2. Scope of Supply Chain Configuration Problem

2.1 Introduction

As firms position themselves to stay competitive, they face the challenge of transforming their operations from a static to a dynamic business environment. An obvious choice for transformation are supply chain operations because of their potential impact on almost every aspect of the business encompassing the extended enterprise. This is a complex undertaking because supply chain management entails managing the following under the umbrella of a common framework:

- Entity relationships, such as product, process, resource, organization, supplier, retailer, customer, etc.
- Flow of goods, services, cash, and information
- Objectives, strategies, and policies

Further, the framework is developed to account for risk and uncertainty caused by factors internal and external to the enterprise. Obviously, this requires reconfiguring the supply chain in order to keep pace with the changing environment.

In this chapter, we focus on studying the nature of the supply chain and its configuration in a dynamic business environment. We develop an understanding of the basis for a supply chain configuration problem, its classifications, and its various dimensions.

2.2 Supply Chain and Supply Chain Management

The management of a supply chain is a complex undertaking. It involves considering its unique system structure, dynamic design, hierarchical modeling needs, multi objectives, and the need for coordination of interactions among its entities. We discuss below how these elements can be brought together to make supply chain management effective.

2.2.1 A Systems Perspective on Supply Chains

Supply chain is a special class of system. Accordingly, it inherits all the general properties of a system. In addition, it has its own characteristics due to the special network structure. Next, we present a system perspective on supply chain.

Supply chain, and Supply Chain System

A supply chain is a network of suppliers, manufacturers, warehouses, distributors, and retailers who, through coordinated plans and activities, develop products by converting raw materials to finished goods inventory. In the process, they share materials, financials, and information flows between their facilities. In this arrangement, the supply chain network performs as a unit (whole) with various business entities (supplier, manufacturer, warehouse, distributor, and retailer) playing the role of its members (parts). The coordinated plans and activities define the relationships among these members according to which flows are shared based on a common objective. This definition leads to the observation that a supply chain is a *system*, as also explained in Sections 1.1 and 1.2 of the book.

We also assert that a supply chain is a *complex* system, as well as a system-of-systems, because it embeds other systems representing product, process, and organizational structures of an enterprise. In this regard, three system facets applied to the supply chain are depicted in Fig. 2.1, and elaborated below.

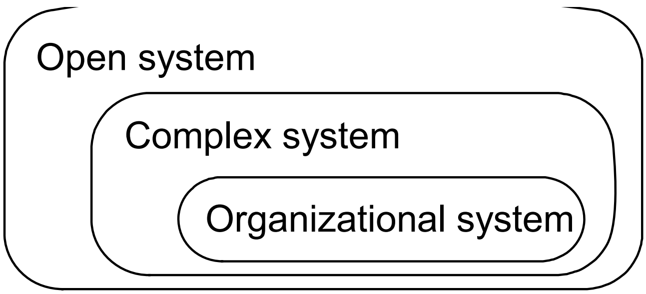

Fig. 2.1 General system facets applied to a supply chain.

From the system management perspective, a supply chain is viewed as an organizational system (Kast and Rosenzeig 1972), because a supply chain has managerial issues that can be classified into three levels − strategic, tactical, and operational (Simchi-Levi et al. 2003). As described in Table 2.1, long-range supply chain management issues need to be planned at the strategic level, in order to accommodate the varieties of policies and objectives across the supply chain network. At the tactical level, mid-range supply chain activities need to be planned and synchronized. At the operational level, day-to-day tasks and operations in the supply chain must be managed.

Table 2.1 Decision-Making Levels in Supply Chains

Decision-Making Level	Timeline	Type of Decision Made
Strategic	3 to 10 years	Investment on plants and capacities. Introduction of new products. Creation of a logistics network.
Tactical	3 months to 2 years	Inventory policies to use. Procurement policies to be implemented. Transportation strategies to be adopted.
Operational	Day-to-Day	Scheduling of resources. Routing of raw materials and finished products. Solicitation of bids and quotations.

A supply chain can also be characterized as a complex system (Agostinho and Teixeira 2003), which is defined as an organization of a large number of simple, mutually interacting parts (such as a supply chain's individual members) capable of sharing information among themselves, as well as with its environment, and adapting its internal structure as a consequence of such interactions. From the perspective of interaction with its environment, a supply chain can be considered an open system. To survive, a supply chain maintains steady state by continuous inflow and outflow from and to its environment, like biological organisms. Steady state implies that its system requirements are fixed for a specific period of time to make the system manageable.

As firms debate the adoption of the supply chain concept to manage their business operations in the extended enterprise, an obvious question arises as to what alternative forms of supply chain to implement − i.e., should it be product focused, or should customer focus be important? The answer lies in the fact that the type of supply chain to be implemented should be a function of both product characteristics and customer expectations. This is quite true, because adopting a supply chain that does not conform to the needs of the product and its customer is not justified (Fisher, 1997). We describe below two types of supply chains that meet this criteria (Vonderembse et al. 2006).

Lean Supply Chain

According to Vonderembse et al. (2006), "a lean supply chain employs continuous improvement efforts that focus on eliminating waste or non-value steps along the chain. It is supported by the reduction of setup times to allow for the economic production of small quantities; thereby achieving cost reduction, flexibility and internal responsiveness. It does not have the ability to mass customize and be adaptable easily to future market requirements." This type of supply chain is essentially based on the lean principles, which advocate the reengineering of business processes to remove all non-value added activity, generally ascribed as the source of waste in the system. Another significant feature of the lean technique applied in the lean supply chain is integration across functions of the enterprise. The accrued benefits are a high capacity utilization rate, shorter lead times, and minimization of total supply chain costs.

