

**SUPPLY CHAIN INTEGRATION:  
ANALYSIS FRAMEWORK AND REVIEW OF RECENT LITERATURE**

by

**Michelle M. Franciose**

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Signature of Author: \_\_\_\_\_  
Department of Civil and Environmental Engineering  
May 26, 1995

Certified By: \_\_\_\_\_  
Yossi Sheffi  
Professor, Civil and Environmental Engineering  
Director, Center for Transportation Studies  
Thesis Advisor

Accepted By: \_\_\_\_\_  
Joseph M. Sussman  
Chairman, Departmental Committee on Graduate Studies

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OF TECHNOLOGY

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**ABSTRACT**

This thesis provides a general introduction to supply chain integration, including a definition and discussion of the concept development. It then develops a framework which divides supply chain integration issues into four basic categories: 1) strategic, 2) process restructuring, 3) organizational and 4) integration enablers. Using this framework, this thesis reviews the issues in each framework area, based on supply chain literature from 1990 to 1995. The supply chain literature references for this thesis are included in a database which is searchable by standard bibliographic fields as well as by framework category. A listing of this database is available on the World Wide Web under the M.I.T. Center for Transportation Studies' homepage (<http://web.mit.edu/cts/www>).

**Thesis Advisor: Yossi Sheffi**

**Title: Professor, Civil and Environmental Engineering  
Director, Center for Transportation Studies**

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## **1.0 INTRODUCTION**

This chapter provides an introduction to the concept of supply chains and supply chain integration. First, Section 1.1 defines supply chain and compares traditional company functional management to the process-oriented supply chain approach. Next, Section 1.2 discusses the motivation for supply chain integration, describing its potential benefits. Section 1.3 provides a brief history of the development of the supply chain integration concept. Section 1.4 discusses the scope of supply chain integration. Last, Section 1.5 introduces the framework developed for this thesis which divides supply chain integration issues into four basic categories.

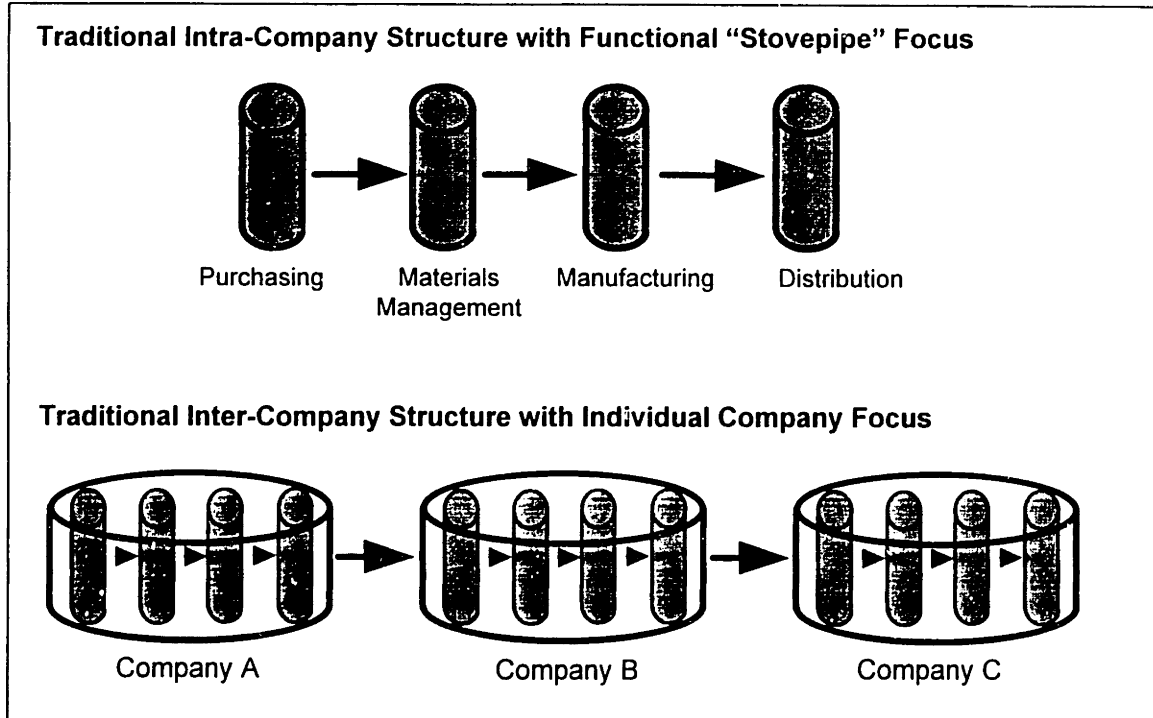
### **1.1 SUPPLY CHAIN DEFINED; CONCEPT INTRODUCTION**

A supply chain is a series of activities/processes which plan, source, produce and deliver products or services to customers. Supply chains vary in length depending on the particular product or service focus, ranging from one contained entirely within a single company to an international multi-company supply chain. The major flows through supply chains are materials, information and cash.

Conceptually, a ‘supply chain approach’ focuses on the process (rather than functions) involved in moving the material, information and cash across traditional functions within companies and across individual companies. The difference between the traditional functional and the process-focused approaches is illustrated by the first two exhibits. Exhibit 1 illustrates the functional ‘stovepipes’ within a traditional company, which in this example include Purchasing, Materials Management, Manufacturing and Distribution. In this traditional company structure, focus is placed primarily on the individual functions and functional excellence. The functions relate to each other through transactional relationships. Products and information are ‘handed-off’ from function to function with clear lines of responsibility and accountability which start and end with these ‘hand-offs’, as opposed to the functions working together to manage a smooth flow of these items. Traditional inter-company relationships are structured in the same manner, with primary emphasis placed on the individual companies. These companies relate to each other through transactional relationships; one company takes information (e.g. ‘an order’) from another, sends it an item, and gets payment in return. Inter-company operations focus on hand-offs between the companies rather than the processes and flows which tie them and the final customer together.

