

# Chapter 2

## Introduction to Supply Chain Management

*"Times have changed since Henry Ford made the River Rouge complex in Dearborn, Michigan, into the ultimate in vertical integration, with iron ore going in at one end and shiny model A's coming out the other. Now vertical dis-integration is the order of the day—in autos, in handheld computers, in pharmaceuticals, in ink-jet printers, in health care, in cameras..."* Dolan and Meredith (2001), p. 107

### 2.1 Historical background and general motivation

The term 'supply chain management' originates from an outlook issued in 1982 by the consultants Oliver and Webber (Oliver and Webber, 1982, reprint: Oliver and Webber, 1992). The first scientific articles to use this term were written by Houlihan (1985) and Jones and Riley (1985). As revealed in Table 2.1, since then there has been an enormous number of publications with this keyword (Burgess et al., 2006; Herrmann, 2010). However, on closer inspection it becomes apparent that many of the problems that are now assigned to the research area of supply chain management were in fact identified much earlier. For example, the first articles on the *bullwhip effect*<sup>1</sup> were already written in the 1950s (Simon, 1952; Forrester, 1958). Nevertheless, it was not before the late 1990s that

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<sup>1</sup>The bullwhip effect describes an amplification of demand variability further up the supply chain. A company exhibits this effect if it purchases materials and components more variably with regard to quantities and time intervals than it sells its products. Several reasons for this phenomenon are listed by Lee et al. (1997b,a) and Moyaux et al. (2007). Cachon and Kök (2007) and Bray and Mendelson (2012) provide empirical evidence.

this ubiquitous issue in current supply chain management theory and practice (Moyaux et al., 2007; Cachon and K  k, 2007; Bray and Mendelson, 2012) was brought into focus by Lee et al. (1997a,b) who coined the term ‘bullwhip effect.’ The problem of *double marginalization*<sup>2</sup> was also recognized long before supply chain management was established as a research area (Cournot, 1897; Spengler, 1950; Machlup and Taber, 1960; Tirole, 1988). Cournot (1838) already pointed to this problem in the 19th century.

Table 2.1: Number of scientific publications with the terms ‘supply chain’ and ‘supply chain management’ in the title (according to scholar.google)

Years	Supply chain	Supply chain management
1981-1984	8	4
1985-1988	22	5
1989-1992	100	31
1993-1996	718	229
1997-2000	4 670	1 459
2001-2004	10 700	3 190
2005-2008	14 400	3 770
2009-2012	16 100	4 090

What applies to many subjects of the current supply chain management research often applies to the underlying models, too. Many of the models used to describe and solve the problems in focus refer to approaches which were also developed long before the 1980s. For example, the frequently cited article by Corbett and de Groote (2000) on lot sizing conflicts in supply chains uses the *economic order quantity model*<sup>3</sup> by Harris (1913). The *newsvendor model*,<sup>4</sup> on which many studies especially on Supply Chain Contracting are based (Lariviere and Porteus, 2001; Taylor, 2002; Cachon, 2003; Cachon and K  k, 2007; Katok and Yan Wu, 2009; Chiu et al., 2010), can be attributed to Edgeworth (1888) and Arrow et al. (1951).

<sup>2</sup>Double marginalization describes a problem of inefficient pricing in monopoly chains. If each supply chain stage sets its product price individually, focusing only on its own profit, under certain circumstances the sum of profits is lower than the total supply chain profit resulting from a joint optimization approach.

<sup>3</sup>Aiming to determine the cost-minimal order (or production) lot size, the economic order quantity model trades off inventory holding costs, which increase in the number of product units per lot, and the one-time order (or set-up) costs incurred by each lot.

<sup>4</sup>Facing stochastic demand, the newsvendor model deals with the problem of determining the optimal order (or production) quantity of a perishable good such as a newspaper, for example. If demand exceeds the order (or processing) quantity, profits are lost. On the other hand, product units unsold after demand is satisfied can still have a salvage value but generally, lead to a loss.