Agile Supply Chain

According to Vonderembse et al. (2006), "an agile supply chain profits by responding to rapidly changing, continually fragmenting global markets by being dynamic and context specific, aggressively changing, and growth oriented. They are driven by customer designed products and services." This type of supply chain is based on the principles of agility, which nurtures a production environment where products are adaptable to future changes in volume, variety, and lead times. In this environment, a high level of synchronization is desired with the result that members of the extended enterprise, such as the suppliers, also implement agility principles in their business operations.

Supply Chain Management

Supply Chain Management (SCM) involves various approaches utilized to effectively integrate suppliers, manufacturers, and distributors in performing the functions of procurement of materials, transformation of these materials into intermediate and finished products, and distribution of these products to customers in the right quantities, to the right locations, and at the right time to meet the required service level with minimal cost.

Supply chain management also involves managing a connected series of activities that is concerned with planning, coordinating, and controlling movement of materials, parts, and finished goods from the supplier to the customer. For this to occur, material, financial, and information flows are managed as decisions are made at strategic, tactical, and operational levels throughout the supply chain. Supply chain management issues span a large spectrum of a firm's activities at these levels (Simchi-Levi et al. 2003). Table 2.1 summarizes decisions made at these levels.

2.2.2 The Supply Chain as a Configurable System

A configurable supply chain is a system that efficiently adapts to its environment, offered in the form of supply and demand issues for the product(s) to be manufactured. A configurable supply chain is needed to manage logistics in a configurable system. This is because the adopted policies for product, process, and resource components of a configurable system have to be integrated with both inbound and outbound logistics decisions to realize benefits of flexible strategies. Some of the key triggers for designing and implementing a configurable supply chain are as follows:

- Introduction of new product(s), or upgrade for existing product(s)
- Introduction of new, or improvement in existing, process(es)
- Allocation of new, or re-allocation of existing, resource(s)
- Selection of new supplier(s), or deselection of existing ones
- Changes in demand patterns for product(s) manufactured
- Changes in lead times for product and/or process life cycles
- Changes in commitments within or between supply chain members

A configurable supply chain can help in assessing the impacts of one or more of the following factors / activities in a configurable system:

- Flows due to materials, inventory, information, and cash
- Throughput due to movement of products
- Capacity utilization
- Costs at various stages of the product development life cycle
- Lead time in product development
- Batch and lot sizing
- Process redesign
- Product development strategies
- Procurement and/or allocation of resources
- Strategic, tactical, and operational policies for the supply chain

Analysis of these factors / activities involves dealing with a wide range of managerial problems and spans across all tiers of the supply chain. Problem-solving approaches need to consider both interactions among factors and activities, and supply chain members.

2.2.3 Supply Chain Management Process

Supply chain configuration is one of the principal supply chain management decisions. It has profound impact on other subsequent managerial decisions. The decision-making process involved in configuring the supply chain analyzes the entire spectrum of system capabilities ranging from deterministic to stochastic systems. This is primarily due to the hybrid environment encountered in a supply chain where key factors in the decision-making process such as product demand, materials inventory, and available capacity may undergo rapid variations due to uncertainties caused by various control mechanisms, such as inventory and procurement policies, supply and revenue contracts, and so on. We propose supply chain configuration as an integral part of the overall supply chain management process.

Supply chain management is carried out as a step-by-step process. This process moves from a macro to a micro perspective that, in effect, aligns objectives to problems and their solutions. We briefly describe these steps.

1. *Definition of strategic objectives*. These high-level objectives are aimed at steering the supply chain on a specific course. These may have significant impact on the performance or operations of the supply chain. These are primarily related to the allocation of resources, positioning of the product, and implementation of key strategies. For example, where to locate plants, investment in manufacturing capacities, decisions on outsourcing or off-shoring of manufacturing or other activities, introducing the product to newer and / or emerging markets, and so on.
2. *Product selection*. A candidate product or products, whose supply chain is to be managed, are selected. Ideally, this would be an established (or matured) product whose product and process life cycles are well established and in which supply chain partners are already collaborating to offer the product to consumers. One could also select a new product whose supply chain has been clearly identified and potential partners are firmly on board. In this case, however, closer attention is warranted in monitoring implementation of various strategies and measuring objectives put in place at the time the supply chain is designed.
3. *Establishing the supply chain*. This is a process requiring a high level of collaboration, coordination, and synchronization among various activities and operations spread over a potentially large and varied number of supply chain partners. It starts with the selection of suppliers of raw materials and components. It may be prudent to have both primary and secondary suppliers. Next, manufacturing and production operations must be clearly identified. This involves

decisions regarding (a) identifying the manufacturing processes (through the process design activity), (b) location of facilities where these processes will be carried out, (c) allocation of resources to processes, and (d) production schedules. Following this step, decisions on product-related logistics must be made, which involves inbound and outbound logistics, such as procurement of raw materials, transportation and warehousing of inventory, and distribution of inventory to retailers. Finally, operations related to marketing the product to the consumer must be defined. In all of these activities, various policies related to forecasting demand, managing inventory, product planning, and so on must be clearly identified.

4. *Classifying the problems*. As described earlier, the supply chain has a complex structure with entities that have the role of a whole (supply chain) and its parts (supply chain members). The interaction of these entities with each other and with the environment creates problems at both the higher (global or macro) and lower (local or micro) levels. Accordingly, the nature of these problems in terms of their complexity and impact on the enterprise performance is different. For example, macro-level problems may have potential impact on the enterprise, while micro-level problems are more focused and may only impact a function or unit of the supply chain. A more detailed discussion of problem classification appears in Section 2.3. Due to the complexity of the supply chain structure, it is prudent to decompose the problem at macro and micro levels to design, model, and solve these problems efficiently and effectively.
5. *Strategic, tactical, and operational level supply chain management.* As a complex and integrated business enterprise, the impact of decision-making on the performance of the supply chain is felt at all levels, such as strategic, tactical, and operational. Table 2.1 summarizes the types of decisions and the frequency with which these are made at various levels. The challenge in designing and modeling the decision-making tools is to incorporate integration of input in the form of shared information and other variables across various decision-making levels.
6. *Classify problem-solving models and solutions.* Similar to classification of problems described above, problem-solving models and solutions for the supply chain are also classified at the macro and micro levels. In fact, these models are designed to solve macro- and micro-level problems, respectively. In addition, an integration model is designed to essentially integrate solutions provided by macro and micro models, and in most cases iteratively, thereby ensuring that an optimal, and more than likely a sub-optimal solution, is obtained. We

provide extensive coverage on various problem-solving models and solutions throughout the rest of the book.