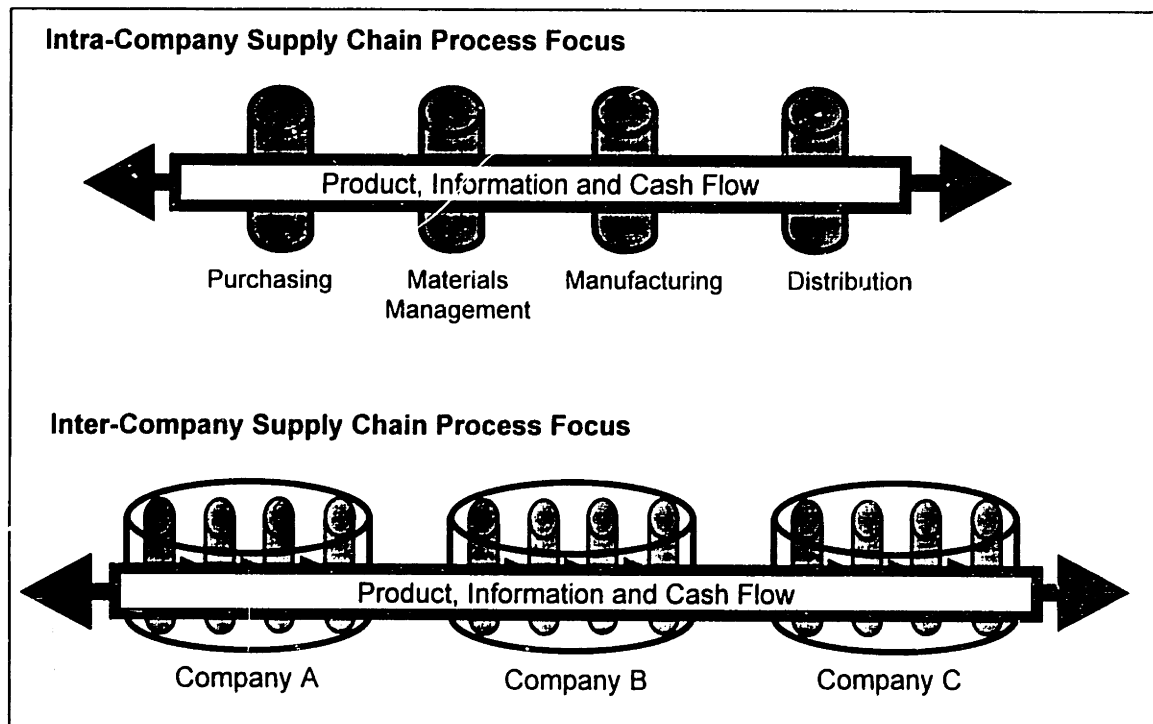
# EXHIBIT 1

## TRADITIONAL INTRA- AND INTER-COMPANY STRUCTURE AND FOCUS



# EXHIBIT 2

## INTRA- AND INTER-COMPANY SUPPLY CHAIN FOCUS



A supply chain approach crosses these traditional boundaries by focusing on the flow of products, information and cash through the various functions and companies. Exhibit 2 illustrates the change from the traditional functional and company focuses to the supply chain process focus. Within each company the supply chain crosses functional boundaries as it focuses on the flow of products, information and cash throughout the company. Traditional transactional relationships are replaced by emphasis on a unified process, and the flows throughout the company are coordinated to maximize benefits for the company as a whole. Similarly, the supply chain process focus in inter-company relationships crosses company boundaries by focusing on the efficient flow of products, information and cash throughout the chain rather than maximizing benefits of the individual companies. Here, transactional relationships are replaced by inter-company ties which work to the benefit of all involved parties.

## **1.2 MOTIVATION FOR SUPPLY CHAIN INTEGRATION**

The motivation behind supply chain integration is the recognition that traditionally “focused” behavior both within and between companies results in sub-optimal performance of the supply chain. Supply chain integration seeks to achieve optimal performance of the supply chain as a whole by finding the appropriate balance of “focused” excellence and process coordination.

Within individual firms, a traditional functional focus leads to efforts to improve the results of particular functional areas rather than optimizing the performance of the firm as a whole. Although the focus on functional excellence has been quite successful in the past, it is now recognized that too much focus on individual pieces of a chain without coordination of these pieces can result in sub-optimal performance of the whole system. (In addition, advances in information and communications technologies now make such coordination possible.) Too often, functional areas operate in relative isolation from each other. Incentive systems support this behavior, since performance measurements focus on individual functional areas to cover “areas of responsibility” and may not consider the performance of the company as a whole. Flows through the supply chain, however, do not stop at functional boundaries and need to be managed for entire company. Inter-functional coordination as well as the sharing of expertise between functions is needed in order to achieve the best results for the entire company. In the traditional environment, efforts to coordinate the company supply chain often turn into “turf wars” as each function attempts to



improve their performance at the price of overall system efficiency. At the company level, the supply chain challenge lies in balancing functional coordination and functional excellence to achieve overall system efficiency.

One example of this sub-optimal behavior is provided by Billington<sup>1</sup>. He describes the situation at Hewlett Packard where local managers often invest to improve their part of the supply chain, but the resulting change brings little or no value to the end customer, or worse, results in lower overall supply chain performance. He cites the example of a manager at a chip fabrication facility who increased capacity (at a considerable expense) to improve responsiveness, yet analysis showed that these chips rarely caused late shipments of the printed circuit assemblies. So even though the chip manager's reliability increased, delivery performance to the supply chain's customers did not improve. Thus, the cost of the total supply chain increased with no improvement in the chain's customer service.

An example of the potential benefits from integrating a company's supply chain is reported by Xerox<sup>2</sup> which began its supply chain re-engineering initiative in 1988. After formulating a total enterprise schema consisting of 14 business processes, three of these were selected for priority redesign, one of which was the Inventory Management and Logistics Process later known as the Integrated Supply Chain. The Xerox case is well-documented and since 1988 \$750 million of inventory reductions and \$200 million of annual operating expense reductions reflect massive efficiency gains on an already well tuned but conventional process, with a simultaneous effectiveness gains being reflected in eight percentage points of Customer Satisfaction Index Improvement. Clearly, significant gains are achievable through supply chain integration at the company level.

Similar to the functional focus within a company, each company within a particular supply chain has traditionally aimed to achieve the best outcome for itself, as opposed to the best outcome for the entire supply chain. Interaction with other companies has been characterized as a zero-sum gain, where one company emerges as the "winner" with reduced costs while the other experiences the opposite result. The problem is that this "turf war" is played at the expense of total system efficiency, increasing system costs each time these battles occur. This means that the final customer/consumer pays more, and the whole channel gets less market share. The supply chain

approach recognizes that, working together, companies can coordinate in such a way as to reduce costs for the entire chain (and the ultimate customer) and create a win-win situation.

Supply chain integration is an action where the entire supply chain, from suppliers through to the ultimate customers/consumers, is integrated and coordinated in order to achieve the “best” outcome for both the whole system and the ultimate customer, focusing on improvements to the flow of material, information and cash throughout the chain<sup>3</sup>. Suppliers, customers, and third-party providers share the information and plans necessary to make the channel more efficient and competitive. The results include a more competitive channel through reduced channel-wide inventory, channel-wide total cost efficiencies, and faster movement of goods and information. In particular, the costly “hand-offs” (i.e., transactions) between organizations can be greatly streamlined. Such process-oriented integration can lead to breakthrough levels of intra-company and inter-company operational efficiency and effectiveness which have previously been unobtainable even in leading-edge companies. Overall, the combined efficiency and effectiveness gains of both intra-company and inter-company supply chain redesign are seen as having the potential to significantly improve total economic productivity.<sup>2</sup>

Byrnes and Shapiro<sup>4</sup> illustrate the potential benefits of inter-company supply chain integration through the example of a leading European industrial supply company. In the example, the company began to focus on their high volume products which were consumed steadily with very little fluctuation by the end users, yet were characterized by erratic order patterns. This forced the company to carry high inventory as well as excess capacity, often interrupting manufacturing schedules to accommodate unexpected peaks. It was discovered that a few large customers were dominating the order patterns and thus causing most of the problem. The solution was to coordinate with the large customers and arrange a standing order agreement. These arrangements did steady the channel product flow, allowing the company to reduce inventories and reorganize the manufacturing process. Operating costs of the channel dropped by over 35%, inventories were cut in half and stockouts dropped dramatically. This example illustrates that integration between two companies was able to reduce costly demand fluctuations, resulting in significant benefits.

This particular example focused on an important benefit of integration, demand management. This is one of the many benefits of integration including concurrency in planning and design, the

reduction of time in the chain and the reduction of operations and transaction costs. Supply chain integration can also provide a firm with important competitive advantages. For example, using the supply chain concept with a strategically chosen set of partners, a firm may be able to reach global markets that would otherwise be inaccessible or impractical due to capital, volume or knowledge requirements.<sup>5</sup> These and other strategic motivations for integration are reviewed in Chapter 2.

