Supply Chain Management

Abstract

Supply chain management is a critical aspect of conducting any business. In this article, we provide an overview of the advancements in supply chain management. In the initial section, we present alternative definitions and key issues related to supply chain management followed by a discussion of complexities associated with managing supply chains. Subsequently, we discuss major inefficiencies of poor supply chain management. Finally, a brief summary of research activity to date and a discussion of future challenges related to supply chain management are presented.

Key words: Supply Chain Management; Operations Management; Manufacturing; Service; Logistics; Sourcing; Outsourcing; Procurement; Competition; Information; Technology; Globalization; Sustainability.

1. Introduction

Supply chain management is one of the most essential aspects of conducting business. Many people outside of the direct community (in research and industry) do not realize this because an ordinary consumer often experiences only its effects. Recall the times when the item that you wanted was not available in your favorite garments or grocery store, recall how many times you got a great 'deal' at the end of the season, recall the sudden increases in gas prices due to shortages, recall the times when your e-commerce site promised availability but later could not send the required product or sent you the wrong product, or recall the times when your customized product (like a personal computer or kitchen cabinet) was delayed to a great extent. All the above and several other experiences that consumers have on a routine basis are direct consequences of supply chain practices followed by firms. As opposed to business-to-consumer transactions, supply chain practices have immediate impact on business-to-business transactions. In the late 2000s, due to glitches of its extensively outsourced supply chain for Dreamliner 787, Boeing experienced substantial delay in launching the new aircraft and incurred more than $2 billion in charges to support and expedite component supplies. Less than two years after the first delivery of Dreamliner 787 in 2011, Boeing was ordered to shut down production of the aircraft due to quality issues with batteries. In 2007, Mattel had to recall of tens of millions of toys made in China, which becomes poster child for concerns about quality of offshore goods. While some firms suffered from consequences of bad supply chain management, firms such as Amazon, Wal-Mart, and Zara, have consistently outperformed competition due to great supply chain capabilities.

2. Definition

Since Keith Oliver, a consultant at Booz Allen Hamilton, coined the term in 1982, supply chain management has evolved from originally being understood as only logistics to a complex

multifunctional corporate undertaking that ranges from procurement and demand forecasting to distribution and after-sales service. Supply chain management is such a vast topic that as a result people often give it a different definition based on their own personal experience. To some, supply chain management is all about managing the supplier base, determining what to outsource and to whom, and managing relationships with the various suppliers. To some others it is efficient ways of transferring goods from one place to another taking into account the distribution and transportation costs. To another set of people it is all about how the different firms in the distribution channel or value chain are integrated in terms of information systems and inventory management practices. To yet another group it is effective management of fixed and variable assets required for running the business. In a sense all these definitions are like the blind men defining the elephant based on its different organs. A comprehensive definition of supply chain management can be given as follows.

A supply chain is the set of entities that are involved in the design of new products and services, procuring raw materials, transforming them into semifinished and finished products and delivering them to the end customers (Swaminathan 2001). Supply chain management is efficient management of the end-to-end process starting from the design of the product or service to the time when it has been sold, consumed, and finally disposed of by the consumer. This complete process includes product design, procurement, planning and forecasting, production, distribution, fulfillment, and after-sales support (see Fig. 1).