2.3 Supply Chain Management Problem Domain

Supply chain management involves dealing with multiple managerial and technical problems (Cooper et al. 1997; Mentzer et al. 2001). These problems highlight several common issues that must be addressed for a supply chain to function effectively and efficiently. We discuss below some of these issues and how they have been addressed in the published literature.

Distribution Network Configuration

This issue deals with the selection of warehouse locations and capacities, determining the production level for each product at each plant, and finalizing transportation flows between plants and warehouses so as to maximize production, transportation, and inventory costs. This issue relates to information sharing: (a) inter-firm between marketing, production planning, inventory planning, and receiving and warehousing functions, and (b) intra-firm between manufacturer, suppliers, distributors / retailers, and transporters. It is a complex optimization problem dealing with network flows and capacity utilizations (Ballou 2001; Beamon and Fernandes 2004; Bozarth and McDermott 1998; Cakravastia et al. 2002; Cochran and Marquez 2005; Duray et al. 2000; Ernst and Kamrad 2004; Garavelli 2003; Salvador et al. 2004; and Schmidt and Wilhelm 2000).

Inventory Management

This issue deals with stocking levels at various echelons in the supply chain. Demands from echelon-to-echelon are considered in making this decision. This is a decision problem solution which involves using forecasting, inventory management, and simulation and optimization algorithms. Retailers, suppliers, and manufacturers deal with this issue in a supply chain by sharing information on customer demand, inventory levels, and replenishment schedules (Childerhouse et al. 2002; Sheffi 1985).

Supply Contracts

This issue deals with setting up relationships between suppliers and buyers in the supply chain through establishment of supply contracts that specify mutually agreed-to prices, discounts, rebates, delivery lead times, quality standards, and return policies. This approach differs from traditional approaches because its central focus is on minimizing the impact of decisions made at not just one echelon in the supply chain, but on all its players. A retailer sets up these contracts with a distributor or directly with a manufacturer. To manage this issue, it is incumbent upon various supply chain players to share information related to product price, cost, profit margins, warranty, and so on. This is a decision problem solution that could range from a simple linear programming problem to a complex game theory algorithm (Cachon 2002; Cachon and Lariviere 2000; Fisher et al. 1997).

Distribution Strategies

This issue deals with decisions pertaining to the movement of goods in the supply chain. Among the strategies available are direct shipments, cross-docking involving trans-shipments, and load consolidation. The objective is to minimize warehousing (storage) and transportation costs. A manufacturer makes decisions about warehousing or direct shipment to the points of usage of various products, utilizing information shared among manufacturers, suppliers, distributors, and retailers in the supply chain. Solutions to this problem involve network algorithm utilizing linear, and nonlinear programming techniques in deterministic and stochastic environments (Frohlich and Westbrook 2001; Lee 2003).

Supply Chain Integration and Strategic Partnering

One of the key issues in managing supply chains is integration (Bramham and McCarthy 2004). Information sharing and joint (or collaborative) operational planning are basic ingredients for solving this issue. Implementation of Collaborative Planning, Forecasting and Replenishment (CPFR) (Aviv 2001; Ng and Vechapikul 2002; Caridi et al. 2005; Fliedner 2003), as carried out by Wal-Mart retail stores in their supply chain aided by information sharing through common software platforms such as Enterprise Resource Planning (ERP) are viable strategies (Akkermans et al. 2003). In a manufacturing supply chain, it would mean CPFR among the retailer, supplier, and the manufacturer of products. The main idea of this technique is to avoid carrying excess inventory through accurate forecasting, and utilizing commonly agreed to demand data, information about which is shared among various supply chain partners (Anonymous 2000).

Outsourcing and Procurement Strategies

An important issue to consider is what to manufacture internally and what to buy from external sources. One of the problems to be dealt within making these decisions is identifying risks associated with these decisions and minimizing them. Another issue to consider is the impact of the Internet on procurement strategies and what channels to utilize (public or private portals) when dealing with trading partners. In arriving at the decision of whether to outsource or buy, various optimization models may be utilized to balance risk and payoffs. Once this decision has been made, use of appropriate information technology components, such as Internet portals and procurement software, plays a key role in these decisions. An example of this issue in a manufacturing supply chain may be the decision to outsource a component assembly rather than making it in-house. Information sharing for outsourcing and other procurement issues is accomplished in the supply chain and its extended enterprise, for intra-firm and inter-firm, via Intranet, Extranet, and Internet portals (Chen et al. 2004).

Information Technology and Decision Support Systems

One of the major issues in supply chain management is the lack of information for decision-making. Information technology plays a vital role in enabling decision-making via information sharing throughout the supply chain. Some of the key ingredients of information technology in the supply chain are use of Internet and Web-based service portals, integrated information/knowledge within ERP software, and decision support systems that utilize proven algorithms for various strategic, tactical, and planning problems in specific industry domains (Fiala 2005). Significant progress has been achieved in enabling physical supply chain integration. Lau and Lee (2000) use the distributed objects approach to elaborate on an infrastructure of integrated component-based supply chain information systems. Kobayashi et al. (2003) conceptually discuss workflow-based integration of planning and transaction processing applications, which allows for effective integrated deployment of heterogeneous systems. Verwijmeren (2004) develops the architecture of component-based supply chain information systems. The author identifies key components and their role throughout the supply network. Themistocleous et al. (2004) describe the application of enterprise application integration technologies to achieve physical integration of supply chain information systems. However, approaches and technologies for logical integration at the decision-modeling level, where common understanding of managerial problems is required, are developed insufficiently (Delen and Benjamin 2003).