Finally, there is an important distinction to be made between the concepts of supply chain integration and re-engineering. Both concepts share a process orientation. The supply chain focus, however, concentrates particularly on the series of activities/processes which plan, source, produce and deliver products to customers, from raw materials to ultimate customers. The extent of the integration focus depends on the supply chain configuration - the chain may be contained entirely within a one company or may encompass several companies. Re-engineering, as defined by Hammer and Champy<sup>6</sup>, is the “fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed”. Re-engineering focuses more specifically on the complete set of activities within a single company. It may address how the company interacts with others, but does not focus on the supply chain (from raw materials to ultimate customer) per se.

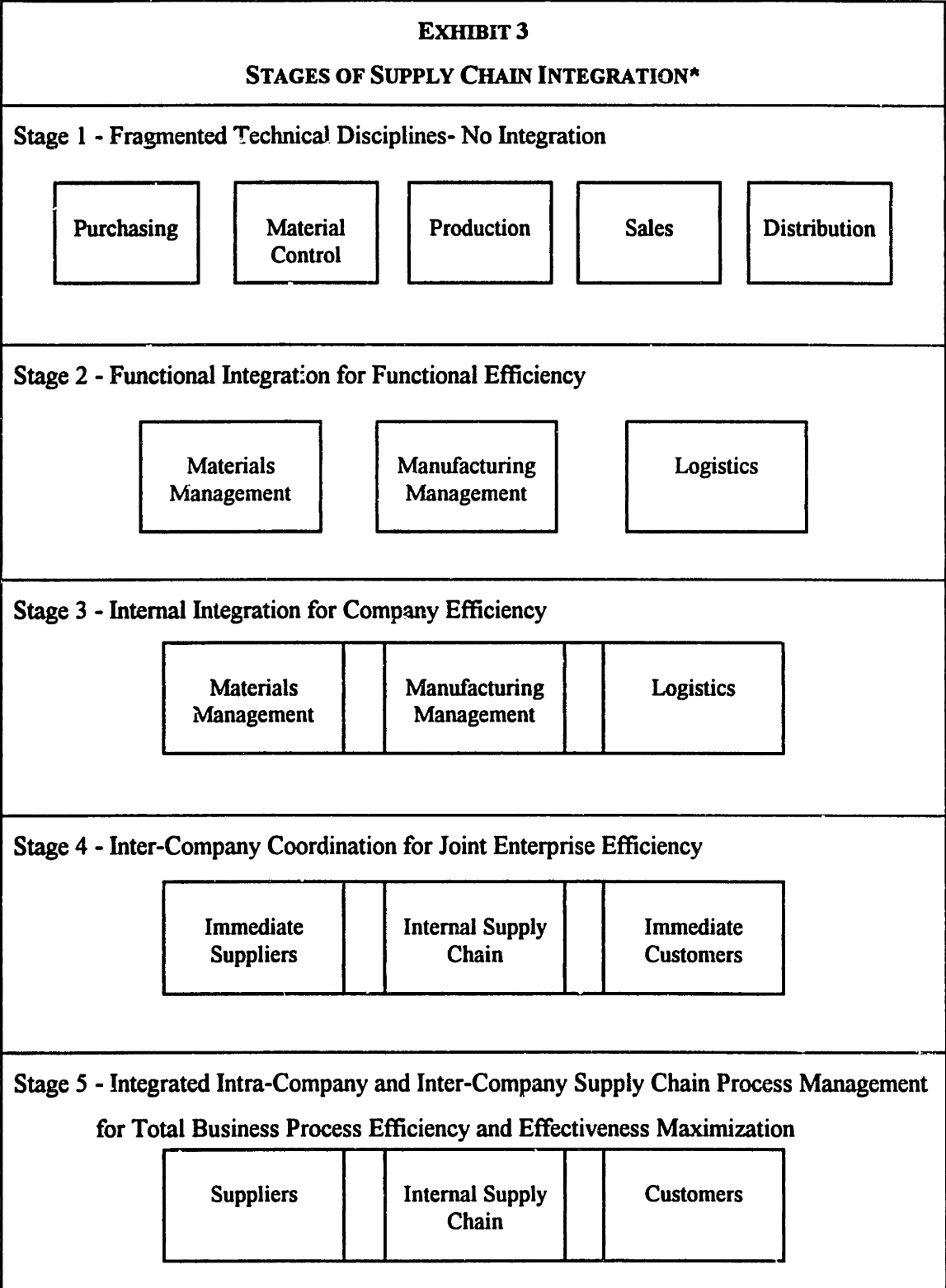
### **1.3 CONCEPT DEVELOPMENT**

Integration, both within and between companies, has been increasing over the past few decades. The Council of Logistics Management bibliography, as a comprehensive history of academic thought in the subject area, and company surveys, present a clear picture of evolving and interacting theory and practice within this area of business activity over an extended period. As described by Hewitt<sup>2</sup>, what emerges is a long series of small steps leading to an increasingly cross-functional and process-oriented view of the supply chain. These small steps towards integration include such well-publicized approaches such as Just-in-Time management, reduction of one's supplier base, partnerships and alliances, supplier integration (JIT II) and concurrent engineering, and illustrate the increasing focus on coordination and integration of business processes. However, progressive coordination of existing functional activities followed by rationalization of these activities have been more common than radical moves to a totally revised process management approach.

Exhibit 3 categorizes five basic stages of supply chain integration. Stage 1 describes the traditional company structure where the responsibility for different activities within the supply chain rests in separate, almost independent, organizations. During the late 1970s and the 1980s, the notion of integrating functional areas within a firm (Stages 2 and 3) became popular among major U.S. corporations as companies began to realize that sub-optimization occurs if each individual function attempts to optimize its own results rather than integrate its goals and activities with other functions to optimize the results of the firm<sup>7</sup>. Concepts of cross-functional teams and concurrent engineering became increasingly popular in literature and practice. At the same time, integration began to extend beyond the individual firm to other firms in the supply chain (Stage 4), using terms such as “partnerships” and “strategic alliances” to describe inter-company integration. Such integration between companies generally focuses on the integration of adjacent companies within a chain with a goal of joint enterprise efficiencies. At this stage a manufacturing company’s supply chain vision may include their material suppliers and their immediate customers and/or carriers in addition to their own company.

There has been much speculation about the next stage of supply chain integration (Stage 5) where the supply chain will encompass all links from the raw material suppliers to the final consumers of the product. This larger supply chain vision encompasses more links of the chain than what is typical today and is focused on total business process efficiency and effectiveness maximization. These benefits are shared by the companies within the chain as well as by the ultimate customer.

The stages of integration identified in the exhibit above provide a conceptual framework of the progression of supply chain integration. In reality however, not all integration efforts follow such a logical progression. For example, it is common for companies to focus on logistics integration with their immediate suppliers/carriers/customers without having fully integrated their own intra-company chain. Discussion of these integration trends are examined in detail in later sections of the thesis.