Supply chain management topics have clearly attracted increasing interest since the early 1980s (see Table 2.1). The strong interest finally resulted in the establishment of this new field of study. As discussed above, existing and related subjects and models were pieced together and also viewed in this new research framework. But what caused the sudden interest in cross-company collaboration issues? Empirical studies (Spekman et al., 1998; Ho et al., 2002) confirm that there has been a development from competition between large nationally operating companies towards competition between global supply chains consisting of highly specialized smaller business units (Christopher, 1992; Cooper et al., 1997; Handfield and Nichols, 1999; Barnes, 2006; Mentzer et al., 2007; Stadtler, 2008), a phenomenon that has boosted the interest in supply chain management (Sachan and Datta, 2005; Burgess et al., 2006). But what, in turn, are the reasons for the tendency towards globally networks of interlinked specialists? The core competency theory (Prahalad and Hamel, 1990) argues that it results from the competition-induced necessity to ensure flexibility and to make use of any cost-savings potential. To adapt more quickly to new market situations and more competitive product prices, many companies specialized, concentrated on their core businesses, and outsourced inefficient steps in the production processes. The transaction cost theory (Coase, 1937; Williamson, 1975, 1985, 1991, 2008), which also provides reasons for the development towards smaller business units, deals with the effects of bounded rationality, opportunistic behavior, uncertainty, and product specificity on the decision whether a transaction should take place via the market, within a centrally controlled company, or within a hybrid form between these two extremes. For example, transaction cost theory assumes that the costs of bureaucracy grow disproportionately to a company's size. Many collaborating specialists are hence likely to be more flexible and competitive than a cumbersome large company with an enormous head office that attempts to administrate all activities centrally.

Among other things, the trend towards global supply networks has been supported by the political developments of the last decades. For example, access to the production sites and markets of the Eastern Bloc and China opened up enormous opportunities (Zhao et al., 2007; Sauvart, 2008). Brazil and India are also becoming more and more appealing (Humphrey, 2003). In addition, scientific and technological progress made this global orientation feasible and profitable. The flows of information within and between companies have been facilitated in the extreme by developments such as RFID (Radio-Frequency Identification) technology (Alshawi, 2001; Lancioni et al., 2003; Croom, 2005; Sarac et al., 2010). Schiffrin (2001) especially highlights the essential significance of the

Internet in the modern business world:

*"Good-bye mergers and acquisitions. In a global market tied together by the Internet, corporate partnerships and alliances are proving a more productive way to keep companies growing."* Schiffrin (2001), p. 26

The following incidents show how interrelated the global economy actually is these days. Not only did 9/11 impact on financial markets and the US economy, it also severely affected the global flow of materials for a long time. Due to stricter transport regulations, Japanese car manufacturers Honda and Toyota, for example, had difficulties supplying their production sites in North America (Czaja, 2009). The volcanic ash cloud in 2010 and the earthquake in Japan in 2011 caused similar problems to companies all around the world. However, most supply bottlenecks are not just due to socio-political issues or natural catastrophes, they are also the result of human failure or bad planning. Taking appropriate measures, many supply shortages could have been avoided by the supply chains' decision-makers. Defective diesel injection pumps delivered by Bosch, for example, forced BMW and DaimlerChrysler to partly halt production in 2005 (manager magazin, author unknown, 2005b) which entailed enormous costs. Bosch traced the defect to a spare part bought from a Czech supplier and subsequently pledged to improve its quality control (Freitag and Noé, 2005). Later that year, defective power brake units also delivered by Bosch led to a recall by US car manufacturer General Motors (manager magazin, author unknown, 2005a). In September 2012, a workers' riot protesting bad working conditions resulted in the brief closure of one of Foxconn Technologies' largest Chinese plants, which employed almost 50 000 workers. This affected electronic giants such as Apple, Hewlett-Packard, Dell, and Microsoft, all of which source large quantities of components for their products from Foxconn (Barboza and Bradsher, 2012). Note that these incidents also reveal the risks of the *just-in-time*<sup>5</sup> supply concept (Ohno, 1988).