Customer Value

The supply chain must be measured by its ability to deliver value to the end customer, or the consumer. This may be in the form of price, quality, service levels, or perceived value. Solutions based on statistics and operations research can be employed to measure the quality of a product, and the reduction of lead-time to enhance service rates. Input for this purpose is acquired via information sharing among various supply chain members (Baiman et al. 2001; Beamon and Chen 2001; Bullinger et al. 2002).

Challenges for Information Sharing in the Supply Chain

In light of various decision-making levels and issues facing effective management of the supply chain, it becomes imperative to find globally optimal integrated solutions. However, it is difficult to achieve depending on whether the problem-solving models designed for the purpose achieve local (or sequential) or global optimization of the supply chain network. Depending on which approach is adopted, the requirement for information sharing will be starkly different. For example, in the case of sequential supply chain optimization, the objective of its individual partners is optimized without regard to the overall supply chain network objective. Accordingly, the need for information sharing is limited and/or closed, sometimes nonexistent and usually offline. For global supply chain optimization, however, the objective for the overall supply chain takes precedence over each partner's objective. For this scenario, information sharing is extensive, open, and online (Beamon 1998; Fiala 2005; Simchi-Levi et al. 2003).

Based on the above review of issues, we summarize the key supply chain problems and their proposed problem-solving approaches in Table 2.2.

2.3.1 Overall Supply Chain Management Problems

From Table 2.2, it can be gleaned that supply chain management issues pose complex problems. The supply chain problem domain can be analyzed at various levels of decomposition. At the first level, the overall problem of supply chain management consists of multiple sub-problems such as product design, network design, logistics management, customer service, and others. For purposes of further discussion, we define these problems as *general* and *specific*. Specific problems occur at the vertical direction of problem decomposition and deal with one particular issue, for instance, inventory management. General problems cross multiple specific problems horizontally. Dealing with these problems requires solving multiple specific problems, for instance, ensuring customer service involves solving problems from logistics and sales areas. The list of problems presented below is composed primarily on the basis of the published literature and experiences of authors.

The problem of coordination and synchronization of activities and resource utilization occurs at all levels of implementation in an enterprise. A common problem encountered is that of “information sharing” among various members/partners in an enterprise. This often leads to misallocation of resources and impacts scarce resources such as capacity and inventory.

Table 2.2 Supply Chain Management Problems and Suggested Problem-Solving Approaches

Supply Chain Issue and Related Problem	Problem-Solving Approach
Distribution Network Configuration	Network Flow Optimization
Inventory Control	Forecasting and Inventory Management
Supply Contracts	Global Optimization
Distribution Strategies	Warehousing and Transportation Costs Management
Supply Chain Integration and Strategic Partnering	Collaborative Planning, Forecasting and Replenishment (CPFR)
Outsourcing and Procurement Strategies	Managing risk, payoff tradeoffs with Outsourcing vs. Buying
Information Technology and Decision Support Systems	Implementing Enterprise Resource Planning Decision Support Systems
Customer Value	Statistical Process Control, Total Quality Management, Service Level Maximization

General Problems

The main general supply chain management problems are:

Competitiveness. The house of supply chain management (Stadtler 2005) considers solving this problem as the ultimate goal of supply chain management. To maintain competitiveness, a supply chain must outperform competing supply chains in at least some aspects such as prices, quality, or delivery responsiveness.

Customer service. It characterizes the ability of supply chains to meet customer requirements. Approaches to addressing this problem are as diverse as the customer requirements representing such aspects as cost, quality, and responsiveness.

Coordination. Coordination of decisions by each supply chain member are made with regard to the impact these decisions will have on the performance of other supply chain members.

Collaboration. Joint activities performed by supply chain members to achieve common goals (Kliger and Reuter 2005) include product design and planning. In the case of collaborative product design, manufacturers, suppliers, and potential customers work together to design product that best suits market requirements and the capabilities of parties involved.

Integration. Addressing the *integration* problem enables customer service improvements, coordination, and collaboration. Information sharing is an important integration sub-problem.

Robustness. Supply chains operate in uncertain environments. Operations need to be planned and executed with respect to this uncertainty.

Flexibility and agility. Customer requirements and operating environments are dynamically changing. Addressing flexibility and agility issues implies the ability of reactive and proactive response to change.

Risk/benefit sharing. Implemented supply chain decisions have different impacts on supply chain members. Some of the units may assume larger risks and incur additional costs in the name of overall supply chain benefit. Risk and benefit sharing is essential for building trust and enforcing commitment among supply chain members.

Globalization. This presents both opportunities and challenges. Cost reduction and expansion in new markets have become possible. On the other hand, increasing competition, local regulations, and cultural adjustments cause additional difficulties.

Outsourcing. Firms focus on their core competencies to achieve a high level of competitiveness in specific areas while allocating supporting functions to partners.

Mass customization. Customers demand individualized products with similar cost and delivery time characteristics as those of standardized products.

Postponement. This is one of the strategies for delivering market-specific and customized products. It implies location (in time and space) of the product finishing close to the point of demand.

Social responsibility. Supply chains are designed and operated with regard to social, cultural, and environmental issues.

Specific Problems

The main specific supply chain management problems are:

Demand planning and forecasting. Demand data are required for other supply chain management activities. Demand planning attempts to influence demand to make supply chain operations more efficient.