\*Adapted from Hewitt, "Supply Chain Redesign"<sup>2</sup> and Towill, Naim and Wikner, "Industrial Dynamics Simulation Models in the Design of Supply Chains".<sup>8</sup>

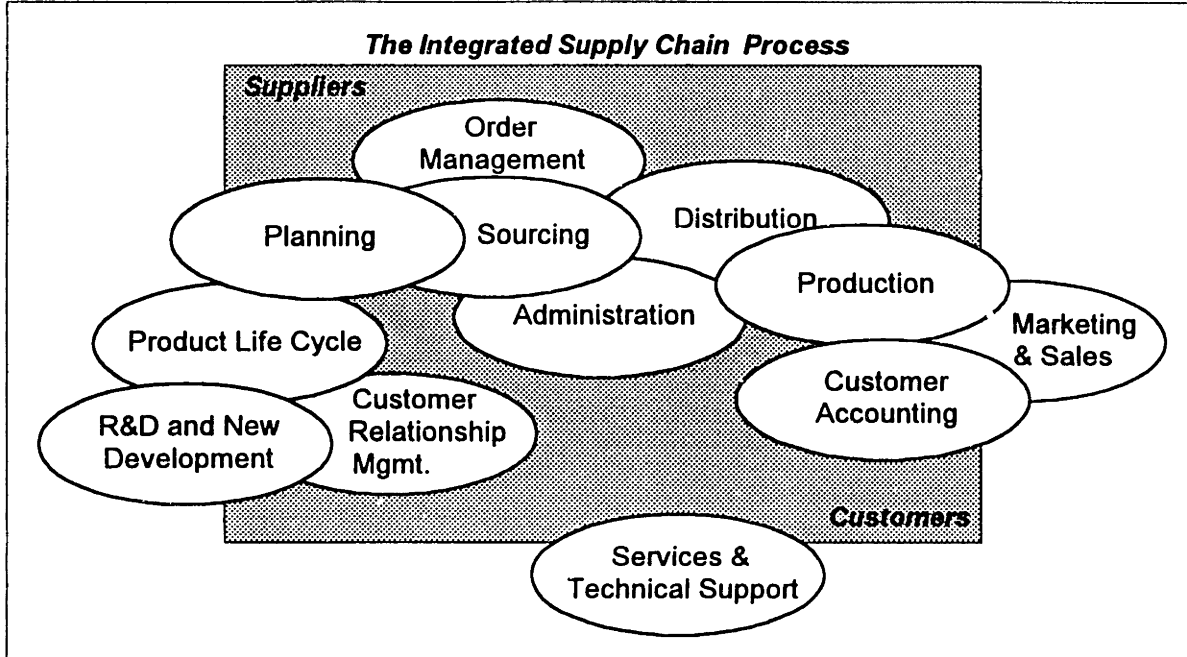
Supply chain integration has been in practice for many decades at various levels under a variety of labels. The specific term “supply chain management” first appears in an article by John Houlihan<sup>9</sup> in 1985. He describes the new approach of supply chain management as differing significantly from classical materials and manufacturing control in four respects. First, it views the supply chain as a single entity rather than relegating fragmented responsibility for various supply chain segments to functional areas. Second, it calls for and depends on strategic decision making where supply is a shared objective of every function on the chain and is of particular significance because of its impact on overall costs and market share. Third, supply chain management provides a different perspective on inventories, which are used as a balancing mechanism as a last, not first resort. Finally, it requires a new approach to systems: integration, not simply interface, is the key.

#### **1.4 SUPPLY CHAIN SCOPE**

Identification of the scope of functions included in a supply chain varies widely and is a subject of some debate. Popular views of supply chain scope identify company functions through which product flows (as shown in Exhibit 3, materials management, manufacturing and logistics) as the primary areas within the supply chain scope. As defined in this thesis, however, supply chain integration focuses not only on product flows but also on the related information and cash flows throughout the chain. Based on this definition one would broaden the scope of primary areas to include company functions affecting flows of information and cash, such as information management and financial management.

Efforts to integrate the supply chain, however, can often involve additional areas within the company, particularly those which influence and enable the product, information and cash flows, or provide necessary support for the company itself. This broader scope can include nearly all company areas not mentioned above including new product development, marketing coordination, customer relations management, legal services as well as human resources. It is the approach to these additional areas that contributes to the variety of supply chain scope definitions. Some companies go as far as to include everything within the company as part of the supply chain. One particular definition of supply chain scope recently reached by a multi-industry consortium consensus is depicted in Exhibit 4.

**EXHIBIT 4  
SUPPLY CHAIN SCOPE**



Source: Multi-Industry Consortium Recommendation, Council of Logistics Management, 1994<sup>10</sup>

It is clear that certain company areas are more central to material, cash and information flow than others. However, in order to achieve the largest benefits possible from supply chain integration, the entire company needs to support integration efforts. Thus, this thesis embraces the very broad supply chain scope encompassing the primary areas as identified above as well as any necessary “supporting” company functions.

## **1.5 Framework for Supply Chain Integration Issues**

Although many companies have used supply chain integration to streamline their operations and connections with others and have generated significant benefits, other companies trying to do many of the same things have encountered serious problems. At first glance supply chain integration can seem deceptively tactical and simple to implement, but in reality the approach requires fundamental changes in the way managers think about how a company does business.<sup>4</sup> The framework developed here attempts to address the basic categories of issues that need to be considered for such fundamental changes and is intended to apply to supply chain integration at all stages, both within and among companies.

The framework in Exhibit 5 divides supply chain integration issues into four basic areas. The first area addresses strategic issues, focusing on strategic goals, choices and considerations driving supply chain integration. The second area addresses process restructuring, including actual changes made to improve the supply chain process. Next organizational issues are addressed, including supply chain organizational forms, changing roles, behavior incentives and monitoring mechanisms both within and between organizations. Last, the framework addresses integration enablers, the necessary supporting infrastructure or tools needed to successfully integrate a supply chain. Thorough supply chain integration efforts should be based on a careful consideration of the first three framework areas, making use of the integration enablers of the fourth.

| <b>EXHIBIT 5</b>                                     |   |
|--|---|
| <b>FRAMEWORK FOR SUPPLY CHAIN INTEGRATION ISSUES</b> |   |
| <i>Framework Area:</i>                               | <i>Addresses:</i>   |
| <b>1. Strategic Issues</b>                           | <p>Strategic drivers of supply chain integration: achieving competitive advantage through focus on:</p> <ul style="list-style-type: none"> <li>• Strategic goals including: increased efficiency, customer focus, reduced costs, reduced time to market, adapting to market changes</li> <li>• Strategic choices: core competency, inter-company ties, supply chain choice</li> </ul> |
| <b>2. Process Restructuring</b>                      | <p>Process restructuring techniques to improve the flow of materials, information and cash:</p> <ul style="list-style-type: none"> <li>• within companies</li> <li>• between two companies and</li> <li>• within a multi-company supply chain</li> </ul>  |
| <b>3. Organizational Issues</b>                      | <p>Organizational issues:</p> <ul style="list-style-type: none"> <li>• Supply chain organizational forms</li> <li>• Changing roles, need for new skill sets, human resource issues</li> <li>• Behavior incentives</li> <li>• Monitoring mechanisms for supply chain relationships</li> </ul>  |
| <b>4. Integration Enablers</b>                       | <p>Supporting systems and tools for supply chain integration:</p> <ul style="list-style-type: none"> <li>• Information systems and technology</li> <li>• Measurement systems and metrics (including costing methods)</li> <li>• Supply chain analysis tools &amp; models</li> </ul>   |



## **CHAPTER SUMMARY**

This chapter provided an introduction to the concept of supply chains and supply chain integration. The process-oriented supply chain approach was compared to traditional company functional management. The motivation for supply chain integration and its potential benefits were examined. A brief history of the development of supply chain integration and a discussion of its scope was provided. Last, the framework developed for this thesis which divides supply chain integration issues into four basic categories was introduced.

The remainder of this thesis is organized into five chapters. Chapters 2 through 5 discuss the four framework areas in detail, one chapter per framework area. Where appropriate, references from supply chain literature are provided and discussed. Chapter 6 provides a summary and conclusions of this thesis.

A broad literature search of supply chain focused articles (and books) published from January 1990 to approximately March 1995 was conducted for this thesis. The articles referenced in this thesis and many others covering a broad range of supply chain topics have been compiled into a database. A description of the database is provided in Appendix 1.