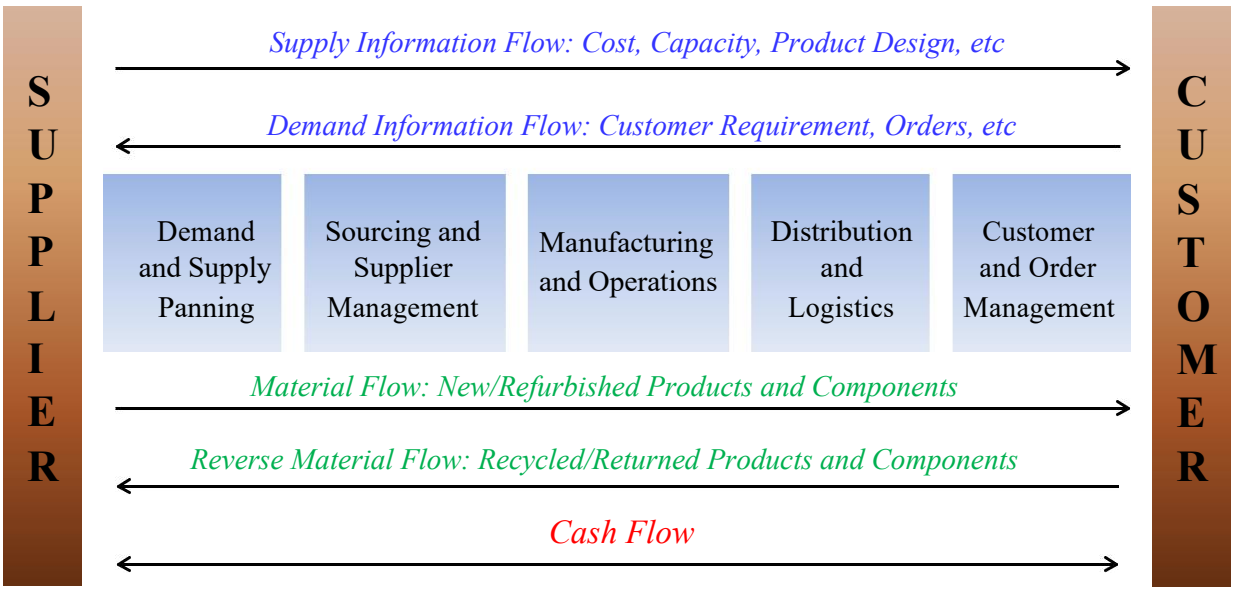

Figure 1. Supply Chain Process

Supply chain management issues can be classified into two broad categories—configuration and coordination. Configuration-level issues relate to the high-level design and basic infrastructure of the supply chain and coordination -level issues relate to the tactical decisions and day-to-day operations of the supply chain.

2.1 Configuration-level Issues

Supply base decisions

How many and what kinds of suppliers to have? Which parts to outsource and which to keep in house? How to standardize and streamline procurement practices? Should one use vertical marketplaces for auctions or should one invest in developing highly integrated supply partnerships? How long or short contracts with suppliers should be?

Plant location decisions

Where and how many manufacturing, distribution, or retail outlets to have in a global production distribution network? How much capacity should be installed at each of these sites? What part of

the supply chain should be kept onshore, near-shore, or offshore? What kind of distribution channel should a firm utilize—traditional brick and mortar, direct to consumer via Internet or phone, or a combination?

Product portfolio decisions

What kinds of products and services are going to be supported through the supply chain? How much variety to provide to customers? What degree of commonality to have across the product portfolio?

Information support decisions

Should enterprise resource planning software be standardized across functional units of a firm? Should the supply chain work on standard protocols such as XML (extended markup language) or on proprietary standards?

2.2 Coordination -level Issues

Material flow decisions

How much inventory of different types of products should be stored? Should inventory be carried in finished form or semifinished form? How often should inventory be replenished? Should a firm make all of its inventory decisions or is it better to have the vendor manage the inventory? Should suppliers be required to deliver goods just in time?

Information flow decisions

In what form is information shared between different entities in the supply chain—paper, voice via telephone, EDI (electronic data interchange), XML? To what degree does collaborative forecasting take place in the supply chain? What kind of visibility is provided to other entities in

the supply chain during execution? How much collaboration takes place during new product or service development among the supply chain partners?

Cash flow decisions

When do suppliers get paid for their deliveries? What kinds of cost reduction efforts are taken across the supply chain (or expected of suppliers)? In a global firm, in which currency will a supplier be paid?

Capacity decisions

How to optimally utilize the existing capacity in terms of manpower and machines? How to schedule on a manufacturing line to complete jobs on time? How much buffer capacity to have for abnormal situations with excess demand?

As is evident, configuration and coordination issues are interdependent. Configuration issues can be viewed as strategic long-term decisions whereas coordination issues are medium-to-short term decisions. Generally, firms develop a strategy for the configuration-level decisions and then constrain the coordination decisions based on those.

3 Complexities Associated with Supply Chains

As evident from discussions in the earlier section, supply chain management spans several functional and geographical areas. This introduces complexities both in terms of design and execution of supply chains. Some of the pertinent factors that complicate supply chain management decisions are as follows.