Product design. This is not an explicit supply chain management problem, although there are significant interactions between design and logistics activities and at this stage it is a major input for further supply chain management activities. From the supply chain management perspective, this problem concerns collaborative product design, balancing product design requirements and supply chain capabilities, and providing the bill of materials for further planning purposes.

Process design. This is a significant supply chain management problem because of the very large number of processes that can be potentially enumerated as the supply chain is functionally decomposed top-down from a tier → unit → function → process level, and then need to be properly managed. One of the key problems that arise is how to develop a composite process design of the supply chain that clusters these processes based on similarities in features and characteristics, and arranges clusters according to an optimal implementation schedule.

Network design. A network of supply chain units meeting product and process design requirements is established. Problems to be addressed concern location and role of supply chain units, allocation of products, strategic-level capacity planning, and establishing transportation and information exchange links.

Marketing and sales. The primary concerns of these managerial problems are attracting customers and processing their orders.

Logistics. Problems deal with delivering products and services to customers, including planning of distribution structure, inventory management, warehousing, and transportation activities.

Purchasing. This deals with procurement of materials and services that are needed from suppliers to satisfy customer demand. The problem includes such issues as identification of materials and services needed, supplier relationships (i.e., supplier selection, contract negotiation, supplier evaluation) and execution of procurement operations.

Manufacturing. These problems address creation of products and services in response to customer demand. It includes such supply chain management concerns as master production planning, capacity allocation, scheduling, maintenance of manufacturing facilities, and manufacturing quality.

Finance. In the supply chain management framework, this concerns planning of supply chain costs and controlling supply chain performance.

Personnel management. Workforce requirements are considered while dealing with the personnel management problem. This includes workforce planning, hiring, layoffs, promotion, training, and incentives.

2.3.2 Subset of Supply Chain Configuration Problems

As discussed earlier in the chapter, supply chain configuration is a high-level supply chain management problem, which either completely or partially incorporates some of the specific supply chain management problems. Problems that are relevant to supply chain configuration are as follows:

Network design. It is the core sub problem of the supply chain configuration problem, thus all its aspects are relevant.

Sales and distribution. Individual ordering and marketing activities do not contribute to identifying supply chain configuration problems. Such aspects as grouping customers and representing aggregated marketing costs, however, are important problem-solving characteristics. For instance, if a configuration model is used to make decisions when opening distribution facilities in new markets, then the cost of attracting new customers is an important parameter.

Logistics design. Deciding on the inventory and distribution approach, such as vendor-managed inventory, cross docking, third party logistics, and associated transportation mode, capacity, and main routes to be adopted.

Purchasing. In the context of configuration problem solving, decisions concerning which suppliers to use for specific materials and in what quantities are addressed. Other purchasing conditions, such as delivery price and lead time are determined.

Manufacturing. This involves deciding on the manufacturing approach, such as pull, push, and master production planning.

Information technology support. It provides the information and processing capabilities needed to support other supply chain management problems.

It is often difficult to draw a line between relevant and irrelevant problems because all supply chain management problems are closely interrelated. However, forecasting and demand planning interacts with configuration decision making by providing demand data or forecasting algorithms, and there are usually no specific forecasting components within configuration decision making models. Therefore, demand planning and forecasting can be perceived as a problem, which is not necessarily an area of expertise for a supply chain configuration analyst, even though configuration problem decision making would not be possible without demand data.

The finance problem area is also a particularly important problem in the context of global supply chains. It accounts for such factors as taxes, duties, and currency rate fluctuations.

2.3.3 Integration

One of the key issues in managing a supply chain process is information integration among its constituents (Bramham and McCarthy 2004). To facilitate this integration, supply chain information resources ought to be effectively organized and shared. Information integration provides channels that convey information from one supply chain constituent to another. One form of this problem involves the integration of existing implementations that have been built in heterogeneous infrastructures, such as different hardware platforms, operating systems, and database management systems. Presenting the data on which applications perform in a uniform, consistent way ensures that they share the same view of the supply chain. Another form of integration is concerned with working collectively on common problems by sharing an understanding of the problems' logic and applying best practices. This provides a common architecture in information sharing so that supply chain members' collaborative activities provide performance improvement to each member and to the entire supply chain.

Information sharing and joint (or collaborative) operational planning are basic ingredients in solving the integration issue in a supply chain. Implementation of CPFR (Aviv 2001; Ng and Vechapikul 2002; Caridi et al. 2005; Fliedner 2003), as reportedly carried out by Wal-Mart retail stores in their supply chain, and aided by information sharing through common software platforms such as Enterprise Resource Planning (ERP) are viable strategies (Akkermans et al. 2003). A manufacturing supply chain would require CPFR among the retailer, supplier, and the manufacturer of products. The main idea of this technique is to avoid carrying excess inventory through accurate forecasting and utilizing one commonly agreed-to demand data, information about which is shared among various supply chain partners (Anonymous 2000).

The management of a complex organization such as a supply chain can be accomplished by the integration of its business processes. Process-oriented management vs. function-oriented management is an important feature that makes the supply chain a distinct enterprise system class. Another facet of supply chain system complexity is its organizational dynamics and operational specifics. Organizational dynamics assume frequent changes in organizational structures such as control hierarchy, goal structure, members' network, and so on. Operational specifics are mainly related to the uncertainty in which supply chain organizations operate. Integration of supply chain processes assumes additional complexity when the decision-making mode (i.e., centralized vs. decentralized) is considered in the mix.

2.4 Supply Chain Configuration Dimensions

Supply chain configuration is based on the basic principles of configuration and is enunciated in the mold of a configurable system as described in detail in Chapter 1. In this configuration, parts are *members* of the supply chain (i.e., supplier, manufacturer, distributor, retailer), arranged (or rearranged) to form the *whole* (i.e., the supply chain) in accordance with a plan executed by implementing various strategies and policies to meet a common objective(s).