## **2.0 STRATEGIC ISSUES**

This first framework area addresses the wide range of strategic issues which drive supply chain integration. Conceptually, it is helpful to categorize two types of strategic issues driving supply chain integration: strategic goals and strategic choices. Strategic goals of an organization driving integration include the desire for increased efficiency and reduced costs within the organization, improvements in customer service and reductions in time to market, among others described below. All of these goals can be included under the basic goal of increasing or maintaining an organization's competitive advantage. Efforts to achieve these strategic goals often prompt situations where strategic choices must be made. Two basic types of these choices include 1) what are the company's core competencies and 2) how should the company be aligned with others in the broader supply chain.

The following discussion of strategic drivers of integration begins at the individual company level and proceeds along increasing levels of integration, finishing with the multi-company supply chain.

### **2.1 INDIVIDUAL COMPANIES**

Beginning at the company level, there are a variety of strategic drivers of supply chain integration. The common thread is that companies are looking to create a competitive advantage for themselves. Major drivers of supply chain integration at this level include strategic goals of increased company productivity, reduced costs (particularly inventory investments), compressed product launch times, and increased customer focus and service. The ability to adapt to changing business environments (particularly the forces of globalization) is another strong driver of supply chain integration.

The goals of increased productivity and cost reduction can drive several types of integration efforts. Generally these goals prompt a focus on the flow of material and information through the company, requiring increased coordination of the functions. More commonly, specific goals of inventory reduction and increased customer service drive company integration.

Examples of supply chain integration driven by inventory reduction goals are widespread since the inventory reduction is fairly easy to measure. Examples of supply chain integration driven by

goals of increased customer service are also common, although customer service goals are more difficult to quantify than inventory. Frequently, customer service improvements are discussed in terms of time measurements and the reduction of order cycle time. The various process restructuring techniques used to achieve these goals are examined in Chapter 3.

The goal of increased customer focus provides a distinct approach for supply chain integration, and recent literature provides several supply chain examples motivated by customer and channel focus. Channel focus is discussed by Fuller et al.<sup>11</sup> as “Tailored Logistics” using the example of various Coca-Cola product channels and the wide range of service levels and associated costs for each channel. Here the “product” is defined as a bundle of goods wrapped in a distinct set of services. Thus, product channels are differentiated by service levels. Such channel focus provides a way of identifying and efficiently providing for customers or channels while having the ability to specifically identify the costs and needs associated with each segment.

Another example of a strategic channel focus is found at Microsoft Ireland<sup>12</sup>. In this case, company reorganization was based on a channel focus in combination with other lean manufacturing techniques. The company operations were transformed from long production runs, and high inventories with a three week order cycle to “focused factories” within the factory, each responsible for a particular language market. (Details of the actual process restructuring are discussed in Section 3.2.) Using this customer focus, batch sizes were cut dramatically, inventory levels in the plant were cut by 70% and lead times dropped to just one day. Copacino<sup>13</sup> also discusses the identification of account segments as a tool for focusing efforts to provide the competitive advantage of tailored logistics.

Other important strategic drivers of integration within companies arise as companies adapt to changing business environments in order to increase or maintain their competitive advantage. For instance, many European businesses are now scrambling to adapt to strict environmental regulations. These regulations drive have prompted packaging and product re-design to minimize waste as well as the integration of product flow back through the supply chain, also called “reverse logistics”<sup>14</sup>.

In another example, the new pan-European environment is prompting companies to integrate their supply chain to achieve a competitive advantage. Specifically, the abolition of border checks, transport deregulation, product standardization and the European Community/European Free Trade Agreement are combining with other forces to propel Europe slowly towards greater integration.<sup>15</sup> Many companies are now integrating their European operations to adapt to this new environment. For instance, Becton Dickinson<sup>16</sup> re-evaluated their European operations on a larger pan-European scale, and integrated logistics, manufacturing and marketing to adjust to the new environment.

The strategic drivers mentioned thus far focus primarily on improving and integrating existing processes within a company in order to reduce costs, increase efficiency and in general increase a company's competitive advantage. The same basic desire to increase a company's competitive advantage can also prompt a rethinking of the entire organization. Instead of simply integrating a company's existing processes, rationalization of costs and operations as well as strategies for the future can become the focus. Such a focus prompts companies to identify and exploit their core competencies<sup>17</sup>.

The strategic focus on a company's core competencies is a significant driver of supply chain integration. In an increasingly competitive business environment, companies have begun to focus on their area of core competency using outsourcing or alliances to provide the non-core functions. These decisions are not, however, simply based on costs: the benefits of outsourcing need to balance the strategic considerations of technology dependence, the need for close coordination and control of the function as well as the company's overall strategy.

Fine<sup>18</sup> examines strategic technology sourcing policies at the firm level. He describes the dynamics of technology supply chains and how the amplifications of business cycle volatility along the supply chain can influence the ability of a firm, industry or region to maintain a strong technology development infrastructure. Because most firms are not technologically self-sufficient, they must make strategic decisions as to what technologies are core to their business and then focus attention on how to best manage technology sourcing for their non-core technologies.

In addition to technology development, recent supply chain literature identifies a wide range of functions being considered for outsourcing including logistics, information management and pieces of manufacturing operations. In the cases where a decision to outsource is made, alliances and partnerships are often developed to carefully integrate the outsourced function with the remaining core company functions.

## **2.2 INTER-COMPANY INTEGRATION**

This next level of integration focuses on inter-company ties, including integration with customers, suppliers, logistics companies or recently outsourced functions. The basic strategic drivers for this level of integration are similar to those at the individual company level and include goals of time and cost reductions for both companies as well as broader strategic issues of market access and technological dependence. As above, the common thread of these drivers is the desire to secure a competitive advantage for the involved parties.

As one moves towards increasing levels of integration, one is able to address the issues impeding efficient operation of the supply chain which occur outside of an individual company. Addressing such supply chain problems at the inter-company level can provide significant benefits for both parties. Byrnes and Shapiro<sup>4</sup> examine several types of inter-company operating ties, drawing from experiences in more than forty companies. They indicate that benefits were produced early through process simplification and inter-company coordination, releasing substantial capital invested in inventories, and requiring little investment in new assets. An example from their paper examined in Section 1.2 illustrates how the strategic focus on demand management was able to smooth costly demand fluctuations.

The strategic goal of demand management is an important driver of integration at this inter-company level. Looking forward in the supply chain to one's customers provides the opportunity to control demand amplification and product flow within the supply chain. Demand amplification throughout the supply chain results when the organizations within the supply chain are not well coordinated. For example, a change in demand at the retail level of a supply chain can lead to irregular oscillations in demand at the wholesale level and uncontrollably growing oscillations at the manufacturing level. In 1958, Jay Forrester at M.I.T. established the foundation for the "beer game"<sup>19</sup>, a model that illustrates precisely this phenomenon. The "beer game" illustrates that a 10

percent change in demand at the point of sale can result in a 40 percent demand fluctuation upstream in the channel, due to amplification and delays in the passing of information. These amplifications and delays cause tremendous swings in inventory and production. Such amplifications within the supply chain result in inefficient product flow and increased costs. Towill et al.<sup>8</sup> also discuss the nature and detrimental effects of demand amplifications between companies in a supply chain and provide an industrial dynamics simulation to illustrate the problem.

Reduction of demand amplification can be approached in several distinct ways, depending on the particular chain type. Several possible demand management techniques, examined in Section 3.3, include stockless systems, push-in systems, standing order arrangements, early visibility of demand<sup>4</sup> as well as pricing strategies.

