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MULTI-LAYER FRAMEWORK FOR SUPPLY CHAIN MANAGEMENT

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Abstract. Supply Chain Management (SCM) has recently attracted the attention of many researchers and practitioners. With the increase in global competition resulted from free trade agreements, companies are increasingly inclined towards establishing and maintaining efficient material and information flows with their upstream and downstream partners, such as suppliers, manufacturers, distributors, transportation carriers, third - party logistics companies and information providers.

Three major developments in global markets and technologies have brought SCM to the forefront of management's attention:

- 1- Information revolution
- 2- Customer demands in areas of products and service cost, quality, delivery, technology and cycle time because of global competition.
- 3- The emergence of new forms in inter - organizational relationships.

1. INTRODUCTION

Supply chain management (SCM) has recently attracted the attention of many researchers and practitioners. To remain competitive, many businesses such as Wal-Mart and HP have attempted to implement it in their enterprises. The success of such attempt is heavily dependant on the span of the enterprise and the collective efforts of the supply chain participants. With the increase in global competition resulted from free trade agreements, companies are increasingly inclined towards establishing and maintaining efficient material and information flows with their upstream and downstream partners. These partners include suppliers, distributors, transportation carriers, third-party logistics companies, and information systems providers.

Implementing supply chain management is not an easy task, but the benefits can be substantial for companies that make it work. Many industries are using SCM principles to turn things around and run their supply chains in a "demand pull" manner. They are using customer demand information to drive the production/supply side of their business and they are reaping many significant benefits in the process such as improved customer satisfaction, lower operating costs, increased throughput and dramatically reduced inventory, just to name a few. Companies need to abandon the traditional functional approach to managing their businesses in favor of process-oriented approach. In short, they have to manage their entire supply chain, not just specific parts along it. The key to effectively managing a company's supply chain is utilizing information regarding the flow or supply of product and customer demand. This information needs to be managed back and forth across the entire supply chain. An information technology solution provides paralleled opportunities for the integration and coordination of such information.

The topic of supply chain management is not new. The term has been around for about 20 years. Several decades ago, industry's concern was simply getting final products to customer. Schofield (1995) [2] states: "the next stage was introduction of logistics", which factors upstream operations in to decision making. He indicates that the main problem with logistics is the fact that it is considered to be a separate function distinct from the rest of organization. According to Schofield, supply chain management implies an unbroken line between customer and production which touches on several different departments and which can branch out to include many different suppliers. This is where supply chain management truly makes sense. The integration of activities seems to be the value that supply chain management adds, to allow an organization make decision considering all affected areas that are optimal for the whole organization.

This paper is organized as follows. In the next section, the concepts and differences of SCM and logistics are discussed. Section 3 addresses the significance of supply chain management. The elements of supply chain management and design considerations of the SCM framework are then discussed in section 4 followed by the strategic design of SCM in section 5.

2. SUPPLY CHAIN VERSUS LOGISTICS

We begin with the definition of supply chain management. There are many definitions for supply chain management in the literature. According to a simple definition, the supply chain encompasses all of those activities associated with moving goods from the raw materials stage through to the end user. A more comprehensive definition can be built upon by expanding the term "activities" in the above definition. Such activities can include sourcing and procurement, product design, production planning, materials handling, order processing, inventory management, transportation, warehousing, and customer service. It also takes in the information systems necessary to communicate among the supply chain partners. Adding a minimum cost objective to this expanded definition gives a more comprehensive definition for supply chain management such as the one proposed by Simchi - Levi *et al.* (2000)[4] as follows:

"Supply chain management is a set of approaches utilized to 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 system wide costs while satisfying service level requirements."

There are the following observations in this definition.

Customer satisfaction: Supply chain management takes into consideration the quality of services and products to a level that conforms to customer needs; whether it is an intermediate customer (e.g., retailer) or the end user.

Intra-organization activities: Because supply chain management revolves around efficient integration of suppliers, manufacturers, warehouses, and stores, it encompasses the firm activities at many levels, from the strategic level through tactical to operational level.