3.1 Multiple Agents

Supply chain issues need to be decided by different entities sometimes having different interests. For example, a retailer may want that the distributor provide very high availability for the products but at the same time not charge anything additional to the retailer. The distributor may

sometimes agree to that but in turn may want information about actual customer sales which the retailer may not want to share. Even when decisions have to be made within the same firm there could be incentive issues. For example, the marketing or sales department, typically a revenue center, presents the future demand forecast to the manufacturing department that is a cost center. Clearly, there is incentive for the former to over-forecast and the latter to under-produce (as compared to the forecast). This creates several difficulties while deciding on the amount of inventory to be stocked. Another related issue is encountered where the marketing department may push for huge amount of variety in the product/service offerings; the manufacturing department may not want to embrace that because additional complexities are created during execution.

3.2 Uncertainty

Accurately matching supply and demand is the ultimate goal of effective supply chain management but that is complicated by uncertainty at various levels of the process. There is uncertainty in product and technology development, in predicting customer demand, in day-to-day operations and manufacturing, and supply. Typically, uncertainty creates more inefficiency in the system. For example, if the final demand for a sweater at a store cannot be predicted accurately then the firm either stocks too little (in which case it suffers from stock-outs) or produces too much (in which case it has to salvage the inventory through a huge sale at the end of the season). Similarly, the uncertainty in supply may necessitate additional buffer inventory.

3.3 Information Asymmetry

Since supply chain processes extend across multiple functional units within a firm and often across different firms there is a high degree of asymmetry in terms of information. This is caused primarily by two main reasons—one relates to lack of adoption of information technology and

the other relates to reluctance to share information with other supply chain partners. The lack of information causes several problems during actual fulfillment. For example, when a consumer goes to an e-commerce site and buys an item off the electronic catalog, the consumer expects to receive the product on time. The consumer is not aware that the inventory status on the product may be updated only once a week and that the information on the site may be outdated. As a result, the consumer is disappointed when the product does not arrive on time.

3.4 Lead Time

Each and every task in the supply chain process needs time to be completed and the resources (labor, machines, or computers) have limited processing capacity. As a result, not all tasks can be completed after the actual demand is known and some of the tasks need to be done up front (which may or may not get utilized based on the actual demand realized). Further, the limited capacity associated with the resources creates variability in the actual realized lead-time, which in turn necessitates greater resource requirements at the next stage in the supply chain. The above complexities lead to several types of inefficiencies in the supply chain that are often perceived as the 'bad effects' of inefficient supply chain management. Some of the major inefficiencies can be classified into the following categories.

3.5 Competition

When making supply chain decisions, firms have to take market competition into consideration. For example, forming exclusive trade relationship with key suppliers helps prevent proprietary technology to be leaked to competitors who may source from the same suppliers. As another example, firms' outsourcing decisions can be shaped by what competitors do (see Feng and Lu 2012). In the computer and electronics industries, many companies rely on contract manufacturers to assemble final products. Due to their location in low-cost regions and scale

economies, these contract manufacturers generally have a lower cost structure than OEMs. For a long time, Dell, operated its own assembly plants in North America to support its build-to-order model. Under increasing market pressure to lower costs, Dell had to change its supply chain strategy by outsourcing assembly work to contract manufacturers, a strategy that has long been adopted by its key competitors.

4 Inefficiencies of Supply Chain Management

4.1 Poor Utilization of Inventory Assets

One common effect of poor supply chain management is having excess inventory at various stages in the supply chain, at the same time having shortages at other parts of the supply chain. Since inventory forms a substantial part of working assets of a firm, poor management could lead to huge inefficiencies. Lee and Billington (1992) provide an excellent overview of pitfalls and opportunities associated with inventory management in supply chains.

4.2 Distortion of Information

Another effect relates to lack of visibility of demand and supply information across the supply chain which causes the bullwhip effect. This effect describes how a small blip in customer demands may get amplified down the supply chain because the different entities in the supply chain generate and revise their individual forecasts and do not collaborate and share actual demand information. Lee et al. (1997) describe the causes and controls for this effect.

