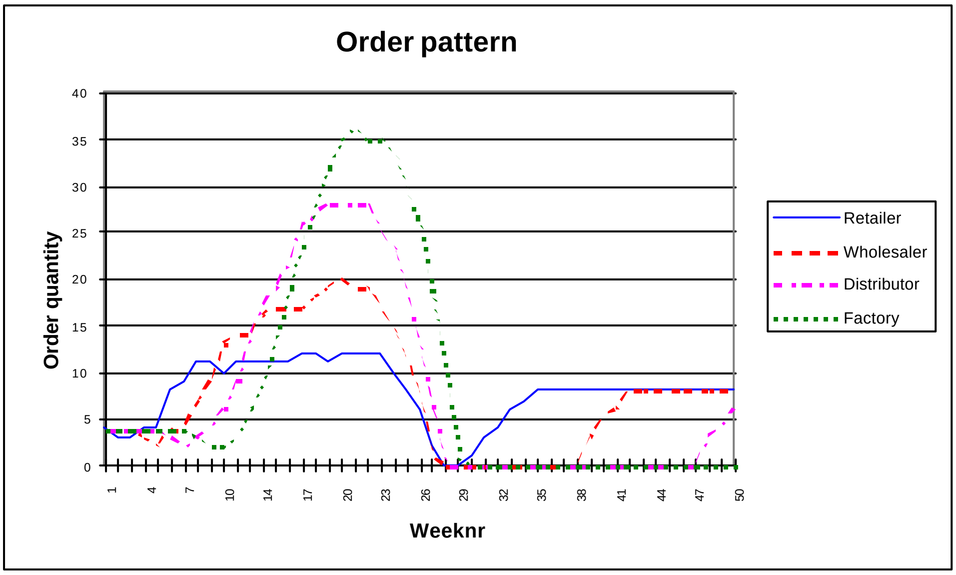

Figure 3 The Forrester or bullwhip effect.

This phenomenon in which orders to the supplier tend to have larger variance than orders from the buyer, and the distortion propagates upstream in an amplified form (i.e. variance amplification) is called the *Forrester effect* (Towill, 1997), named after the person who discovered it, or the *Bullwhip effect* (Lee et al., 1997), named for the variations in reaction down the length of a whip after it is cracked. The effect has serious cost implications. The increased variability in the order process (i) requires each facility to increase its safety stock in order to maintain a given service level, (ii) leads to increased costs due to overstocking throughout the system, and (iii) can lead to an inefficient use of resources, such as labour and transportation, due to the fact that it is not clear whether resources should be planned based on the average order received by the facility or based on the maximum order (Chen et al., 1999). Furthermore, material shortages can occur due to poor product forecasting.

2.3. Causes of the bullwhip effect and potential solutions

The amplification is not caused by external factors (e.g. consumer demand) but created by the parties in the supply chain themselves. The main causes are the perceived demand, the quality of information and the inherent delays that may be found within the supply chain (Lewis and Naim, 1995). There is no timely information on changes in demand and one has to deal with a long lead time between placing an order and receiving the products. Because of this long lead time, the reaction time is too long; in the game it takes over 4 weeks to respond to sudden changes in demand. This also leads to 'misperceptions of feedback', i.e. subjects tend to disregard the inventory in the pipeline they ordered earlier and keep on ordering more (Sterman, 1989). Next to these aspects Lee et al (1997) found a number of additional causes in real-life supply chains:

?? order batching due to economies of scale in ordering (quantity discounts) and transportation (full truck loads) and the use of periodic planning systems;
?? price fluctuations driven by promotions; and
?? rationing and shortage gaming; i.e. the incentive to increase orders during shortages, place orders with multiple firms, and cancel orders once inventory arrives.

Several redesign strategies are proposed to reduce demand amplification and improve supply chain performance:

?? Eliminate all *time delays* in goods and information flows from the supply chain;
?? Exchange *information* concerning true market demand with parties upstream the supply chain;
?? Remove one or more intermediate *echelons* in the supply chain by business take-over;
?? Improve the *decision rules* at each stage of the supply chain: modify the order quantity procedures or their parameters.

Evans et al. (1995) quantified the impact of these improvement options and showed that the performance could be drastically improved if the configuration and operational management of the supply chain, the essence of SCM, is changed (Table 1).

Table 1. Implications of redesign strategies for the Beer Distribution Game (Evans et al., 1995)

Scenario	*Total chain cost*	*Costs index*	*Demand amplification (%)*
Base case Beer Distribution Game	3358	1.47	900
No ordering delays	1944	0.85	500
No intermediaries between producer - retailer	939	0.82	350
Producer has access to consumer demand data	2295	1.01	425
All stages have access to consumer demand data	1293	0.57	200

Current research shows that the bullwhip effect is still present in all kinds of supply chains (food, health, insurance, and so on). Current designs of supply chains are still causing inefficiencies and inflexibility. To improve supply chain performance, a new way of managing the supply chain is required that focuses on the alignment of supply chain processes: i.e. SCM.

3. What is Supply Chain Management?

3.1. Definition of Supply Chain Management?

The term 'Supply Chain Management' is relatively new. It first appeared in logistics literature in 1982 as an inventory management approach with an emphasis on the supply of raw materials (Oliver and Webber, 1982). Around 1990, academics first described SCM from a theoretical standpoint to clarify how it differed from more traditional approaches to managing the flow of materials and the associated flow of information (Cooper and Ellram, 1993; see Table 2). Literature on SCM stresses the need for collaboration among successive actors, from primary producer to final consumers, to better satisfy consumer demand at lower costs (see, for example, Bechtel and Jayaram, 1997; Lambert and Cooper, 2000). A driving force behind SCM is the recognition that sub-optimisation occurs if each organisation in a supply chain attempts to optimise its own results rather than to integrate its goals and activities with other organisations to optimise the results of the chain (Cooper et al., 1997). SCM focuses on the management of relationships. We define SCM as follows:

SCM is the integrated planning, co-ordination and control of all business processes[1] and activities in the supply chain to deliver superior consumer value at less cost to the supply chain as a whole whilst satisfying requirements of other stakeholders in the supply chain (e.g. government and NGO's) .