Ever more complex and competitive global markets with enigmatic supplier-buyer-relationships mean that well-coordinated cross-company material, information, and cash flows are essential for success. This argumentation, which is used to motivate almost every publication on supply chain management, is supported by the above and many more real-life examples, explaining why supply chain management has attracted

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<sup>5</sup>The just-in-time concept, a prevailing supply chain management measure, aims to prevent or at least minimize all waste of resources along the supply chain. However, reducing buffer inventories to minimize tied-up capital, can put some supply chain stages or even the entire supply chain at the risk of supply shortage induced production breakdowns.

so much attention over the last decades. But what can supply chain management actually achieve?

The literature provides numerous hints as to the often enormous potential offered by appropriate supply chain management measures. For example, Cachon and Lariviere (2005) deal with a change in contract design between US home video rental chain Blockbuster and film studios. Shortly after their release, films were often not available due to high demand, causing severe customer frustration. Instead of paying the studios \$65 per copy of one video, the parties agreed on a price of only \$8 plus a share of the rental fee Blockbuster earned off its home videos. This share was approximately 30–45%. The so-called *revenue sharing contract* made it profitable for both Blockbuster and the film studios to provide a larger number of copies of a new film. Using a specimen calculation, Cachon and Lariviere (2001) show the coordinating effect of this new type of contract on the video rental supply chain. Blockbuster was able to increase its market share from 24 to 40% between 1997 and 2002 (Warren and Peers, 2002). In their introduction, Stadler and Kilger (2005) mention other impressive examples of successful supply chain management measures at Hewlett-Packard, Campbell Soup, IBM, and BASF (Lee and Chu, 2005; Cachon and Fisher, 1998; Grupp, 1998; Lin et al., 2000). These companies achieved enormous savings by improving material provision along their supply chains.

Brinkhoff and Thonemann (2007) carry out a large-size empirical investigation of the use of supply chain management measures in practice. 57% of the companies questioned stated that they already participated in cross-company collaborations. As many as 97% said they intended to extend their partnerships with other companies to 2012. However, the study also reveals that more than 50% of the supply chain management initiatives failed for various reasons. In one case, an information sharing project with a supplier that served to increase the service level and reduce inventory stocks was stopped at the last minute. Having heard of the project, top management was apprehensive about the high level of data transparency it would entail. This empirical investigation indicates that there is still great potential and demand for research on supply chain management topics such as Supply Chain Scheduling and Contracting.

## 2.2 Basic definitions

Developing concise definitions can be very painful since there are typically many people with divergent opinions ready to defend their perspectives on the subject in question. The benefit of going to the trouble of producing generally accepted definitions often

turns out to be limited relative to the elaborate and extensive discussions this involves. Such definitions have the habit to be very broad and distracting. Nevertheless, the lack of consistency in the literature concerning the definitions of the terms ‘supply chain’ and ‘supply chain management’ (Ho et al., 2002; Burgess et al., 2006; Jain et al., 2010) makes it imperative to discuss the way these terms are used here. But note that the aim is not to develop yet another definition. Instead, common definitions are analyzed with regard to their most important elements.

Chopra and Meindl (2012) contribute the following fairly broad definition of the term ‘supply chain:’

*“A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers, and even customers themselves. Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving and filling a customer request. These functions include, but are not limited to, new product development, marketing, operations, distribution, finance, and customer service.” Chopra and Meindl (2012), p. 13*

This definition encompasses two perspectives (Stadtlér, 2005):

- The inter-organizational perspective and
- the intra-organizational perspective.

### 2.2.1 The inter-organizational perspective

The inter-organizational perspective addresses a network of independent, meaning legally separated, companies that is referred to as a supply chain (Ross, 1998), which is the more common definition mentioned in the dissertation’s outline. The word ‘chain’ suggests a linear sequence of companies. However, in practice, the structure of business relationships between companies is generally not linear but arborescent. Since companies often pursue a dual or multiple sourcing strategy,<sup>6</sup> meaning they source required materials and components from several suppliers, ‘supply network’ would be the more accurate term to describe real-world business structures. Nevertheless, the term ‘supply chain,’ often meaning a supply network, has become accepted in the literature. Figure 2.1 depicts a classic inter-organizational supply chain structure.

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<sup>6</sup>A detailed discussion of the reasons for a dual or multiple sourcing strategy follows in Chapter 4 on page 63.