Integrative approach: The objective of supply chain management is to be efficient and cost effective across the entire system. All costs, from transportation and distribution to inventories of raw materials, work in process, and finished goods are to be minimized. Thus, the emphasis is not on simply minimizing transportation cost or reducing inventories, but rather taking a system approach to supply chain management. Indeed in some supply chain analysis, it is necessary to account for suppliers' suppliers and customers' customers because they have impact on supply chain performance. Therefore, it is important to integrate the objectives of a single company with those of the *enterprise* that includes all participants along the main line of business. As Handfield and Nichols (1995)[5] stated, the supply chain management encompasses all activities associated with flow and transformation of goods from the raw material stage (extraction) through to end user as well as associated information flows. Supply chain management is the integration of these activities through improved supply chain relationships to achieve a sustainable competitive advantage. Successful supply chain management, therefore, coordinates and integrates all of the activities and it embraces and links the different partners in the chain in addition to the departments within the organization.

Of course, an ordinary question is "what is the difference between supply chain management and logistics management?" To answer this question, one needs to understand the definition of logistics. The definition given by the Council of Logistics Management (CLM) is:

"Logistics is that part of supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods and services"

A study done by CLM found that world-class firms are more apt to exploit logistics as a core competency than their less advanced competitors. This logic can be extended to inter-organizational supply chains. The CLM study identified what the "best of the best" logistics firms do to achieve world-class status. The key focus areas include:

- 1- Positioning concerning the selection of strategic and structural approaches to guide logistic operations.
- 2- Integration of internal achievement of logistical operating excellence and boundary-spanning development of solid supply chain relationships.
- 3- Agility in terms of the firm's competency with respect to relevancy accommodation and flexibility.
- 4- Measuring of internal and external performance.

Integrated SCM will increase the importance of logistics activities. SCM provides supply chain members with the opportunity to optimize logistical performance at the inter-organization level. At the limit, this means integrated management of the movement of materials from initial raw materials supplier across the chain to the ultimate end customer. This represents a major departure from current logistics practices that are often characterized by independent efforts with limited coordination between organizations. Logistics professionals will continue to be challenged to manage the movement of products across the enterprise in a timely and cost-effective manner that meets customers' required service level. In order to meet this challenge, a supply chain-wide logistics strategy is required. Such a strategy will be the primary driver for the specific logistics activities within each of the supply chain member organizations. Distribution networks, transportation models, carrier management, inventory management, warehousing, and order processing are among such activities. The scope of the logistics strategy is then the entire supply chain rather than each individual unit in the chain. It will no longer be necessary or desirable for each supply chain member organization to manage its logistics activities on an independent basis.

3. THE SIGNIFICANCE OF SUPPLY CHAIN MANAGEMENT

All organizations are part of one or more supply chains. Whether a company sells directly to end customer, provides a service, manufactures products, or extracts material from the earth, it can be characterized within the context of supply chain. Until recently, however, organizations focused primarily on their direct customers and internal functions, and placed relatively little emphasis on their organizations within their supply

chain network. However, three major developments in global markets and technologies have brought supply chain management to the forefront of management's attention:

- 1- The information revolution.
- 2- Customer demands in areas of products and service cost, quality, delivery, technology, and cycle time brought about by increased global competition
- 3- The emergence of new forms of inter-organizational relationships.

Each of these developments has fostered the emergence of an integrated supply chain approach. Figure 1 illustrates the nature of supply chain management and an integrated framework that encompasses all three developments mentioned above. As shown in this figure, information is an essential part of the supply chain. The success of the participant organizations depends heavily on the accuracy and promptness of information across the chain. Unlike cash flow and material flow, the flow of information is bi-directional, from suppliers through manufacturer to customers and vice versa.