Value is the amount consumers are willing to pay for what a company provides and it is measured by total revenue. The concept 'value-added activity' originates from Porter's 'value chain' framework and characterizes the value created by an activity in relation to the cost of executing it (Porter, 1985).

Table 2. Characteristics of SCM according to Cooper and Ellram (1993)

Element	*Traditional Management*	*Supply Chain Management*
Inventory management approach	Independent efforts	Joint reduction in channel inventories
Total cost approach	Minimise firm costs	Channel-wide cost efficiencies
Time horizon	Short term	Long term
Amount of information sharing and monitoring	Limited to needs of current transactions	As required for planning and monitoring purposes
Amount of co-ordination of multiple levels in the channel	Single contact for the transaction between channel pairs	Multiple contacts between levels in firms and levels of channel
Joint planning	Transaction-based	On-going
Compatibility of corporate philosophies	Not relevant	Compatible at least for key relationships
Breadth of supplier base	Large to increase competition and spread risk	Small to increase co-ordination
Channel leadership	Not needed	Needed for co-ordination focus
Amount of sharing of risks & rewards	Each on its own	Risks & rewards shared over longer term
Speed of operations, information and inventory flows	'Warehouse' orientation (storage, safety stock). Interrupted by barriers to flows. Localised to channel pairs	'DC' orientation (turnover speed). Interconnecting flows; JIT, Quick Response across the channel

It is worth noting that a growing number of terms are being utilized by individuals and organisations that are presented as being more appropriate, comprehensive and/or advanced than SCM. Such terms include *demand chain management* (to distinguish it from the type of management in which 'supply' begins and drives the chain of activities), and *value chain management* or *value*

[1] A business process can be defined as a structured measured set of activities designed to produce a specified output for a particular customer or market (Davenport, 1993). For example, order fulfilment, demand management or product development.

networks (to emphasise the value-added focus on processes). Since in our view the essence of these terms is alike, we will employ the most commonly used term SCM in this chapter as a representative for all these terms.

3.2. Key decisions in Supply Chain Management

Lambert and Cooper (2000) distinguish three key decisions in SCM, summarised in Figure 4. The conceptual framework emphasizes the interrelated nature of SCM and the need to proceed through several steps to design and successfully manage a supply chain. Each step is directly related to the *supply chain objectives*, i.e. the degree to which a supply chain fulfils end-user requirements concerning the key performance indicators at any point in time, and at what total cost. *Key Performance Indicators* (KPIs) refer to a relatively small number of critical dimensions which contribute more than proportionally to the success or failure in the marketplace (Christopher, 1998). KPIs compare the efficiency and/or effectiveness of a system with a norm or target value. A well-defined set of supply chain performance indicators will help establish benchmarks and assess changes over time. A good example is the Supply Chain Operations Reference-model (SCOR) developed by the Supply-Chain Council (SCC) as the cross-industry standard for SCM (see www.supply-chain.org). SCOR provides an integrated, heuristic approach for supply chain improvement via (i) the modelling of business processes, (ii) the definition of SCM metrics for evaluating the supply chain and rapidly identifying high value opportunities and (iii) the identification of best practices to provide a candidate list of improvement options.

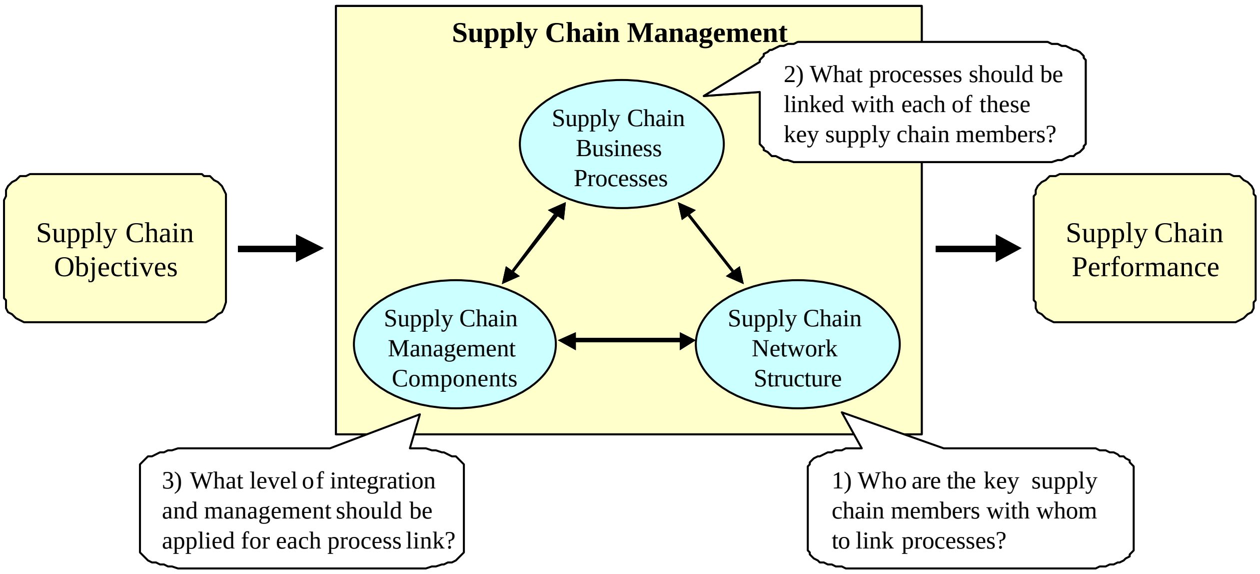

Figure 4. Key decisions in SCM (adapted from Lambert and Cooper, 2000).