4.3 Stock-outs

Poor supply chain management also results in late deliveries and large stock-outs. Fundamentally, these effects are caused due to an inability of the firm to predict the requirement for raw material and equipment capacity together with the uncertainty associated with obtaining

deliveries of products on time from its suppliers. Fisher et al. (1994) describe how accurate forecasts in the apparel industry could potentially reduce this inefficiency.

4.4 Customization Challenges

As the degree of customization has increased in the marketplace, one of the immediate effects of poor supply chain management relates to late deliveries of customized products. Firms are developing several strategies in order to provide variety while keeping costs under control. These include delaying differentiation of the product and introducing more commonality and modularity in product lines (see Swaminathan and Tayur 1998).

5 New Developments in Supply Chain Management

5.1 Global Supply Chains

In the increasingly globalized world economy, even a small manufacturing firm may face the challenge of managing an oversea supply relationship. Globalization is not a new phenomenon, but the globalization trend developed in the first decade of the 21st century created a more flattened world than history has seen. However, in the recent years the cost differential between the emerging economies and the developed ones is gradually disappearing. This forces many firms to reconsider their supply chain configurations, particularly their cost-driven offshoring strategy. In the last few years, some manufacturing firms, large and small, have brought offshored production back onshore. Meanwhile, the growing market size of the economies outside the developed has made expansion of one's global supply chain footprint a more attractive option. Striking the right balance between onshore and offshore sourcing will continue to a key task in firms' supply chain strategy.

5.2 Sustainable Supply Chains

In the last decade, building sustainable supply chains has gathered tremendous attention from environmentalists, NGOs, and businesses. This society-wide sustainability initiative has influenced many firms' supply chain strategies. For instance, Wal-mart in 2005 launched three overarching sustainability goals: (1) use 100% renewable energy; (2) produce zero waste; (3) sell products that sustain our resources and environment (Denend and Plambeck 2007). To achieve these goals, the company examined various aspects of its supply chains to identify areas that offered the most potential for sustainability. And it used various incentives to motivate its suppliers to contribute to its sustainability goals.

5.3 Humanitarian Supply Chains

Between 1974 and 2003, there were 6,637 natural disasters worldwide with more than 5.1 billion people affected and a reported damage of $1.38 trillion USD (Ergun et al 2009). Although the occurrence of these events was hard to forecast, the social and financial impact could have been reduced with proper planning. In particular, humanitarian supply chains, i.e., supply chains for disaster planning and response, can be well designed and maintained for the purpose of quick response and relief effort after disasters strike. Humanitarian supply chains differ from regular supply chains in terms of their supply and demand patterns. Refer to Ergun et al (2009) for a detailed review on the subject. Another important type of humanitarian supply chains relates to delivery of essentials (food supplements, bednets, and vaccines) to people in need during non-emergency times (see Swaminathan 2010 and Komrska et al. 2013).

5.4 New Technologies Impacting Supply Chains and Big Data

In the last two decades, digital technologies have had a lasting impact on how supply chain activities are conducted. According to a recent study by Intermec, a leading supply chain solutions provider, the top 10 technologies that have the most impact on supply chain operations

include: (1) comprehensive connectivity – from 802.11 wireless LAN technologies, cellular networks, and Bluetooth; (2) voice and GPS communication integrated into rugged computers; (3) speech recognition; (4) digital imaging; (5) portable printing; (6) 2D & other bar coding advances; (7) RFID (radio-frequency identification); (8) RTLS (real-time locating system); (9) remote management; (10) wireless and device security.

The proliferation of the aforementioned digital and communication technologies in business and consumer uses has created tremendous amount of data on business transactions, logistical activities, customer characteristics, etc. According to IDC, approximately 750 exabytes (EB) of data were created online in 2009, and it is forecasted to exceed 35 zettabytes (ZB) by 2021. Big data, according to Gartner, is defined as "high-volume, high-velocity, and/or high-variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization." The real impact of big data on improving supply chain efficiency is yet to be seen, and companies are only starting to tap into the potential offered by the vast amount of data being collected in their information systems. In the face of explosive growth of data, the information industry is going through a revolution, and sophisticated tools are yet to be developed to analyze supply chain related data for performance improvement.