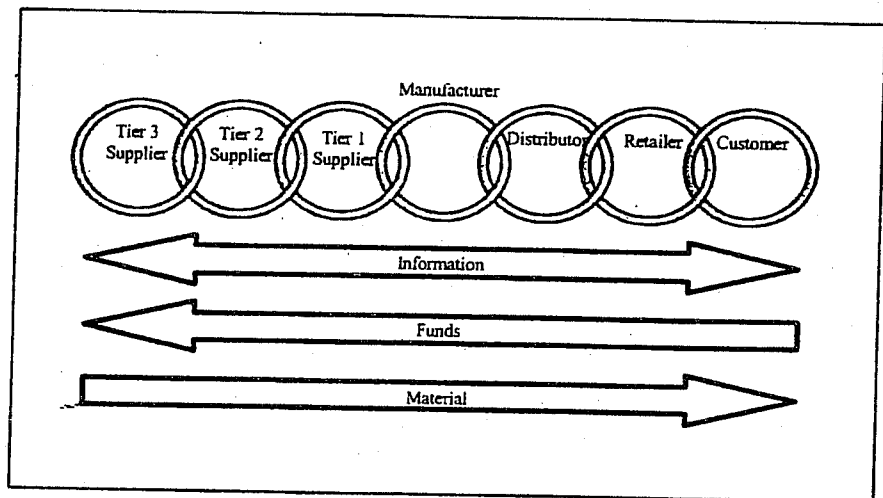


Figure 1. The integrated framework of supply chain management

With the explosion of the Internet and company intranet, future systems will possess the following set of characteristics (Dubois and Carmel, 1994) [8]:

- Centralized coordination of information flows.
- Total logistics management: integrating all transportation, ordering and manufacturing systems.
 - Order change notices that trigger a cascading series of modifications to production schedules, logistics plans and warehouses operations.
 - Global visibility into transportation resources across business units and national boundaries using the advanced technology of global positioning systems.

- Global inventory management: ability to locate and track the movement of every item.
- Global sourcing: consolidation of the purchasing function across organizational lines, facilitating purchasing leverage and component standardization across business units.
- Intercompany information access: clarity of production and demand information residing in organizations both upstream and downstream throughout value chain.
- Data interchange between affiliates and non-affiliates through the standard telecommunication channels.
- Data capture: ability to acquire data about an order at the point of origin and to track products during movement and as their characteristics change.
- Transformation of the business from within: managers who can see the big picture and accept the new form of business processes and systems.
- Improvements in supplier-customer relationships to justify investments in technology linkages.

Two decades ago, an integrated supply chain that includes all of the above characteristics might have looked too far from reality, but it is far more likely to be achieved considering today's advanced technology.

Another major trend facing organizations today is the demand for ever-greater levels of responsiveness and shorter defined cycle times for deliveries of higher quality goods and services. A variety of changes in markets have resulted in an increasingly competitive environment. As Pine (1999)[9] says: "the rapid rate of changes leads to a condition in which managers must make decisions on shorter notice and less information with higher penalty costs. At the same time, customers demand quicker delivery responsiveness. These same customers require production that incorporates state of the art technology and features. Products are becoming less standardized and customers are demanding options that are tailored to their unique requirements. In many segments of marketplace, only those firms that have the ability of mass-customization are successful."

Managers throughout the supply chain are feeling the full effect of these changes. Cutbacks in staffing are forcing managers to handle a greater number of channels with fewer people, while cost pressures require that they do so with fewer inventories. Because of ever-increasing levels of competition found in many markets, supply chain-related mistakes leading to lost sales cannot be easily dismissed and written off. Furthermore, both customers and suppliers are becoming more efficient in measuring performance, so that these mistakes are more easily detected, requiring a supply chain that is quick, precise and provides top quality products every time.

Despite the imposing challenges of today's competitive environment, some organizations are thriving. These firms have embraced changes and have integrated quick response and flexibility into their day-to-day culture. They are managing the above aspects by paying attention to time. For example, the reduction of delivery times both in the marketplace and throughout the supply chain has earned such firms as Hewlett-Packard, Northern Telecom, Toyota and Xerox a reputation as time-based companies. Entire industries have changed to reflect time-based capabilities. A number of "buzzwords" have emerged to describe time-based capabilities: throughput reduction, delivery speed, fast cycle

capability, quick response or resupply time, lead time reduction, and time compression. Unlike many management fads, however, time-based competition is a phenomenon that is here to stay because of its direct linkage to profits. The advantages achieved by time-based competitors enable them to grow faster and earn higher profits relative to other firms in their industry increase market share through early introduction of new products and control overhead and inventory costs, and move to positions of industry leadership.