Supply chains can be managed as a single entity through the dominant member or, alternatively, through a system of partnerships requiring well-developed co-operation and co-ordination. Formulating supply chain objectives is therefore not an easy task since all partners have to agree on the selection of indicators, the definition of the indicators and the target values. The present performance measures used in most companies have several problems that prevent them from effectively measuring total supply chain performance. Supply chain participants should start with jointly identifying order winners and satisfiers for the supply chain, because these provide the intended direction of control actions to improve supply chain performance. By analysing the goals of each individual organisation and by identifying market requirements, integrated KPIs can be defined and norms established. We will now discuss the three key decisions in more detail.

1. Who are the key supply chain members with whom to link processes?

The first step in analysing and redesigning a supply chain is to determine the organisations that are part of the supply chain under investigation. For most manufacturers, the supply chain looks less like a pipeline or chain than an uprooted tree, where the branches and roots are the extensive network of customers and suppliers. The question is how many of and how intensive these branches and roots need to be managed. Management will need to choose the level of partnership appropriate for each particular supply chain member knowing that firm capabilities in time and effort are limited (Lambert & Cooper, 2000). With some suppliers partnerships are required since the raw materials they deliver are crucial; others are less important and only have to be monitored. The key is to sort out which members are critical to the success of the company and the supply chain – in line with the supply chain objectives - and, thus, should be allocated managerial attention and resources.

2. What processes should be linked with each key member?

Successful SCM requires a change from managing individual business processes within one organisation to integrating activities over organisations into key supply chain processes. Lambert and Cooper (2000) have identified eight key business processes that could be integrated with the key members in the supply chain (see table 3). It is usually not necessary to integrate all processes; e.g. if the order winner is responsiveness focus should be on order fulfilment, whereas if the order winner is innovation focus should be on joint product development.

Table 3. Business processes that could be integrated in the supply chain.

Business process	*General description*
Customer relationship management	Specifying service level agreements with key customers
Customer service management	Providing the customer with real-time information on promised shipping dates and product availability through interfaces with the organizations' production and distribution operations
Demand management	Balancing the customer's requirements with the firm's supply capabilities
Order fulfilment	Delivering products and meeting customer need dates
Manufacturing flow management	Pulling product through the plant based on customer needs
Procurement	Developing strategic plans with suppliers to support the manufacturing flow management process and development of new products
Product development and commercialisation	Customers and suppliers must be integrated into the product development process in order to reduce time to market
Returns process	Aligning processes to realise an efficient return of re-usable items

SCM literature suggests several redesign strategies to improve the effectiveness and efficiency of these business processes in the supply chain. Van der Vorst and Beulens (2002) have identified a generic list of SCM redesign strategies to facilitate the redesign process and accomplish joint supply chain objectives. These are the following:

?? Redesign the roles and processes performed in the supply chain (e.g. change or reduce the number of parties involved, re-allocate roles and eliminate non-value-adding activities);

?? Reduce customer order lead times (e.g. change the position of the decoupling point (see the next section), implement ICT systems for information exchange and decision support, reduce waiting times, increase manufacturing flexibility);

?? Create information transparency (e.g. establish an information exchange infrastructure in the supply chain and exchange demand/supply/inventory or WIP information, standardise product coding);

- ?? Synchronise logistical processes to consumer demand (e.g. increase execution frequencies of production and delivery processes, decrease the lot sizes); and
- ?? Co-ordinate and simplify logistical decisions in the supply chain (e.g. co-ordinate lot sizes, eliminate human interventions, differentiate and simplify products, systems and processes).

Van der Vorst and Beulens (2002) propose that in order to identify the most effective strategies in a specific supply chain one should focus on the identification and management of the sources of uncertainties in the supply chain's decision-making processes. We refer to their article for an elaborated discussion.

3. What level of integration and management should be applied to each process linkage?

The literature on business process reengineering and SCM suggests numerous possible components that must receive managerial attention when managing supply relationships. Lambert and Cooper (2000) distinguish two groups of management components; see table 4. The first is the physical and technical group, which includes the most visible, tangible, measurable and easy-to-change components. The second group, the managerial and behavioural components, defines the organizational behaviour and influences how the physical and technical management components can be implemented. If the managerial and behavioural components are not aligned to drive and reinforce an organizational behaviour supportive to the supply chain objectives and operations, then the supply chain will likely be less competitive and profitable. If one or more components in the physical and technical group are changed, then management components in the managerial and behavioural group likewise may have to be re-adjusted. Especially the managerial and behavioural components are well-known obstacles to SCM as they might hinder the development of trust, commitment and openness between supply chain members (as we will discuss in section 4).

Table 4. Two groups of management components that have to be aligned in the supply chain.

Physical and technical components	*Managerial and behavioural components*
?? planning and control methods (e.g. push or pull control); ?? work flow/activity structure (indicates how the firm performs its tasks and activities); ?? organisation structure (indicates who performs the tasks and activities, e.g. cross-functional teams); ?? communication and information flow facility structure (e.g. information transparency); ?? product flow facility structure (e.g. location of inventories, decoupling points).	?? management methods (i.e. the corporate philosophy and management techniques); ?? corporate culture and attitude; ?? risk and reward structure; ?? power and leadership structure.