Because the objective in configuring a supply chain is essentially similar to that of a generic configurable system, it can be construed that a configured supply chain is a special class of the configurable system. The primary difference between these two types of systems is that, in configuring a supply chain, the system dimensions considered are attributable to a supply chain system, and more particularly to the logistics network represented by it.

To fully appreciate the concept of supply chain configuration, it is important to understand its various system dimensions. In this section, we shed light on some of the significant dimensions.

2.4.1 Horizontal Extent

The supply chain is usually divided into tiers (or stages, or echelons). Each tier consists of units with the same general functionality. The concept of tier should be treated with care, however, as differentiation between tiers is often fuzzy and units can belong to multiple tiers. That has become even more profound as supply chains assume networked structures. Still, tiers help structure the supply chain configuration problem and facilitate identification of common features of supply chain units.

The typical supply chain tiers (see Fig. 2.2), which can be further decomposed, are

- Customer tier – the most downstream tier
- Distribution tier
- Manufacturing tier
- Supply tier – the most upstream tier

Demand for supply chain products or services originate at the customer tier and it is transmitted upstream along the supply chain. In many cases, techniques where customers aggregated into customer zones according to their geographical location (Simchi-Levi et al. 2003), using the zip code as a grouping criterion for consumer products). Each customer can be represented as an individual node in studies considering industrial customers.

The distribution tier receives customer requirements and is responsible for delivering required products or services. It involves such general units as warehouses, distribution centers, and cross-docking points. These units are grouped into distribution sub-tiers. Alternatively, supply chain units in the distribution tier can be classified as wholesalers, retailers, and brokers Third-party logistics providers present a special case for belonging to the distribution tier. In some situations, these can be represented by a single supply chain node.

There are two distinct scenarios to organize the supply chain's operations. The first, where manufacturing tier directly creates products or services demanded by the supply chain's customers. It receives demand information from the distribution tier. In return, it provides products to the distribution tier and orders materials from the supply tier. In the second scenario, the manufacturing tier can also be divided into several sub-tiers, such as pre-processing, assembly, final assembly and finishing. Manufacturing outsourcing can be represented either in the manufacturing tier or in the supply tier. The first scenario is more relevant to representing the manufacturing tier for an engineering company such as *Ericsson*, which has outsourced almost all manufacturing operations and retained only product and process design as their primary competency, or in the case of capacity sharing agreements. The second scenario is more relevant for representation of manufacturing of components (for instance, the Ford and Visteon case).

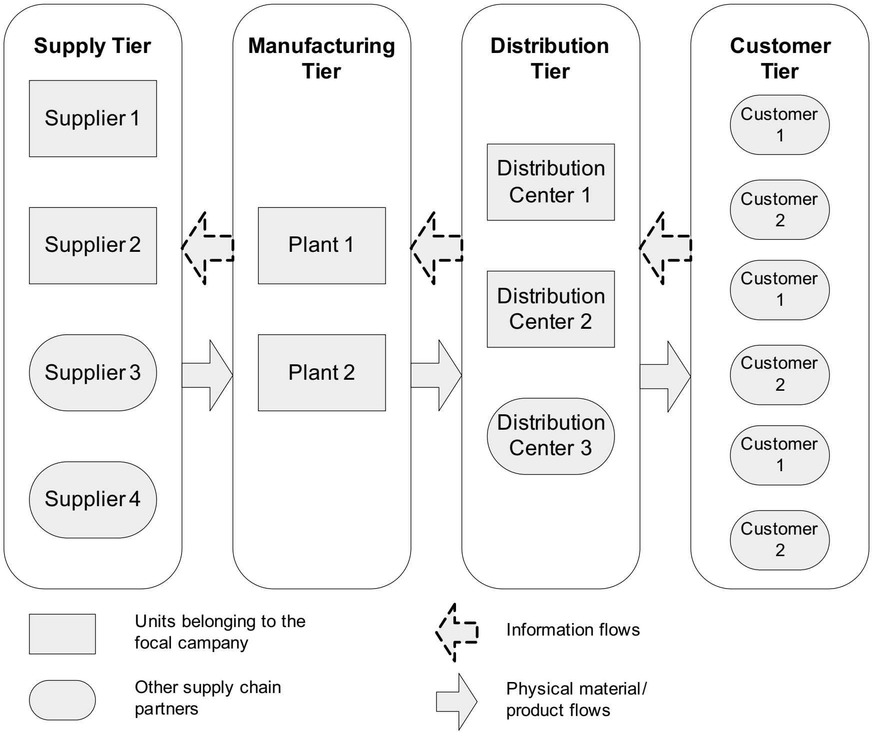

Fig. 2.2 A typical supply chain structure.

The supply tier provides materials to manufacturing according to orders received. This tier can be divided into sub-tiers, linking raw materials suppliers, secondary suppliers, and direct suppliers. Representation of the supply tier depends upon the importance of supplied materials. Suppliers providing widely available materials do not need to be represented by individual nodes.

One additional supply chain tier not sufficiently exposed in the literature is the utility tier. This tier includes providers of basic infrastructural services such as electricity, water, and recycling. That could be of particular concern for global supply chains, because availability, cost, and quality of such services vary substantially.

Definition of this supply chain configuration dimension includes specifying the number of tiers in the supply chain, defining general types of units in each tier, and identifying specific constraints for the tier as a whole (for instance, the number of suppliers required).

2.4.2 Vertical Extent

As noted earlier, a supply chain consists of several members spread across many tiers (echelons, or stages). Each of the tiers consists of one or many business units (entities). Each of these business units is, by itself, an enterprise comprising functional areas such as design, marketing and sales, production planning and control, inbound and outbound logistics (procurement, receiving, warehousing, shipping), and so on. Each unit may also pursue its own independent strategies to manage its functions and strive to achieve specific goals and objectives.