4. DESIGN CONSIDERATIONS OF SCM

In order to better understand the strategic framework of SCM, one needs to identify the major elements of supply chain and their role within the framework. These elements include but are not limited to: goals of SCM, network of participants, information systems and technologies, distribution of material and information, benchmarking, cycle time and customer values. These elements are discussed in the following subsections.

4.1 Network Design

According to Handfield and Nichols (1995)[5], an organization's supply chain consists of three major groups: upstream supplies, intra-organizational units, and downstream customers. While the intra-organizational units deal with purchasing, manufacturing and sales, the management of upstream supplies focuses on supplier selection and on-time delivery of materials to manufacturing units. Also, the management of the downstream customers makes sure that the good quality products are distributed and delivered to customers in a timely manner (Abdinnour-Helm, 1999)[28]. A proper network design that links subunits of participating organizations in a supply chain can facilitate communication and exchange of information, material and cash. The benefits of such networks have been proved to be significant improvements in effectiveness and efficiency of all participants. Interested readers are referred to Quinn (1998)[29] and Gibson (1998)[30].

4.2 Warehouses and Facilities Location

Since transportation and distribution costs can be a significant part of supply chain management costs, the types and number of facilities to construct or acquire and the problem of where to locate them are strategic design issues. Wal-Mart, for example, has incorporated these various characteristics into an effective and successful supply chain strategy to provide quality products for its customers at a lower price. The key to achieving these strategic goals has been a feature of supply chain design known as *cross-docking* in which products are delivered to warehouses on a continual basis where they are sorted, repackaged and distributed to stores without sitting in inventory (Figure 2). In the case of Wal-Mart, goods cross from one loading dock to another in forty-eight hours or less. Retailers do not at all use cross-docking because it is difficult to coordinate and manage. To make it work, Wal-Mart has invested heavily in an integrated support system that provides continuous contact between all of its suppliers, distribution centers, and

every point-of-sale in every store via its own satellite communication system. This information system sends out point-of-sale (bar code) data directly to Wal-Mart's 4000 suppliers. In addition, Wal-Mart owns 2000 trucks to serve its 19 distribution centers. This allows the company to ship goods from warehouses to stores within 48 hours and restock store shelves an average of twice a week, compared to the industry average of once every two weeks.