Concluding remark

The groundwork for successful SCM is established by an explicit definition of the supply chain objectives and related key performance indicators and, successively, by taking the three key SCM decisions. The optimal supply chain design will differ for each supply chain depending on the competitive strategy and the market, product and production characteristics. To illustrate this, the next section will discuss in more detail one of the main trade-offs to be made in SCM, that is, the trade-off between efficient and responsive supply chains.

3.3. The trade-off between efficiency and responsiveness

Marshall Fisher (1997) suggests that the nature of the demand for a product should be carefully considered before a supply chain strategy is (re)devised. Fisher divides products into two categories:

?? primarily *functional products* satisfying basic needs which have stable, predictable demand and long life cycles typically with high levels of competition resulting in low profit margins;

?? primarily *innovative products* with higher profit margins, have unpredictable demand and short life cycles and, usually higher levels of product variety.

Fisher states that the root cause of the product availability problem in present-day supply chains is a mismatch between the type of product and the type of supply chain. Supply chains that deal with functional products should focus on *efficiency / leanness* to minimise the physical costs related to production, transportation and inventory storage. On the other hand, supply chains that deal with innovative products should be designed focussing on *responsiveness / agility* to minimise market mediation costs (i.e. the cost that arise when the variety of products reaching the marketplace does not match what consumers want to buy resulting in lost sales opportunities and dissatisfied customers). Table 5 compares both types of supply chains.

Table 5. Physically efficient versus market-responsive supply chains (Fisher, 1997).

	Physically efficient (lean) process	*Market-responsive (agile) process*
Primary purpose	??Supply predictable demand efficiently at the lowest possible cost	??Respond quickly to unpredictable demand in order to minimise stock outs, forced markdowns, and obsolete inventory
Manufacturing focus	??Maintain high average utilisation rate	??Deploy excess buffer capacity
Inventory strategy	??Generate high returns and minimise inventory throughout the chain	??Deploy buffer stocks of parts or finished goods
Lead-time focus	??Shorten lead time as long as it does not increase cost	??Invest aggressively in ways to reduce lead time
Approach to choosing suppliers	??Select primarily for cost and quality	??Select primarily for speed, flexibility and quality
Product-design strategy	??Maximise performance and minimise cost	??Use modular design in order to postpone product differentiation for as long as possible

What we have seen in the last 15 years is that consumers and retailers have become much more demanding and product-life cycles have shortened significantly in all kind of sectors (e.g. computers, food, automotive). In today's marketplace the keys to long-term competitive advantage are flexibility and customer response. This has resulted in functional products becoming innovative products. The problem is that the supply chains that produce those innovative products are still efficient. According to Fisher they should transform towards responsive customer-driven supply chains in order to be competitive again; see figure 5.

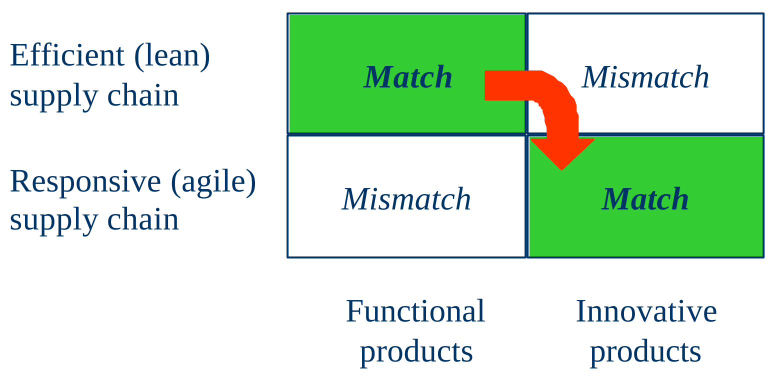

Figure 5. Supply chain design in relationship with the nature of product demand.

It is not necessarily the case that a complete supply chain should be either lean or agile. Mason-Jones et al. (2000) and Christopher and Towill (2000) expanded on the thoughts of Fisher and also state that the supply chain strategy and structure should be in tune with the characteristics of the marketplace. They focus on hybrid strategies by integrating the lean and agile paradigms and introduce the concept of *leagility*, i.e. “the combination of the lean and agile paradigm within a total supply chain strategy by positioning the decoupling point so as to best suit the need for responding to a volatile demand downstream, yet providing level scheduling upstream from the decoupling point”.

The decoupling point (DP) refers to the inventory point the most upstream the supply chain at which real demand penetrates upstream in a supply chain. Downstream of the DP the material flow is controlled by customer orders/demand and the focus is on customer lead time and flexibility (employing small batch sizes). Upstream towards suppliers, the material flow is controlled by forecasting and planning, and the focus is on efficiency (usually employing large batch sizes). The DP creates the opportunity for upstream activities to optimise independently from irregularities in market demand. It must be determined where the decoupling point should be for each product-market combination or product group in the company. Therefore a company can have several different DP’s and even a single product can have more than one, as it can serve multiple product-market combinations. However, the control complexity will increase significantly when the number of DP’s increases. Hoekstra and Romme (1992) distinguish five positions of the decoupling point depicted in Figure 6.