Integration with one's suppliers also provides opportunities for strategic benefits. These inter-company ties, often identified as supplier or purchasing alliances, again focus on product and information flow improvements and cost reductions. Specific integration techniques in these relationships are also examined in Section 3.3 and include: production coordination, shared forecasting, capacity purchase, integrated production, strategic postponement and satellite plants<sup>4</sup>.

The benefits of inter-company ties with one's supplier are examined frequently in the literature. Ellram<sup>20</sup> writes extensively on the strategic advantages of purchasing partnerships over the traditional adversarial relationship, categorizing the potential advantages into three areas: management, technology and financial. In the management area potential advantages of purchasing partnerships include a reduced supplier base, increased mutual dependence (lowers risk of losing supply source and creates greater stability through increased supplier loyalty), a reduction in time needed to look for new supplier/gather competitive bids, and joint planning and information sharing based on mutual trust and benefit. Potential technological advantages include participation of partners in product design, which may improve quality and reduce time to market for new products or design changes. Finally, potential financial advantages include the sharing of business risks through joint investment, and joint research and development, the reduction of inventory through information sharing and increased stability of supply prices.

As mentioned above, one benefit from supplier integration is that of joint engineering and design, often greatly reducing time to market for new products. This type of benefit has been documented in several cases including the case of Bose<sup>21</sup> and Chrysler<sup>22,23</sup>. By including suppliers early in the design stage for their latest line of platform vehicles Chrysler cites benefits of dramatically shorter development times, better quality, and lower costs. Details of the Chrysler case are provided in Section 3.3.

The strategic benefits of entering into an alliance/partnership with a logistics company is also a popular topic in supply chain literature. Bowersox<sup>24</sup> describes the growing frequency of logistics alliances, citing benefits of lower distribution and storage costs as well as improvements in customer service. Mitchell et al.<sup>25</sup> explore the underlying factors behind symbiotic logistics alliances, while strategies for negotiating such logistics partnerships are presented by Rinehart<sup>26</sup>. Ellram and Cooper<sup>7</sup> examine the strategic benefits (and risks) of these logistics alliances. For the shipper, the strategic reasons for entering into a logistics alliance include leveraging the positioning of the supply chain and meeting customer service objectives. The carrier's benefits accrue from potentially more stable environments and longer term relationships with fewer shippers, thereby reducing the risks of open market uncertainty. A detailed discussion of these benefits is also provided.

Specific companies undertaking these types of alliances are numerous, reflecting the current popularity of this trend, and include BMW<sup>27</sup>, Lands' End<sup>28</sup>, DuPont<sup>29,30</sup>, and Coors Brewing Co.<sup>31</sup>. In fact, a recent Traffic Management survey<sup>32</sup> indicates that up to 75% of shippers have partnership agreements with carriers. Specific process restructuring techniques employed in these relationships are addressed in Section 3.3.

Cost and financial linkage advantages provided by inter-company ties based on differences existing between firms' cost structures, factor inputs, management skills and buying powers are addressed by Cavinato<sup>33</sup>. He examines inter-firm total cost factors in supply chain relationships, identifying six key areas of opportunity for cooperative analysis. The analysis of inter-firm total cost factors focuses on which firm has the following: 1) lowest labor rate, 2) most effective process, 3) most capital available, 4) lowest cost of capital, 5) highest tax rate and 6) most depreciation and other

tax elements to use. Cavinato suggests that these factors can be used as extensions of current purchasing analyses of suppliers when considering potential partner relationships.

Other inter-company ties focus on the integration of financial processes throughout the supply chain. Holland et al.<sup>34</sup> describe a case involving Motorola, its suppliers and Citibank where the integration of cash management into the supply chain resulted in significant cost reductions as well as improvements in the flow of cash/capital. Details of the restructured cash management process are provided in Section 3.3.

In addition to flow efficiencies and cost savings opportunities through partnerships and alliances, there are other strategic issues driving integration. The trend towards globalization is one such issue. Globalization has expanded the size of the firm's markets, broadened the expertise needed to compete effectively and increased capital requirements. Many companies do not have the global expertise and capital to perform all supply chain activities in such a complex environment. Thus the question has become one of which outside firms to include in the supply chain rather than whether to involve other firms in the supply chain<sup>5</sup>. Muller<sup>35</sup> discusses the advantages of third-party logistics alliances in foreign markets and the growing trend towards third-party logistics particularly in Europe.

## 2.3 MULTI-COMPANY CHAINS

The previous section described integration either forward (with customers) or backward (with suppliers) in the supply chain and the strategic drivers for these efforts. Just as inter-company supply chain integration provided opportunities beyond those of individual companies, integration at a multi-company level broadens the scope even further. As one begins to coordinate both forward and backward through the supply chain, the opportunities for benefits increase as the ability to understand and efficiently manage flows throughout the chain increases. The basic strategies driving integration remain the same, and include goals of increased efficiency, reduced costs, increased customer service and, in general, an increased competitive advantage.

One example of a company managing both directions of their supply chain is Benetton<sup>36</sup>. Based in Italy, Benetton maintains a supply chain composed of in-house expertise and outsourced resources. In all, Benetton links 180 raw material suppliers, 450 manufacturers and 6,000 retailers to deliver



60 million garments a year to customers in 83 companies. Coordination of the entire system is possible through a global EDI network, where EDI allows Benetton's agents in each country to regularly transmit orders to Benetton's head office. Each day Benetton receives information describing the exact behavior of their ultimate customers. This market knowledge is updated every 24 hours and allows Benetton to carefully track and react to demand by manufacturing only those garment styles, colors and sizes required.

Currently, there are few organizations which identify themselves as a unified multi-company supply chain, since most integration is approached on an inter-company level. As more companies move towards supply chain integration, issues of strategic supply chain alignment will become important as we begin to see multi-company supply chains competing against each other. Companies will face strategic choices of which supply chain to align themselves with as supply chains, rather than individual units, become the competitive unit. Those that wait too long to explore the benefits of these alliances may find themselves locked out of potentially profitable markets as the alliances formed by other firms could create entry barriers. As mentioned earlier, globalization will also prompt companies to address strategic issues of market access. In order to increase their ability to serve various global markets, most companies will need to build global supply chains.

Such strategic concerns were the subject of a recent Wall Street Journal Article<sup>37</sup>. The article discussed consolidations and alliances driven in part by a fear among corporate chiefs in some industries that they will be left behind as competitors undertake "marriages" designed to bolster their presence in growing markets. In particular, the article's discussion of the health care industry cites the emergence of great purchasing power among certain customers as drivers of alliances, while pressures of globalization drive alliances in the telecommunications industry. Many more alliances, as opposed to mergers, are predicted as companies with product expertise recognize that their future lies on their ability to distribute their products and expand their services.

## **CHAPTER SUMMARY**

This chapter has reviewed the wide range of strategic issues which drive supply chain integration. The issues were presented in two basic categories, strategic goals and strategic choices. Strategic goals driving integration include the desire for increased efficiency, reduced costs, improvements in

customer service and customer focus, a more efficient flow of products through the chain, reductions in time to market, and the need to adapt to changes in the business environment. The common thread of these integration drivers is the desire to create, maintain or increase competitive advantage. Attempts to achieve these goals often prompt situations where strategic choices must be made. Two basic types of these choices include 1) what are the company's core competencies and 2) how should the company be aligned with others in the broader supply chain.