A *within* unit (local) vertical integration would entail synchronizing and coordinating strategies and policies, for example, between its sales and marketing and manufacturing functions to achieve a common objective for the unit.

A *between* (global or supply chain level) vertical integration within a tier (comprising all units) would be to implement common strategies and policies to achieve a common (global) objective across units in their tier.

Vertical integration could be achieved at strategic, tactical, and operational levels of decision making within a tier of the supply chain. This is primarily achieved by means of implementing strategies and policies appropriate at these levels that are aimed at achieving long-term, mid-term, and short-term goals and objectives.

Definition of this supply chain configuration dimension includes specifying the number of units in each tier in the supply chain and identifying specific constraints and objectives: (a) within a unit at high level and by functional areas at low level, and (b) between units at high level and across functional areas at low level.

2.4.3 Objectives and Criteria

Decision-making objectives are chosen according to general strategic objectives. Certain quantitative criteria or metrics are associated with each identified objective.

General managerial concerns related to the supply chain configuration problem are

- What is the current supply chain performance?
- "What if" analysis?
- How to improve customer service?
- How to improve supply chain robustness and delivery reliability?
- Could supply chain be made more profitable?
- Is supply chain sufficiently flexible?

- How to improve cooperation?
- How to comply with local requirements?
- Whether to pursue outsourcing?
- Which partners to choose?
- Where to locate supply chain facilities?

Answering these questions leads to formulation of general supply chain configuration decision-making objectives. These objectives can be formulated on the basis of performance attributes identified in the Supply Chain Operations Reference (SCOR) model (Stewart 1997):

- Objective 1: To improve supply chain delivery reliability.— the performance of the supply chain delivering the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.
- Objective 2: To increase supply chain responsiveness.— the velocity at which a supply chain provides products to the customer.
- Objective 3: To increase supply chain flexibility. — the agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.
- Objective 4: To optimize supply chain costs. — the costs associated with operating the supply chain.
- Objective 5: To improve supply chain asset management efficiency — the effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets — fixed and working capital.

Objectives can similarly be identified on the basis of discussion provided by Beamon (1998), such as

- Objective 1: To improve customer satisfaction and customer responsiveness.
- Objective 2: To improve flexibility and risk aversion.
- Objective 3: To improve information and material flow integration.
- Objective 4: To optimize costs (other related performance measures are total cost, sales value, profit, inventory holding cost, return on investment, and others).
- Objective 5: To optimize suppliers' performance.

A large number of criteria are used for solving the related supplier selection problem. Weber et al. (1991) provides a comprehensive survey of supplier selection criteria used. The survey is based on the list of criteria compiled by Dickson (1966). The most frequently considered criteria, which can be attributed to the suppliers' performance objective although they contribute to other objectives as well, are

- Net price
- Delivery
- Quality
- Production facilities and capacity
- Geographic location
- Technical capability
- Management and organization
- Reputation and position in industry

Other important criteria are financial position, performance history, repair service, and attitude.

It is surprising that in the supply chain configuration framework only the supply tier is being evaluated under such a wide range of criteria, because location of manufacturing and distribution facilities is evaluated in a similar fashion in practice. For instance, companies consider incentives offered by local governments as a major decision-making factor.

2.4.4 Decisions

Initially, general supply chain configuration decisions are identified following the supply chain configuration decision-making objectives. These are subsequently specified using particular decision variables. Five groups of decisions are defined, characterizing structure, links, quantity, time, and policies used.

Structural decisions are

- Location of supply chain facilities at different tiers
- Facility opening
- Supplier selection
- Product allocation
- Definition of facility's capabilities

Decisions characterizing links among supply chain units are:

- Establishing a fixed link among a pair of units–if a link between units cannot be established on the spot, decisions must involve which units' link should be established
- Restricting cooperation to specified links–implies that a particular unit can cooperate only with a limited group of other units (i.e., a customer zone is served by only one particular distribution center)

- Choice of products or services delivery mode
- Choice of information exchange mechanisms

Alternative production location according to ownership, international/global, and product state are described by Meixell and Gargeya (2005).

Decisions characterizing quantity are:

- Quantity of purchased materials
- Quantity of products produced
- Quantity of products processed
- Quantity of products delivered
- Quantity of products stored in inventory
- Shipment quantities along supply chain links
- Capacity-related decisions

Decisions characterizing quantity often differ by their interpretation and level of detail. For instance, manufacturing capacity is specified for each product separately at a plant or for the entire plant. The main decision characterizing time is delivery time.

Decisions characterizing policies are

- Choices of manufacturing strategies. The most general values of these decisions are make-to-plan (make-to-stock), make-to-order, and assemble-to-order. The choice of the manufacturing strategy influences propagation of demand information along the supply chain and functions performed by different units
- Adoptions of information sharing policies. Information sharing policies affect manufacturing, inventory, and transportation, as well as several other decisions and characteristics. They also influence requirements towards information exchange infrastructure, where possible values of decisions are deployment of Electronic Data Interchange (EDI), or use of the Internet. Other IT-related decisions, such as implementation of ERP and manufacturing execution systems can also be considered
- Choice of distribution channels. Values these decisions assume include Internet-based distribution, third-party logistics, direct sales, quick response, continuous replenishment, and vendor-managed inventory. Some of the policies may be represented in relation to the horizontal extent dimension. For instance, the direct shipment policy implies the absence of intermediate distribution tiers. Multiple distribution strategies can be used in a single supply chain
- Choices of procurement policies. Some alternatives include volume consolidation, alliances and partnerships with suppliers, just-in-time

(JIT), and manufacturing resource planning (MRP). From a technical perspective, various types of e-procurement can be chosen (for instance, EDI, Internet-based business-to-business (B2B) approaches, and trading networks)
- Adoption of outsourcing. Decisions apply to separate supply chain functions and indicate whether these are outsourced or not. That influences the way supply chain costs are accounted for. For instance, outsourcing may reduce fixed costs associated with a facility opening

Each of these policies can be parameterized by a set of particular structural, linkage, quantitative, and time parameters. For instance, if the decision is between using EDI or the Internet for information exchange purposes, a parameter characterizing a fixed cost for establishing links among manufacturing facilities and suppliers is larger for the first. Policies influence which supply chain management problems need to be addressed during decision-making. For instance, evaluation of the built-to-stock manufacturing strategy requires consideration of the inventory management problem.