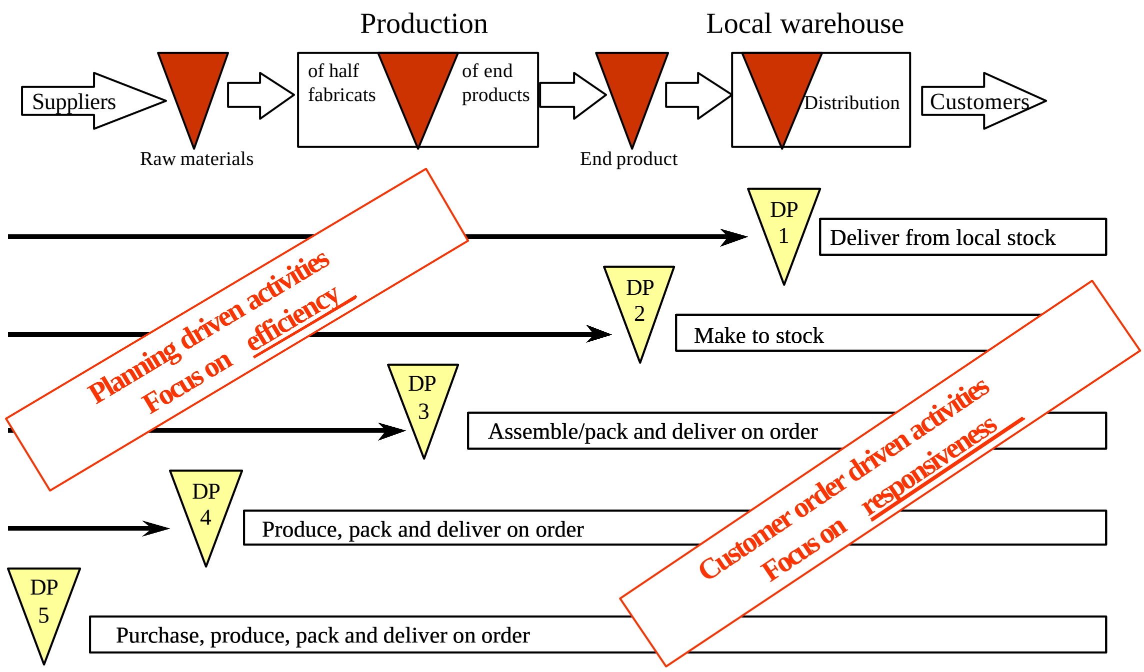

Figure 6. Five positions of the DP (after Hoekstra & Romme, 1992).

There are many factors exerting an upstream or downstream influence on the DP. It is a balancing process between (i) market related factors, such as the delivery lead time requirements set by the market, product demand uncertainty, product range and product customisation requirements; (ii) product related factors, such as possibilities for modular product design and product customisation opportunities; and (iii) production related factors, such as the production lead time and the flexibility of the production process (Olhager, 2003). All these factors indicate to what extent it is possible or reasonable to make products to order or to stock; e.g. the more unpredictable the demand, the more responsive the supply chain should be. And the longer the delivery lead time can be, the more efficiently the supply chain can be managed.

The general trend for the position of the DP is to shift upstream the supply chain, i.e. the planning and execution of activities at industrial manufacturers and primary producers are more and more based on consumer demand information (van der Vorst et al., 2001). A good example is the fabrication of cars; nowadays cars are assembled only after the customer order has been received requiring very flexible manufacturing systems (see also box 2 and 5).

Box 2. Increasing responsiveness by relocating the decoupling point in the supply chain
15 years ago, the computer industry was characterised by delivery lead times up to multiple weeks – mainly because the production lead time was very long. Since then, customer requirements have changed resulting in a request for short delivery lead times and a large product portfolio. Producers have reacted to this by shifting the decoupling point upstream in the supply chain. In order to keep the business profitable they focused on (1) internet technology to establish high-speed information exchange and have direct customer order information (thereby eliminating the dealer network), (2) product standardisation and modularisation (by using generic or modular inventory the final commitment to a specific customer order is postponed), (3) close partnerships with suppliers that deliver the requested modules at the requested time and place, (4) increased production/assembly flexibility, and (5) fast transportation structures. Nowadays, computers are assembled to order and the requested configuration can be delivered within a few days (see for example, www.dell.com).

3.4. Benefits of Supply Chain Management

The profitability of the supply chain could be improved drastically via better delivery performance (improved responsiveness and reliability of deliveries, fewer stock outs, higher product quality, more receiver-friendly loads) and increased information availability (better demand insight, more predictable order cycles, accurate, real-time) at the operational level and a reduction of time-to-market at the tactical and strategic level. The potential for improvement when applying SCM-concepts is based on the reduction of inventory-carrying (reduced overstocks, faster inventory turns) and transportation costs (pooling of transport), the reduction of indirect and direct labour costs and the increase of sales and sales margins.

Many companies are re-engineering and rationalising their supply chain network to obtain these benefits. The next section will discuss the currently most prominent SCM projects in practice.

4. Practices in Supply Chain Management

4.1. An overview

In the last ten years numerous projects on supply chain collaboration were done to analyse how firms could use their suppliers' and customers' processes, information, technology, and capability to enhance competitive advantage. Most projects were done in the front-end of supply chains, that is in the interface between retailer and manufacturer. But also in the interface between manufacturers and suppliers and/or third parties numerous enhancements were made. The last years manufacturers have been instigated to focus on core business resulting in the outsourcing of non-core activities such as transportation and the centralisation of manufacturing activities. The practical experiences can be categorised into the following areas (see figure 7), which we will discuss in more detail in the coming sections:

?? Collaborative demand planning and replenishment: retailers and manufacturers work together to assess consumer demand and to determine the most appropriate supply management and replenishment approach to meet this consumer demand;

?? Collaborative production: manufacturers and suppliers work together to harmonise the supply of raw materials and the production of end products in such a way as to minimise the stocks within the supply chain and maximise the responsiveness;

?? Collaborative logistics planning: co-ordinating transport and warehousing between the various parties involved, including transshippers, logistic service providers, carriers and recipients.