This chapter addressed these strategic drivers of integration beginning at the individual company level and proceeding along increasing levels of integration, up to the multi-company supply chain. Although the basic strategic drivers remain the same at the various levels of integration, as more of the supply chain is integrated, opportunities to address causes of inefficient chain operation, as well as potential benefits of integration, increase.

This chapter also discussed the impact of globalization. In this global business environment, strategic issues of market access and supply chain competition are becoming increasingly important strategic considerations.

## **3.0 PROCESS RESTRUCTURING**

The second framework area focuses on process restructuring techniques for supply chain integration. Restructuring efforts which aim at increasing the efficiency of material, information and cash flows, both within and between organizations is at the core of supply chain integration. Process restructuring is one of the most easily identifiable supply chain integration outcomes and as such it receives much of the literature focus. The framework discussion below looks at the wide range of process restructuring techniques. The discussion begins with a conceptual introduction to process efficiency, followed by a discussion of process restructuring within supply chains. Again, the discussion proceeds along increasing levels of integration, starting at the individual company level and finishing with the multi-company supply chain.

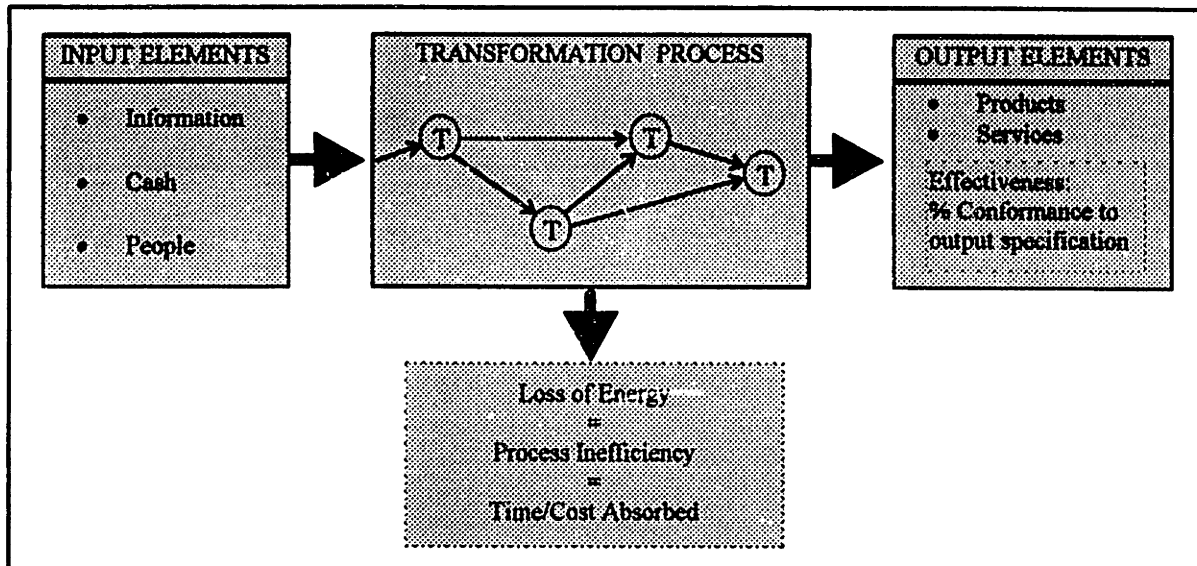
There are several popular business terms which indicate various levels of process restructuring. Process reengineering and process innovation both imply radical changes to or complete reinvention of a process, while process improvement implies lower levels of change. This chapter focuses on a wide range of process restructuring as it applies to supply chain integration, from streamlining to radical process changes. Classification of the various levels of process restructuring is provided in Section 3.5.

### **3.1 PROCESS EFFICIENCY**

After the strategic goals and focus have been determined, actual process restructuring can begin. Hewitt<sup>2</sup> provides a conceptual introduction to process restructuring beginning with a definition of a business process as “a set of logically related tasks performed to achieve a defined business outcome.” He continues to equate the business process to a transformation function which uses energy to convert inputs to outputs. Further extending this concept, he defines process efficiency as the reciprocal of the loss of energy used during the transformation process, expressed in terms of time and/or cost. Similarly, process effectiveness can be defined as the frequency with which process outputs conform to specifications. Exhibit 6 illustrates this concept. Process efficiency and effectiveness are the basic motivation behind process restructuring.

The scope of process restructuring is wide and encompasses changes made within and across specific company functions as well as those which encompass an entire multi-company supply chain.

EXHIBIT 6  
A BUSINESS PROCESS MODEL



Source: Hewitt, "Supply Chain Redesign."<sup>2</sup>

### 3.2 INDIVIDUAL COMPANIES

Addressing supply chain process restructuring within company functions is tricky since there are many process improvements which are not part of supply chain integration. Process improvements within narrowly defined company functions do not have a broad enough scope to be considered supply chain improvements. However, as companies have begun to combine fragmented technical disciplines into broader functional areas (moving from Stage 1 to Stage 2 in Exhibit 3), certain process restructuring efforts at the broader functional level can be characterized as supply chain integration. The following discussion looks at process restructuring as companies move from these fragmented disciplines towards broader company functions (Stage 2 in Exhibit 3) as well as process restructuring which spans these broad functional boundaries (Stage 3 in Exhibit 3).

There are many examples of process restructuring within broad functional areas. The logistics function in particular is the focus of many of these efforts. Again, process restructuring within the

broadly defined logistics function can be considered supply chain integration since logistics connects many functions within the company including materials management and manufacturing. On a general level, Ballou<sup>38</sup> identifies three key decision areas for logistics system restructuring as 1) inventory policy, 2) facility location and 3) transport selection/routing and discusses various approaches and the system implications for each.

Specific examples of company successes in restructuring their logistics systems are plentiful. Many companies have restructured their logistics systems focusing on the nature and location of product flow throughout the entire company, and particularly on warehousing locations and improvements. These examples include Stride Rite<sup>39</sup>, Nintendo<sup>40</sup>, Timberland<sup>41</sup>, Texas Instruments<sup>42</sup> and Becton-Dickinson<sup>16,43</sup>. Most of these examples also involve the establishment of an efficient logistics information system, which enables logistics to track product from the factory to its final destination. Such focus on the product flow throughout the chain by the logistics function can be categorized as supply chain integration, since the effort spans many functions within the company and the information goes to all channel players. As observed by Hewitt<sup>2</sup>, the results of integrated logistics can be impressive: even within high performance companies, massive productivity gains in logistics are being recorded when the supply chain is specifically redesigned to be operated in a holistic manner as a total “process” or “system”.

Materials and inventory management is another area which has seen significant process restructuring. As mentioned in Section 2.1, Fuller et al.<sup>11</sup> discuss new approaches to identifying inventory and logistics costs for various distribution channels within Coca-Cola. Copacino<sup>44</sup> discusses three “radically different operating principles” changing the role of inventory and warehousing within the supply chain. The first, flexible manufacturing, allows a manufacturer to offer daily production of most items, contract manufacturing that provides flexible capacity and the use of “mini-facilities” for both fabrication and assembly located close to the market. The second, flow-through distribution, relies on cross-docking capabilities and decreases the number of stocking locations. The third, shifting of value-added activities to the distribution center, uses the concept of (distribution) postponement where distribution centers are expanding into activities traditionally performed in the plant.

As process restructuring encompasses more functions within the company, the number of functional barriers and turf wars to overcome increases. Even with the proper incentives and education, traditionally focused behaviors are difficult to change. While these broader integration efforts present a larger challenge, the potential benefits of integration at this level also increase.