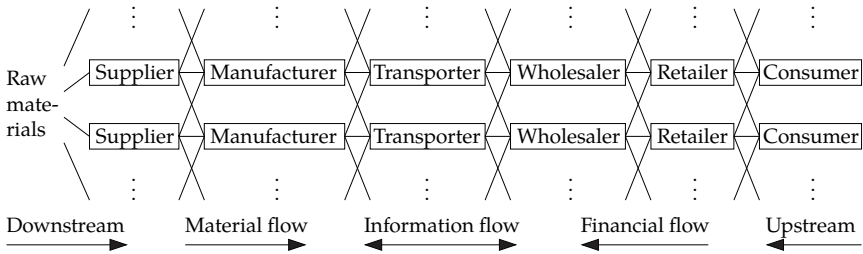


Figure 2.1: A classic inter-organizational supply chain structure

For example, Dr. Oetker, a German manufacturer of food products, purchases ingredients such as pepperoni, cheese, flour, and tomato sauce for frozen pizzas from its suppliers. The suppliers in turn source raw materials such as pork, milk, grain, and tomatoes from farmers. Having passed through Dr. Oetker's production process, the frozen pizzas are stored in central warehouses where third-party transporters pick them up and deliver them to wholesalers. The end-consumers buy the pizzas from retailers who are supplied by the wholesalers. While the material flow generally proceeds down the supply chain, information flows in both directions. For example, orders are given up the supply chain, while the arrival times of the materials are communicated down. The financial flow generally proceeds up the supply chain. Note that Figure 2.1 does not claim to represent all of the supply chain business relationships that exist in practice. In case of product recycling or reverse logistics of load carriers, for example, the material flows down as well as up the supply chain. The same holds for monetary payments. Contractual tardiness penalties can cause downstream financial flows, too. Figure 2.1 only presents a classic structure that is relevant in many branches of industry.

Consistent with the inter-organizational perspective, Simchi-Levi et al. (2008) propose the following definition of supply chain management:

*"Supply Chain Management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize systemwide costs while satisfying service level requirements."*

Simchi-Levi et al. (2008), p. 1

This definition contains three key elements (Stadtler, 2008):

- Integration,
- coordination, and
- the goal of supply chain management.

Supply chain **integration** means that several companies enter into a very close collaboration with a cross-company planning focus. Since such commitments are generally made for at least a mid-term time horizon, the careful selection of suitable partners is of fundamental importance to the partnerships' success. Integration aims to facilitate channel **coordination** which implies that the products are processed and distributed in the right quantities, in the right locations, and at the right time. Matching logistics equipment is the first step towards integration and coordination. Real-time data exchange via joint EDI (Electronic Data Interchange) systems (Ho et al., 2002), for example, allows for the exchange of up-to-date information on inventory levels. Improving the coordination of cross-company material flows can contribute towards mitigating the previously mentioned bullwhip effect. Also, the effectiveness of the prevalent just-in-time and *vendor managed inventory*<sup>7</sup> (Çetinkaya and Lee, 2000; Disney and Towill, 2003) approaches strongly depends on well-integrated EDI systems.

Without effective integration and coordination, the competitiveness of a supply chain as a whole is put at risk. Competitors may outperform the supply chain in terms of product quality and service level standards such as lead times, compliance with due dates, and shortfall quantities. Since the overall cost structure directly affects pricing decisions and profits, the system-wide costs, as mentioned in the definition by Simchi-Levi et al. (2008), are also of major importance. Taking into account all of these aspects, the primary **goal** of supply chain management is to improve overall competitiveness. However, when dealing with inter-organizational supply chains, there is the additional constraint of having to ensure Pareto improvements for all companies involved. As described in the dissertation's outline, major conflicts arise if at least one party suffers because it has to comply with the measures required to optimize overall performance. Since it entails cost and profit sharing mechanisms, suitable Supply Chain Contract-

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<sup>7</sup>The term 'vendor managed inventory' describes a specific logistics concept involving a supplier and a manufacturer. Provided with all relevant information on the manufacturer's material flows, the supplier is in charge of managing the inventory stock of a component that the manufacturer sources from him. The primary aim is to optimize the material flows between the two supply chain partners and thus to reduce logistics costs.