6. Supply Chain Research: Past, Present, and Future

The science related to supply chain management traces its history back to the early 1950s when several researchers were interested in understanding the optimal policies related to inventory management. One of the first pieces of work in this stream relates to the models developed by Clark and Scarf (1958) for managing inventories at multiple echelons. Several hundreds of researchers have studied related inventory problems under stochastic and deterministic environments since the 1950s.

This research is captured concisely in the research handbook edited by Graves et al. (1993). There is a large amount of literature in the area of transportation and distribution as well as plant location models in the context of supply chain management. Traditional researchers focused on developing optimal policies and rules for specific supply chain issues assuming a centralized control of the supply chain. In the 1990s researchers have started to study problems which take a decentralized multi-agent approach to analyzing supply chain problems, integrate information availability across the supply chain with logistics decisions, develop new models for supply contracts, and demand forecasting and integrate product design with supply chain management. A collection of prominent pieces of research in this area is contained in Tayur et al. (1998) and de Kok and Graves (2003). After several decades of studying supply chains with mathematical models, researchers started to use data and empirical methods to validate supply chain theories and to systematically characterize supply chain practices. For example, using industry-level U.S. data, Cachon et al (2007) document the strength of the bullwhip effect, i.e., the phenomenon that demand variability increases moving from the downstream of a supply chain to the upstream. Using firm-level data, Cachon and Olivares (2009) examine the factors that contribute to the difference in finished-goods inventory between several leading auto manufacturers. The empirical stream of research will continue to grow as researchers become more creative in finding relevant data on supply chains.

In addition to academic research, several firms in the 1990s developed successfully and employed large analytical and simulation models for supply chain optimization and execution. Arntzen et al. (1995) describe one such system developed for Digital Equipment, and in 2004, Motorola was awarded the Franz Edelman Award by INFORMS (The Institute for Operations Research and Management Sciences) for using operations research methods to launch a

comprehensive online negotiation system to support the company's sourcing process which led to $600 million in savings.

In the twenty-first century, firms face severe challenges in terms of global competition and customer requirement for greater variety, shorter and reliable delivery times, and lower prices. The advent of e-commerce has created immense opportunities but at the same time has made firms more vulnerable to logistics pitfalls. Today customers do not just buy products but they buy delivered products. As a result fulfillment is as important as making the sale. As opposed to traditional channels where inventory could be stored to hide other inefficiencies in terms of lead time and poor forecasts, in the fast-paced electronic business environment such arrangements are not as useful. As a result, firms are beginning to pay more attention towards supply chain management. Both business-to-consumer and business-to-business e-commerce environments have introduced several issues related to supply chain management which are likely to be studied by researchers in the near future.

The prevalence of the Internet has led to the development of vertical market places that promise to reduce the inefficiencies in the buying process in several industries. On one hand, these market places are likely to reduce the cost of goods for the manufacturer due to more competition leading to better prices. This line of thought indicates that in the future supply chains may be more agile and supplier relationships may be short-term oriented. On the other hand, several firms realize that greater benefits can be attained if some of these market places can in fact be used for process integration and collaboration across the supply chain. In such an environment, firms need to develop greater trust so that they would be willing to share information with their supply chain partners. Researchers today are trying to identify under what conditions one or the other scenario may play out and what kinds of new models and analysis

need to be developed. A related effect of the Internet is the expansion of global supply chains. Today it is much easier for any supplier located in a remote part of the world to bid on contracts from large firms in developed nations with whom they may not have done business in the past. Issues related to coordination of global supply chain management are likely to be an integral part of supply chain management research in the future. Another important research topic is sustainable supply chain management. Traditionally, researchers have only concerned themselves with efficient movement of goods from supplier to the customer. Now a greater number of researchers are studying problems related to disposal of used products, refurbishing old products, making packaging more environmentally friendly, and basing supplier selection on environmental criteria in addition to traditional criteria related to cost, quality, and reliability. Another new stream of research is the study of supply chains in the service industry. As opposed to traditional manufacturing-oriented supply chains, service supply chains are more complicated due to the inability to store inventory. Uncertainty is handled in those cases using additional buffer capacity. Finally, researchers are beginning to look at behavioral issues such as trust, bounded rationality, mental accounting, etc. that may arise in supply chain management..

See also:

Commodity Chains; Location Theory; Market Areas; Market Structure and Performance; Marketing Strategies; Retail Trade