A precondition for supply chain coordination is the establishment of connectivity and transparency, i.e. interconnecting the information systems of the successive partners in the supply chain and exchange information via this infrastructure.

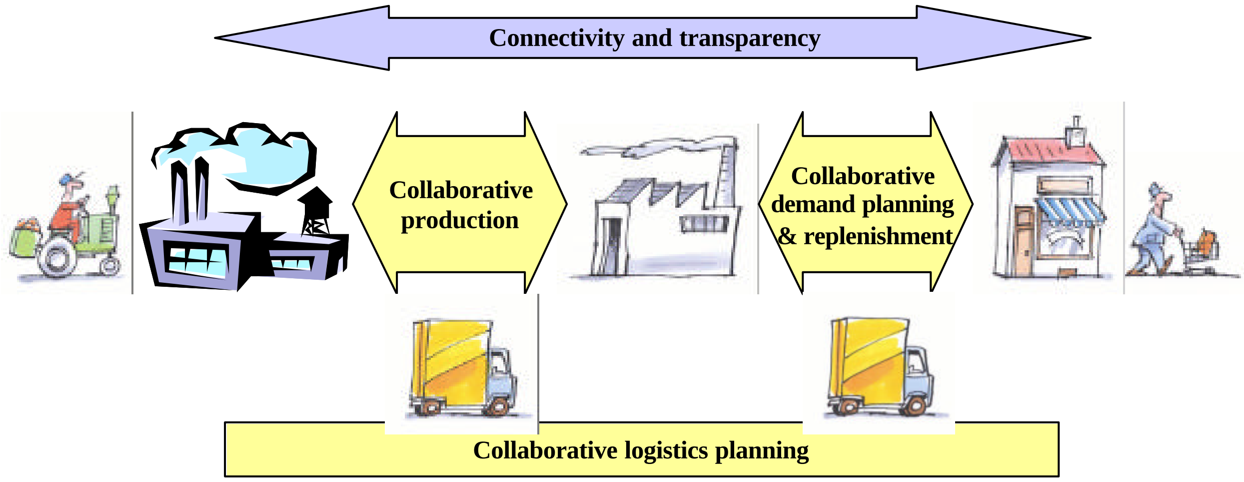

Figure 7. Areas for collaboration in the supply chain (after Barratt and Oliveira, 2001).

Although a lot of research and practical experience with SCM-issues has been obtained, we have to acknowledge that few companies have actually established a management environment that supports the integration required for effective SCM. Instead, many chains are still functionally oriented and are characterised by a lack of trust and credibility among the supply chain organisations. In the coming sections we will focus on companies and efforts that have excelled in SCM. The reader should keep in mind that they are the front-runners.

4.2. Collaborative demand planning and replenishment

Vendor Managed Inventory (VMI) is a technique developed in the mid 1980s, whereby the supplier has the sole responsibility for managing the customer's inventory policy, including the replenishment process. VMI was adopted by many companies in different business sectors; two of the first companies to put the theory into practice were Procter & Gamble and Wal-Mart in the USA (see box 3). The major weakness of VMI lies in the insufficient visibility of the whole supply chain; point-of-sale (POS) data as well as the backroom inventory level data are disregarded whilst the replenishment process (and the inventory policy) is based in the variation of stock level in the customer's main warehouse or distribution centre (Barratt and Oliveira, 2001). This has led the search for alternative, more effective, techniques.

Box 3. Wal-Mart and Proctor & Gamble

Several well-known firms involved in supply chain type relationships (e.g., Procter & Gamble (P&G) and Wal-Mart, the US's fastest growing retailer) owe much of their success to the notion of information and the systems utilised to share this information with one another. Through state-of-the-art information systems, Wal-Mart shares point-of-sale information from its many retail outlets directly (via satellite) with P&G and other major suppliers. The product suppliers themselves become responsible for the sales and marketing of their products in the Wal-Mart stores through easy access to information on consumer buying patterns and transactions. P&G expanded these working methods with a new distribution system that allowed customers to buy and receive all P&G products together on the same truck – regardless of which business sector manufactured the brand. This development, together with the introduction of new pricing structures, pallet standardisation, electronic invoicing and new procedures for handling damaged products resulted in huge savings. Because of the speed of this system, Wal-Mart pays P&G after the merchandise passes over the scanners as the consumer goes through the checkout lane.

The first robust initiative created to enable integration in the food supply chain dates back to 1992, when Kurt Salmon Associates (1993) issued a report on *Efficient Consumer Response*. Supply chain benefits could be achieved by excelling in four core strategies: efficient promotions, efficient replenishment, efficient store assortment and efficient product introductions. The report proposed, for the first time, the driving need to "develop a trust-based relationship between manufacturers and retailers (including suppliers and customers in general), with the sharing of strategic information in order to optimise overall supply chain results''. Having this requirement outlined, the various sectors of the industry began to develop a number of techniques to make the ECR promise a reality. More information can be found on www.ecrnet.org with hyperlinks to all national initiatives and currently running projects.

The logistical branch of ECR, *Efficient (or Continuous) Replenishment* (ER), moves one step ahead of VMI and reveals stock levels in retailers' stores and uses POS data to generate a sales forecast. It aims for a.o. the establishment of responsive and efficient replenishment by shifting the decoupling point as far upstream the supply chain as possible. ER uses concepts such as automatic replenishment systems based on (i) the sales forecast, built from historical demand data and no longer purely based on the variations of inventory levels at the customers' main stock-holding facility, (ii) high frequent deliveries with short lead times, and (iii) cross docking, i.e. eliminating product storage at warehouses where products received are turned around for shipment to retail stores within 24 hours. The process of creating the sales pattern and then predicting future events is ER's major weakness (Barratt and Oliveira, 2001).