ing is thus especially important in inter-organizational supply chains. Stadler (2005) emphasizes this:

*"While hierarchical coordination in globally operating enterprises is already a demanding task, the real challenge arises in an inter-organizational supply chain where hierarchical coordination is no longer possible."* Stadler (2005), p. 576

To sum up, the task of supply chain management is to provide approaches that efficiently integrate and coordinate the individual supply chain stages. In doing so, it aims to enhance the competitiveness of the supply chain as a whole. In the case of inter-organizational supply chains, it also needs to be ensured that all companies involved benefit from the close collaboration. Note that the inevitable costs of integration and coordination, caused by a need for new software licences and labor input, for example, must be traded off against the resulting improvements in performance.

### 2.2.2 The intra-organizational perspective

The intra-organizational perspective deals with the supply chain within a company, which can be explained by the *supply chain planning matrix*<sup>8</sup> in Figure 2.2. The focus is on the activities carried out within a company.

	Procurement	Production	Distribution	Sales
Long-term	Strategic network design			
Mid-term	Master planning			Demand planning
Short-term	Purchasing and material requirement planning	Production planning	Distribution planning	Demand fulfillment
		Machine scheduling	Transportation scheduling	

Figure 2.2: The supply chain planning matrix (Rohde et al., 2000, p. 10)

Assumed to be linked by information flows in all directions, the rectangles represent typical planning issues arising in most industrial companies. The *y*-axis addresses the

<sup>8</sup>The supply chain planning matrix focuses on logistics related planning tasks. Business functions such as new product development, marketing, and finance are ignored. Fandel et al. (2009) identify two main groups of definitions of the term 'supply chain management.' While the first group deals with logistics aspects only (Göpfert, 2004), the second also addresses other functions (Cooper et al., 1997). Note that Mentzer et al. (2001) mark out the differences and commonalities between supply chain management and other fields of study such as traditional logistics.

time horizon of these issues (Fleischmann et al., 2008). The *x*-axis exhibits the material flow through the main activities *procurement*, *production*, *distribution*, and *sales*. For example, *strategic network design* requires making structural decisions with a long time horizon. The challenge is to determine capacities, transportation modes, strategic business relationships, and locations of processing sites and warehouses. These decisions should be made simultaneously since they concern procurement, production, distribution, and sales more or less at the same time. A mid-term task is *master planning* which comprises the assignment of production quantities to processing sites, identification of bottlenecks, adjustment of capacities, and contracting with suppliers and third-party transporters. Covering the next sales cycles, master planning is based on demand forecasts provided by the department responsible for *demand planning*. Based on the results of master planning and a bill of materials explosion, the short-term material requirements can be planned and the materials purchased. *Production planning* and *machine scheduling* means determining lot sizes and production schedules for a given week, day, and/or hour. *Distribution planning* and *transportation scheduling* refer to assigning completed products to transportation batches and scheduling deliveries to customers.

Intra-organizational supply chain management focuses on the integration and coordination of the company-internal activities. Its aim is to improve the company's performance and competitiveness. Heizer and Render (2011) propose a definition of 'supply chain management' that is consistent with this definition:

*"Supply chain management is the integration of the activities that procure materials and services, transform them into intermediate goods and final products, and deliver them to customers."* Heizer and Render (2011), p. 326

Compared with inter-organizational supply chains aligned by coordinating contracts, intra-organizational supply chains seem to have the advantage of a central head office that can issue instructions. However, in practice centrally unmanageable structures often involve the need to split companies into a number of departments with certain degrees of responsibility such as cost centers, profit centers, and investment centers (Ewert and Wagenhofer, 2008). The department managers' salaries are often directly affected by their department's performance. Since the managers are therefore primarily concerned with their individual department's performance, the conflict potentials arising in inter- and intra-organizational supply chains can be very similar. As in inter-organizational supply chains, incongruent incentives amplified by information asymmetries between the various parties put the overall success at risk (Milgrom and Roberts, 1992). Sophisticated transfer prices (Martini, 2007) and other framework ar-

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