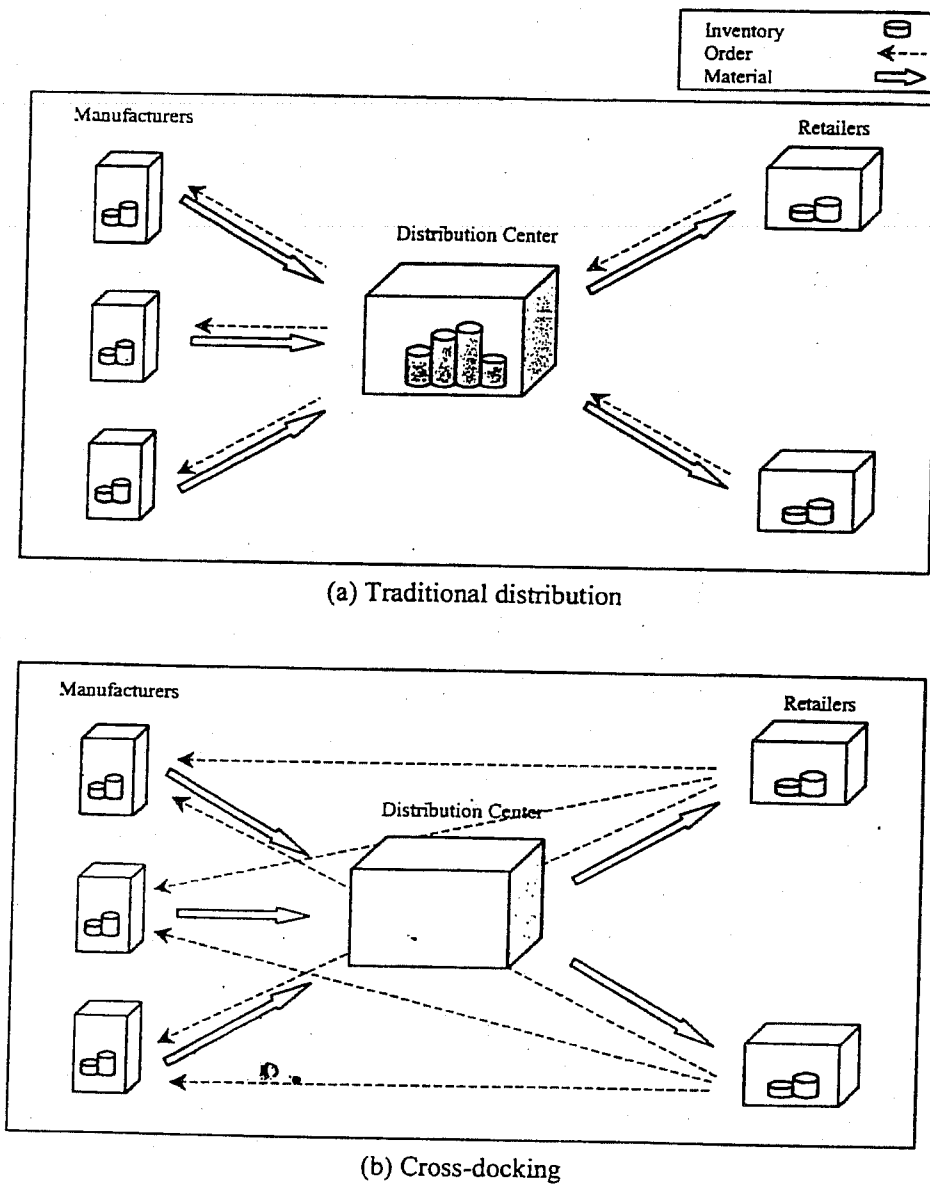


Figure 2. Inventory and flows of orders/materials in distribution systems.

Cross-docking also requires close management cooperation at all levels. Store managers are connected to each other and to corporate headquarters via a video link that allows for frequent information exchanges about products, pricing, sales and promotions. If the cross-docking strategy works so well for Wal-Mart, shouldn't all companies use the same strategy? Clearly, different retail chains use other distribution strategies including the traditional distribution strategy in which inventory is kept at the warehouses (Figure 1a), and direct shipping in which goods are distributed from the suppliers directly to the retail stores.

4.3 Information Systems and Technologies

Information technology (IT) infrastructures today may be quite complex and comprehensive, supporting the firm's communication networks, databases and operating systems. In fact, IT infrastructure capabilities underpin the competitive positioning of business initiatives such as cycle time reduction, implementing redesigned cross functional processes, utilizing cross-selling opportunities and capturing the channel to the customer. (Broadbent and Weill, 1997)[13]. These infrastructures also support the development, management and maintenance of inter-organizational supply chains.

Information requirements determination is indeed one of the most critical issues to be considered when developing inter-organization information systems (IOISs) to support a supply chain. In a study of 12 large IOISs, it was found that no organization had a formal structure in place to manage the IOIS, but all felt that such a mechanism should be in place to ensure the balanced and widespread exchange of information (Levinson, 1994)[14]. It was suggested that a steering committee with representatives from each organization be formed to identify the information to share across IOIS. This group also needs to dictate standards and facilitate implementation of IOIS.

According to Wetherbe and Vitalari (1994)[16], four fundamental mistakes were made when determining information requirements:

- 1- Viewing systems as a functional instead of cross-functional.
- 2- Interviewing managers individually instead of jointly.
- 3- Not allowing for trial and error in the detail design process.
- 4- Asking wrong question during interviewing.

Several information technologies have gained popularity recently due to their ability to facilitate the flow of information across the supply chain. Many of them are under the heading of "e-communication". Electronic commerce (e-commerce) is the term used to describe the wide range of tools and techniques utilized to conduct business in a paperless environment. Electronic commerce, therefore, includes electronic data interchange (EDI), email, electronic funds transfers, electronic publishing, image processing, electronic bulletin boards, shared databases, magnetic/optical data capture (such as bar-coding), the Internet, and web sites. With the rise of the Internet and the ability to transfer information cheaply and effectively worldwide, e-commerce has had an increasingly significant effect on how organizations conduct business. E-commerce is becoming a major focus for organizations and represents a significant opportunity for integrated supply chain

management efforts. Recently, three big auto makers (Ford, GM and Chrysler) have started joining forces to create an electronic commerce company that would connect the rival auto makers to their suppliers through a single Internet portal, and slash their \$240 billion annual purchasing costs. At a news conference, the big three announced that they are giving up on their separate e-commerce strategies to set up the world's "largest" virtual marketplace.