Collaborative Planning, Forecasting & Replenishment (CPFR) deals with this weakness and has been described as a step beyond ECR, because of the high level of co-operation and collaboration needed. Rather than trying to independently project demand patterns, buyers and sellers share information in advance and work together to develop realistic, informed, and detailed estimates that can be used to guide business operations (Stank et al. 1999). Utilizing principles of CPFR, a retailer and manufacturer work together to jointly create a single, combined promotion calendar in advance of the selling period which is subsequently up-dated on a real-time basis over the Internet. The retailer also provides point-of-sale (POS) data, longer-term promotional plans, prescribed inventory levels, etc. for the consumer goods trading partner. Both firms create sales and order forecasts and a collaborative system is used to compare the retailer's forecast to the consumer goods firm's own forecast. Discrepancies or exceptions are identified and appropriate managers advised. Working together, the "team" decides on one, i.e. collaborative, forecast extending across the supply chain.

It is clear that this intensive collaboration is not suitable for all businesses; the additional management attention is only fruitful if the product volume in the relationship is large enough, demand uncertainty is high and the partner (wants to!) deliver additional knowledge/information which reduces the forecast error. If volumes are small it might be wiser to use low delivery frequencies. This has been called *Supply Chain Synchronization*. It aims to synchronise the replenishment to the efficient production schedule facilitating full truckload (FTL) transport and shift stocks downstream to the stores where they are needed.

Practice shows that the true benefits are realized only when collaborative plans are linked to operational change; the information must also be used for production and distribution planning. Accurate demand planning enables manufacturing to postpone production of anticipatory stock and can also result in shorter, more predictable order cycles. Guaranteed sales targets allow logistics and distribution managers to make better use of storage and delivery resources to reduce costs as well as to increase customer service by tailoring operations. Retail receiving departments, for example, may work more closely with a manufacturer's shipping department to allow shipments to be loaded in the order in which products are needed, facilitating off-loading and sorting time and further streamlining cycle times (Stank et al. 1999). For more information on CPFR we refer to www.cpfr.org.

Box 4. Shortened Fresh Collection (www.klict.org)

Nowadays, consumers and retail demand a varied assortment of floricultural products and a year round supply of top quality produce, all for a reasonable price. To meet the growing consumer demands the floricultural chains will have to be reversed from product oriented (push) to market-oriented (pull). A consumer driven chain can only be successful if the chain is organised in a flexible, efficient and responsive way. In order to speed up the flow of goods throughout the chain, from the grower to the retailer or florist, new logistical chain concepts have been developed in the project "Shortened Fresh Collection". These new concepts where inspired by the need to deliver more frequent, in lower batches within a lead time shorter than the current 27 hours.

The project aimed at optimising the logistical processes of the ornamental plant cultivation network in Bleiswijk, the Netherlands. The objective was to clarify and significantly reduce the lead time of the product range for a supply chain, from the moment the exporter places an order to the time of actual delivery to the exporter's premises. Participants in the project were FloraHolland Flower Auction, growers, wholesaler Lemkes and carriers.

Via chain analysis, simulation of logistical flows and a pilot study new logistical chain concepts were tested in practice and evaluated on environmental burden, feasibility, total costs and lead time. The results showed that lead times could be significantly decreased at lower costs. It requires: (1) the use of electronic ordering systems; (2) reduction of waiting times in the supply chain implicating a change in the working methods of especially growers; (3) collaboration in the transport of plants from specific regions.

The project showed that "people make the difference" in vertical chain partner shipping. Time is needed to build trust and to create commitment between the successive links in the chain. It requires the use of tools like workshops with the partners, chain performance measurements, agreements on responsibilities and the division of costs and revenues. In the project, trust between the partners in the chain has grown significantly. Especially the understanding of each other's role, added value and wins for chain cooperation lead to a common competence to act as a whole. The chain as a whole has changed their way of working, from a daily trade operation being concerned with daily prices and orders, into a long term partner shipping in which joint consumer concern is leading and supply performance is under control. This should be followed by scaling up by means of developing a universally applicable solution with which to reduce the lead times of an ornamental plant cultivation cluster.

4.3. Collaborative production

The second area where a lot of SCM practices are achieved is collaborative production. The need for customer-order driven supply chains that are responsive at low cost has placed a high demand on the flexibility and efficiency of the manufacturing processes. These are enhanced by several practices: product standardisation, re-allocation of production and warehousing facilities, outsourcing of production volume, sharing capacity of a single plant, and supplier partnerships/contracting. Especially in food industry were one has to deal with seasonality in supply and perishable products, production capacities are often limited. Supplier contracting is a common way of assuring supply of the right products at the right time at the right place. Several manufactures have started to cooperate within a single plant to exchange capacities and increase manufacturing flexibility (e.g. automotive, call centres and printing services). Others have started partnerships with its suppliers and have integrated supplier activities within their plant – see box 5.

Box 5. The Smart car (van Hoek and Harrison, 2003)

Micro Compact Car AG (MCC), a wholly-owned subsidiary of Daimler-Benz, is the company behind Smart. Together these manufacturers have developed a new supply chain concept that went beyond existing practices. It is characterised as follows:

?? customers can say how they want their product to be configured;

?? cars are built from about 50 modules to customer order with lead-times counted in weeks;

?? dealers/importers have been eliminated in the supply chain; smart centres can order directly at the plant;

?? suppliers have co-invested in the production location and take a greater share in the final assembly process;

?? the value added during final assembly, which takes just 4,5 hours, is just 10 per cent of the production cost price because of the modular product layout. This enables MCC to supply customer choice with minimum product complexity, facilitates 'upgrading' during its lifetime, and permits engineers to renew the car or extend the product line within short time frames. Features that might disturb production if made optional (such as ABS, etc.) are integrated as standards in the car.