The decisions listed above do not provide an exhaustive list of all supply chain configuration decisions. That, especially, applies to policy decisions. Decisions relevant to a particular decision-making problem, and decision variables characterizing these decisions, are defined during the supply chain configuration problem-solving process.

2.4.5 Parameters

Parameters usually are more specific to a particular decision-making problem compared to other supply chain dimensions discussed earlier. Some common features, however, can be identified.

Parameters are traditionally classified as internal and external. External variables for the supply chain configuration problem are customer demand and requirements in general, taxes, governmental regulations, and others.

The first group of internal variables represents structural characteristics. That includes representation of the existing supply chain structure, bill of materials, available capacity, and capacity requirements. This group also includes parameters describing attributes of alternative transportation channels (e.g., distance, speed).

Supply chain operations are described by cost- and time-related parameters. These are classified as fixed and variable parameters. Fixed cost parameters describe costs due to opening (closing) and operating supply chain facilities, capacity build-up costs and costs associated with establishing and maintenance of links among supply chain units. Inventory replenishment, manufacturing setup, and fixed transportation costs can also be considered. Variable costs are incurred per each processed product. Processing can assume various forms including transportation, assembly, inventory handling, and others. Parameters for representing processing time can also be used.

Specific parameters may be needed to describe various attributes of the supply chain management policies considered.

2.5 Aligning Objectives

One of the major tasks of any supply chain configuration effort is to align the objectives of the enterprise at both macro and micro decision-making levels. This is primarily due to the fact that objectives at individual business unit levels, at the tier (echelon or stage) level, as well as across tiers, are conflicting in relation to each other. To solve a composite supply chain problem with conflicting objectives, it is imperative that the objectives be organized according to some priority (or importance) in the optimization models. The resultant aligned objectives are the basis for the multi-criteria decision-making models, which are usually implemented for optimizing supply chain networks. We describe these concepts below.

Table 2.3 provides an example of performance measures for a business unit belonging to a supply chain tier whose objectives at a strategic level are closely aligned with its tactical and operational levels. For instance, marketing decisions are taken at strategic level, mainly dealing with, which product to introduce to the market. Row 1 lists objectives in marketing a new product, what policies will likely are implemented for it, and the specific goal to be achieved. Obviously, the objective, policy, and goal must be aligned, if the strategic marketing decision is to be successfully implemented. Similarly, a tactical decision related to procurement planning must have the maximizing inventory turns objective closely aligned with its just-in-time policy, and an inventory turnover goal of 2.5 to 3. The objective of minimizing merchandizing costs at the operational decision-making level must implement a same day shipment policy and achieve a 98 percent shipment fill rate of within 4 hours of order to be successful.

If we analyze column entries in Table 2.3, we can see that the objectives for marketing, procurement, and warehouse operations are closely aligned with each other. This is because we cannot meet the marketing objective of maximizing customer service unless the procurement planning objective of maximizing inventory turns is achieved and the warehousing operations objective of minimizing merchandising costs is met. We can also see clear alignment of policies in Column 3 and goals in Column 4. For example,

Table 2.3 Alignment of Objectives at Micro Level

Function	Objective (s)	Policy (ies)	Goal (s)
Marketing	Maximize customer service	Implement a procure-to-stock policy	Achieve a 98 percent order-fill-rate of within 4 days of order processing
Procurement Planning	Maximize inventory turns	Implement a just-in-time procurement policy	Achieve 2.5 to 3 inventory turns
Warehouse Operations	Minimize merchandising costs	Implement a same day shipment Policy	Achieve a 98 percent shipment-fill-rate of within 4 hours of order

for a procure-to-stock policy to be successful, a just-in-time procurement policy is desirable, and a same day shipment policy. We can analyze goals and observe that in order to achieve a 98 percent order-fill-rate, inventory turns of 2.5 to 3 must be met and achieving a 98 percent shipment-fill-rate is important.

Table 2.4 is analogous to Table 2.3, except that it represents decision-making at the macro level. In this case, the strategic, tactical, and operational level decision parameters, such as objectives, policies, and goals, are closely aligned. The objectives, policies, and goals at each of the three levels are also complementary to each other.

Table 2.4 Alignment of Objectives at Macro Level

Function	Objective (s)	Policy (ies)	Goal (s)
Marketing	Maximize customer service	Evaluate and implement a pull policy	Achieve an industry benchmark of 98 percent order-fill-rate within 48 hours
Production Planning	Maximize production under-runs Maximize inventory turns	Evaluate and implement a just-in-time scheduling or planned production scheduling policy	Achieve a 90% effective capacity utilization Achieve inventory turns of 4 or above
Plant Operations	Minimize manufacturing costs Maximize yield per production run	Evaluate and implement a just-in-time manufacturing policy	Achieve over 85 percent actual capacity utilization Achieve less than 2% rejects

2.6 Summary

In this chapter, we explore supply chain as a systems concept, and its configuration in the face of a dynamic business environment. We discuss various aspects of supply chain configuration problems, its classifications, and its various dimensions. We posit supply chain configuration as a supply chain management problem and argue that it can be successfully achieved if properly modeled around the decision-making levels and aligned with objectives at the macro and micro levels.

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