Besides information systems, technology is another critical element of supply chain management. Sophisticated manufacturing, warehousing, and transportation systems enable supply chain managers and participants to integrate their operations. Global positioning systems and satellite communications technology now can track the physical distribution and flow of materials and finished goods across the chain.

4.4 The Role of Benchmarking in SCM:

In developing understanding of existing supply chains and their associated processes, benchmarking analysis has been shown to be an effective means to determine the supply chain's performance relative to those of other organizations. Cook (1997)[19] defines benchmarking as:

"The process of identifying understanding, and adopting outstanding practices from within the same organization or from other businesses to help improve performance. This involves a process of comparing practices and procedures to those of the "best" to identify ways in which an organization can make improvements. Thus new standards and goals can be set, which in turn help better satisfy the customer requirements for quality, cost, product and services."

The steps typically found in the benchmarking process include:

- 1- Identify and understand current processes.
- 2- Form benchmarking team
- 3- Determine what to benchmark.
- 4- Identify benchmarking partners.
- 5- Collect data.
- 6- Analyze data and identify performance gaps.
- 7- Take actions to improve.
- 8- Review results.

Benchmarking provides a means to focus the supply chain management efforts in those areas most in need of improvement. Identification of these high priority areas is also useful prior to undertaking initiatives.

4.5 SCM and Cycle Time Reduction

Increasingly, organizations are realizing that they are competing on the basis of time. Reducing the time required to provide the end customer with products or services is one

of the major forces that is leading organizations to participate in supply chain management initiatives. Adopting and integrating supply chain management approach provides the means to make significant reduction in the cycle time required to move materials between supply chain members and the end customer. Time has also been shown by several authors to be a higher effective area to focus overall improvement efforts within an individual organization. The opportunity for improvement appears to be just as abundant in an inter-organizational supply chain environment.

Jordan (1993)[21] defines the cycle time as follows:

“Cycle time is the time required to complete a particular process, such as the product development process, from start to finish. Cycle time is distinct from timeliness. It should be viewed from customer’s perspective in that it includes time required for testing, validation, modifications and rework. Although not all aspects of cycle time may be under an organization’s control, it is important to know where the time is spent in order to best identify opportunities for cycle-time reduction.”

By focusing on key processes, supply chain member organizations can make significant improvements in cycle time performance that can provide a source of competitive advantage for supply chain. An approach based on process improvement presented by Harrington (1991)[22] is focused on cycle time performance. This approach consists of six steps:

- 1- Establish a cycle time reduction team.
- 2- Develop and understand the given supply chain process and current performance.
- 3- Identify opportunities for cycle time reduction.
- 4- Develop and implement recommendations for cycle time reduction
- 5- Measure process cycle time performance.
- 6- Conduct continuous improvement efforts for process cycle time reduction.

In conducting research with organizations that have successfully completed cycle time reduction efforts in a variety of supply chain management areas, several major success elements have been identified. These elements are:

- top management support,
- a commitment to significant cycle time reduction goals,
- use of a cross-functional team with team members that possess thorough process knowledge,
- application of TQM tools (e.g., process mapping, Pareto analysis, fishbone diagram, etc.),
- training in cycle time reduction approaches,
- establishing, monitoring and reporting formal cycle time performance measures,
- application of information systems and technology, and
- collaboration with supply chain members.

In the next section, we discuss a key element in establishing a successful supply chain reengineering effort.

4.6 Customer Value within SCM

In short definition, customer value is the way the customer perceives the entire company's offerings, including products, services and other intangibles. The customer perception can be divided into several dimensions (Simchi-Levi *et al.*, 2000)[4]. The list of dimensions starts with the following three essential items:

- 1- conformance to requirements,
- 2- product selection, and
- 3- price and brand.