?? 7 first-tier suppliers are integrated in the assembly hall of MCC; their pre-assemble of modules is synchronised to the planning of the final assembly process and modules are delivered on a just-in-time basis. 16 non-integrated suppliers deliver the first-tier suppliers and MCC.

Contracts with the suppliers are intended to last the entire life cycle of the SMART car, and are based upon single-sourced modules satisfying high-standard requirements. Each partner receives a share of the profit of each sold car (related to the investments made) instead of being paid for the modules delivered. To facilitate communication and the exchange of ideas among staff and partners, a central area of the factory (which in total covers 68 hectares!) is designed as a open meeting room. Furthermore, standard performance measures for each sub-section of the process are displayed electronically for everyone to see.

4.4. Collaborative logistics planning

The third area for SCM projects is related to the transportation of goods between stages in the supply chain. Whereas in the past every actor organised its own transport, technological advances in logistics and ICT enable the development of new paradigms based on cooperation. This facilitates the consolidation of goods which decreases costs and increases responsiveness. A good example is the development of *Manufacturing Consolidation Centres* by Lever Fabergé, Kimberly Clark, Ola and Iglo Mora. In these centres many small incoming lots of material from different suppliers, that are to be delivered to the same customer, are consolidated into fewer, larger loads for efficient onward despatch.

Recently, activities have been deployed to evaluate the concept of *orchestration* in which a fourth party manages the execution of business activities (e.g. transportation) on behalf of the business owners. Logistical service providers can adopt the orchestrator role and perform the management of logistics processes for manufacturers and retailers. This requires the support of sophisticated ICT tools that provide product flow monitoring capabilities, resource capacity and product visibility and flow planning and scheduling of information. See box 6 for an interesting case.

> *Box 6. An internet Hub for the Vos Logistics Supply Chain* (Hillergersberg et al., 2003)
> Vos Logistics is a third party logistics service provider that is active in adding value to its portfolio of logistics services. Vos is one of the larger, asset based, transport and logistical companies on the European Market. The company employs more than 4000 people working at more than 30 offices throughout Europe. The firm's long-term strategy is to become a full logistics service provider for its customers, offering services such as warehousing, transportation management and supply chain (re)design.
>
> The case is concerned with the Vos sea containers transport from its Veendam terminal to the Rotterdam harbour for customers such as Avebe, Friesland Dairy Foods, Kappa, Akzo and Dow Chemical. Dependent on the cost and speed requirements of the customer, transport takes place over road, water and rail connections. Several parties are involved in the supply chain such as rail operators, barge operators, charters, terminals, etc. Current limitations in the supply chain are the following: there is lack of real-time information on the status of containers, a large number of containers are involved in exceptions such as no shows and delays, and the same order information is entered in the system multiple times. Although the transport of containers seems simple, many parties are involved, and many pieces of information from these parties need to be consolidated at the right place at the right time in order to avoid operational problems.
>
> Early 2000, Vos and Informore, an ICT company that specializes in providing logistics hubs, initiated a project to create a central logistics information hub that would register and communicate data within the supply chain and optimises the planning and monitoring of the transportation system. Using the hub, Vos can monitor the information exchange and the activities taking place on a real-time basis. Other parties connected can monitor part of the information in the hub of interest to them. The case showed that there were a lot of benefits to be obtained: chain transparency and coordination resulted – via the hub – in shorter throughput times and increased resource utilisation and productivity. For an elaborated description of the case, we refer to Hillergersberg et al. (2003)

One of the latest trends is called *Factory Gate Pricing* (FGP) – which makes the retailer the orchestrator of transportation. The manufacturer makes its products available at its warehouse and gets the price of goods without transportation costs. The logistic service providers that also take care of the distribution from retail warehouse to outlets and returns flows, can optimize the total flows by incorporating the flows from suppliers. Whether FGP is interesting depends on demand characteristics (volume/variability), type of replenishment (degree of responsiveness), product characteristics (perishability/value), the geographical distances and infrastructural characteristics such as the number of docks available. When we compare FGP with CPFR, we can conclude that FGP is interesting when volume and demand variability are low; CPFR is interesting when the volume and the demand uncertainty are high. The main barrier for manufacturers to implement FGP are the required internal changes at suppliers (to facilitate the pull flow), the reduction of transport volume (which makes the efficient planning of the remaining flows difficult) and the required transparency in product prices and transportation costs.

5. Concluding remarks

Despite many considerable efforts SCM is to a large extent still only a promise. Most supply chains are characterised by a lack of chain transparency and co-operation, and SCM projects usually deal with only a part of the supply chain. Most SCM-concepts (such as VMI, CPFR and FGP) require transparency and the open calculation of costs and revenues to allocate them between supply chain partners. However, the definition of cost drivers and the related norms is not an easy task. It requires trust and an in-depth insight in each other processes, which is difficult, since the widely followed competitive model suggests that companies will lose bargaining power - and therefore the ability to control profits - as suppliers or customers gain knowledge. Although organizations perceive the benefits of SCM, main barriers to the implementation are the lack of trust, diverging objectives, compatibility of managerial philosophy, and reward structures that support the chain objectives.

The development of an ideal supply chain is not a one-time exercise. Each relationship has its own set of motivating factors driving its development as well as its own unique dynamic operating environment. Therefore, the duration, breadth, strength and closeness of the partnership will vary from case to case and from time to time.

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