Then, it goes on to more sophisticated types of features that may not always critical:

- 4- value added services, and
- 5- relationship and experiences.

Supply chain management strategy affects customer value. Such considerations must be part of any strategy or plan, not an afterthought. It is important to choose the appropriate supply chain strategy to match customer value with the company's market. Excellence in supply chain management translates in many dimensions from availability and selection to influencing the price at which product can be sold.

Customer access to information about the availability of products and the status of orders and deliveries is becoming an essential capability. This also creates opportunities to learn about customers and their preferences, and to create new modes of interaction. There is no customer value without a close relationship with customers. Today, this is possible only through direct interaction, but also through information and communications technology. By allowing customers to state their preferences and learning from them, a true two way interaction, a firm will develop the means to achieve greater customer value and therefore loyalty. Dell company has inadvertently been able to achieve this because of its direct supply chain model. The company has taken full advantage of close relationships with its customers.

5. STRATEGIC DESIGN OF SCM

The proposed framework of the supply chain management focuses on cross-functional integration of the intra-organizational network with inter-organizational networks. The elements discussed in section 4 above, are reorganized and included in the proposed network. This framework has the following characteristics.

Multi-layer framework. The distinguishing feature of the proposed framework is the way the intra-organizational units are linked with other participants of the supply chain. Most of the existing studies in the literature assume a single layer network connecting all participants of the supply chain. For simplicity, in a single layer network it is assumed that each participant is a single unit organization that is linked to its immediate next tier organization through a single link. Such a network is depicted in Figure 3.

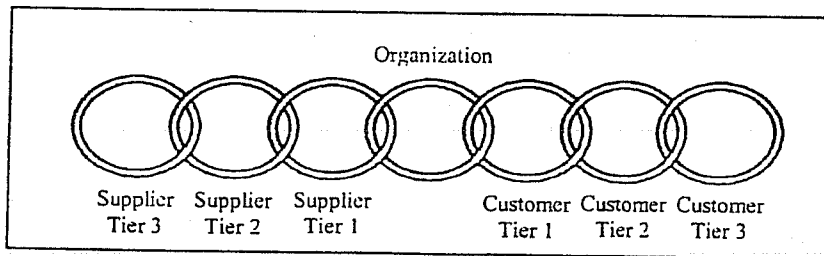


Figure 3. A schematic single layer network

In contrast, the multi-layer network distinguishes the role of intra-organizational units and establishes multi-channel links among subunits of all participants. In the multi-layer network, each organization has a vertical mini-chain that embraces all intra-organizational units. While each unit is linked with some other units within the same organization, it is also linked with similar units in other organizations. The exchange of entities among participants is carried out through three layers: *information* layer, *material* layer, and *funds* layer. Each unit within an organization may take a position in one or more layers, but not necessarily in all. For instance, the manufacturing department, in a supply chain organization, may not participate in the funds layer but it takes a position in both material and information layers. The proposed multi-layer framework is illustrated in Figure 4.

Goal sharing. The central component of the strategic planning is a goal or set goals. In supply chain management before goals can be established, it is necessary to know what is the current performance and what performance could be achieved after improvement or reengineering. In Total Quality Management (TQM), this is referred to as benchmarking, measuring where the company (and/or its competitor) is now and using that as a guideline determining where the company wants to be in the future. However, company must measure performance and set global goals for the supply chain as a whole and not only for itself. A company may set goals for itself for minimizing inventory. But if the inventory levels of its suppliers are required to be excessively high then the company can achieve its own local goals. In such a case, the suppliers' costs of high inventory will eventually pass on the company as higher materials delivery and parts costs. Also, if a company tries to achieve its own quality goals and ignores quality programs of its suppliers, then its quality will be adversely affected. Thus, the supply chain must be designed to minimize inventory and achieve high quality among both suppliers and customers.

Selection of suppliers. The high level of interdependence and goal sharing makes the selection of suppliers (sourcing) and purchasing process (procurement) important strategic decisions for the company. Suppliers must be reliable in terms of quantity, timeliness and quality. An effective means for reducing uncertainty is to strategically apply the principles

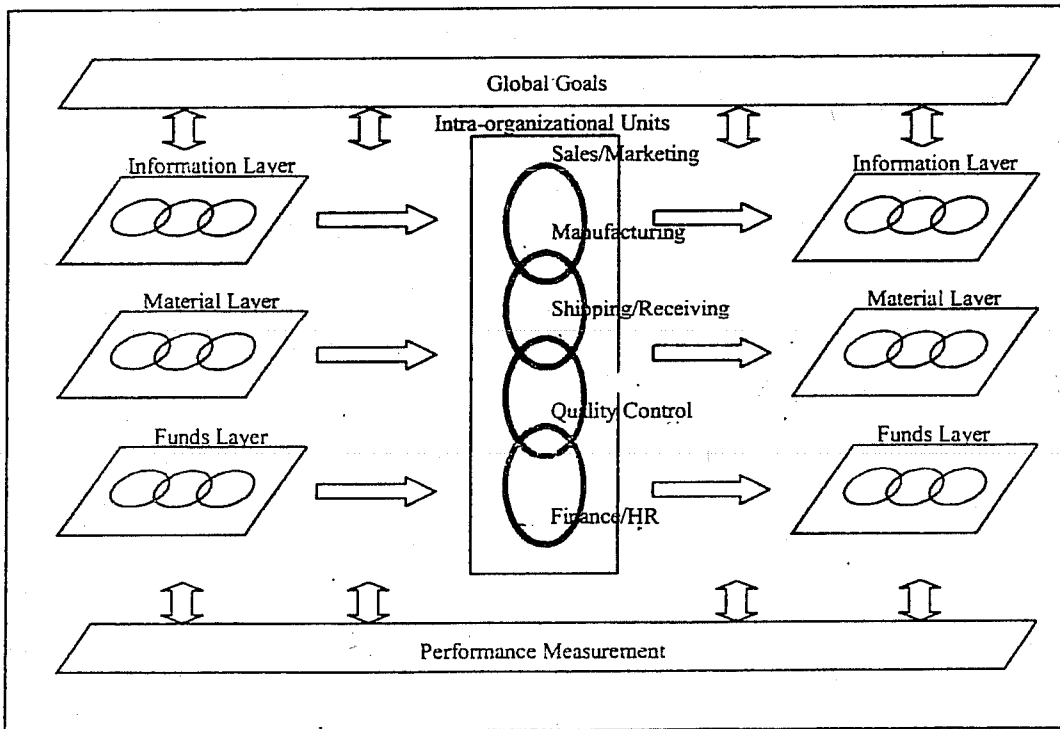


Figure 4. Multi-layer framework of supply chain management

of TQM along with the supply chain. This means that suppliers use TQM to ensure quality products are delivered on time to customers; distribution centers employ TQM to make sure that products are packaged, handled and shipped on time with no damage and processing errors; and shippers deliver products undamaged to the right place on time.

Communication and information technology: Another strategic aspect of supply chain design is communication and information flow. If every entity within the supply chain has access to information at the same time, it enables them all to be closely coordinated and thus reduce uncertainty, which in turn allows them to reduce inventory levels. In a sense, the information technology represents one of the fundamental elements that link the organization of supply chain into a unified and coordinated system. In the current competitive climate, little doubt remains about the importance of information and information technology with respect to the ultimate success, and perhaps even to the survival of any supply chain management initiative. Therefore, the information layer becomes an integral part of the proposed framework that links almost all units of participating organizations.

Performance measurement: Performance measures very often are strictly defined so as to optimize local operations. An enterprise-wide supply chain goes beyond the local department or an individual company. To succeed with implementation of supply chain

management, all participants must agree upon global performance measures. These global measures, that are aligned with the global objectives of the supply chain, may address quality, on-time delivery and customer satisfaction. Among several performance measures available to supply chain managers, customer responsiveness has been recognized as one of the most important objectives of the supply chain. Lee and Billington (1992)[26] argued that customer responsiveness must be the ultimate measure of effectiveness of a supply chain. Such a statement has been supported by experiences of some companies such as Xerox, Philips and General Motors which show that focusing on on-time delivery and customer responsiveness is very important for the integration of a supply chain (Armistead and Mapes, 1993)[27].

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