One example of company-wide process restructuring is documented by Digital Equipment Company (DEC). Arntzen et al.<sup>45</sup> describe the Global Supply Chain Model DEC uses to evaluate global supply chain alternatives and determine worldwide manufacturing and distribution strategy. According to the article, supply chain restructuring assisted by the recommendations of this model have saved over \$100 million for DEC. A discussion of this model is provided in Section 5.3.

Restructuring of the product design process can also contribute to efficient supply chain operation. Product designs should be evaluated not only on functionality and performance but also on the resulting costs and service implications throughout the product's supply chain. One technique which focuses on eliminating functional barriers between engineering and manufacturing is called "design for manufacturability", and relies heavily on improved communication and cross-functional teaming. For example, Xerox's development and manufacturing division has developed a prototype expert system to facilitate design for manufacturability that, when fully developed, will help engineers evaluate alternative designs using internal Xerox information about what components already exist or could be easily sourced<sup>46</sup>. The system discourages components that are totally new or that require extensive additional work.

Although product designs that enable fast and precise manufacturing are critical for cost and quality effectiveness, Lee and Billington<sup>47</sup> assert that often the implications for supply chain inventory are ignored or poorly understood. The result may be that anticipated savings may be lost to increased distribution and inventory costs. They continue, citing an example of how these costs are being considered by a U.S. computer peripherals manufacturer making printers for worldwide distribution. The printers have a few country specific components, and if the printers are assembled with these components in place, changes in anticipated country demand can result in high inventory stockpiles for some and backlogs for others. The manufacturer is now redesigning the assembly process so that the distribution centers can add the country-specific components. The expected results include tremendous savings in inventory investment and flexibility for the supply

chain. Such flexibility is particularly important for new products, whose demand can be highly variable.

As mentioned briefly in Section 2.1, several companies have restructured their processes around specific customer channels. Microsoft Ireland<sup>12</sup> provides one example of the company-wide channel restructuring, where company operations were transformed from long production runs, and high inventories with a three week order cycle to “focused factories” within the factory responsible for a particular language market. Each focused factory is charged with dealing with the specific geographic markets and has its own manufacturing cells, production equipment and work teams. In addition, the possibility of extra paperwork and administration was eliminated by extending the concept of focus to suppliers. For example, printing suppliers now typically deliver to only one focused factory. Results of this customer focused restructuring (in addition to lean manufacturing techniques) included a 70% drop in plant inventory, and reduction of lead times to just one day.

Copacino<sup>48</sup> describes “fluid production and distribution” as the ultimate form of supply chain integration providing companies with unmatched competitive capabilities. This concept calls for a fully integrated company, with specific components of inventory visibility, management of product flow, flexible distribution, JIT manufacturing, inter-functional cohesion and advanced information systems. He cites Sony Corp. as an example of a company making considerable progress in developing a fluid production and distribution operation, with its sell-one-make-one (SOMO) system.

At a more abstract level, Malone et al.<sup>49</sup> describe the making of a process handbook able to help redesign processes by generating and analyzing possible restructured process alternatives. A key element of this work is their approach to representing processes at various levels of abstraction, using ideas concepts of inheritance and coordination theory about managing dependencies.

As the scope broadens to include process restructuring at the inter-company level, one might assume from the stages of integration identified in Exhibit 3 that the companies involved in integration at this level have already achieved internal supply chain integration. In reality, however, it is not uncommon that integration between two companies is established without each having achieved a high level of intra-company integration. Those companies that are able achieve

integration of their own piece of the chain will be able to reap greater benefits from inter-company operating ties.

### 3.3 INTER-COMPANY INTEGRATION

Many inter-company process restructuring efforts focus on the function which ties the two together, logistics, with goals of reducing time and inventory costs within the supply chain. Cooke<sup>50</sup> provides a general discussion of the variety of logistics process restructuring techniques including Just-In-Time, Quick Response, and Efficient Consumer Response. Cross-docking is also recognized as a technique to streamline the distribution process. These and other process restructuring techniques are described briefly below.

The Just-in-Time (JIT) technique in particular has been the focus of a large number of recent articles. JIT reduces inventory by substituting buyer-supplier logistical coordination. Giust<sup>51</sup> explores the development of the JIT concept and describes material handling trends in a JIT environment. Specific examples of JIT implementation are numerous. For example, the Saturn Plant<sup>52</sup> in Georgetown, Kentucky maintains almost no inventory of components. Instead, a central computer directs trucks to deliver pre-inspected and presorted parts at precise times to the factory's 56 receiving docks, 21 hours a day, six days a week. Especially striking about this JIT system is that most of Saturn's 339 suppliers aren't located anywhere near the plant. They are in 39 states and an average of 550 miles away from the factory. The logistics supply portion of this JIT system is coordinated by Ryder System, who maintains a "command post" two miles from the plant where trailers are received and delivered by specially designed shuttle tractors to the plant. Implementation of the JIT technique varies widely. Examples of JIT implementation which illustrate the wide variety include how McDonnell Douglas ships JIT to from California to China<sup>53</sup> and how Simmons Co. coordinates production and delivery of mattresses JIT to their customers<sup>54</sup>.

A great deal of literature also focuses on the weaknesses of JIT implementation in companies. Hassan et al.<sup>55</sup> discuss the holistic approach of the Japanese which allows them to gain larger productivity using JIT than U.S. firms. The difficulties of handling both JIT and non-JIT channels in a single company are discussed by Ferrin<sup>56</sup>. Keys<sup>57</sup> puts forth "five critical barriers to successful JIT implementation", and Delbridge and Oliver<sup>58</sup> identify the weaknesses of JIT if the rest of the supply chain is not synchronized with JIT deliveries. Zipkin<sup>59</sup> also explores the



difficulties of JIT providing a contrast between the “pragmatic” and “romantic” JIT. The difficulties of trying to balance JIT and global sourcing strategies are described by Fawcett and Birou<sup>60</sup>.

As mentioned in the previous chapter, looking forward in the supply chain to your customers provides opportunities to control demand amplification and product flow within the supply chain. Byrnes and Shapiro<sup>4</sup> discuss several possible demand management approaches including stockless systems, push-in systems, standing order arrangements as well as early visibility of demand. Standing order arrangements, as described in the example in Section 1.2, are suitable only for steady channels and require close monitoring for changes in underlying consumption patterns. In stockless systems a company maintains and replenishes its customers’ inventories with a high level of service, often performing internal distribution within the customers’ facilities. The approach is best suited for channels characterized by steady demand. Generally, the customer’s materials can be eliminated or significantly reduced in size. Stockless is usually an exclusive arrangement, with one vendor serving a customer or customer department’s needs, and can lead to significant sales increases for the vendor.

Baxter Healthcare, a major medical equipment and health care supplier, pioneered the stockless concept, distributing a wide variety of hospital supplies (including those purchased from its competitors) directly to hospital wards. Baxter’s customers are connected to Baxter through a direct electronic customer channel<sup>61</sup>. The system contains a platform, a single interface, for buyers to reach their many suppliers. Benefits to Baxter include a major new revenue stream as well as a smoothing of demand amplifications. Benefits to the hospital include the elimination or drastic reduction of its centralized, in-house inventories, its stockroom space and its materials-related labor costs. The attendant savings amount to a significant portion of a hospital’s annual operating budget.

In push-in systems, the supplier receives information on customer sales and inventory levels and is responsible for pushing-in stock. Generally the supplier has authority to schedule deliveries of its product without receiving an order. Push-in techniques are particularly suitable for fluctuating channels where product consumption is variable and unpredictable, because it provides rapid, unimpeded product flow. Push-in systems are increasingly common in the grocery, apparel and

consumer goods industries<sup>4</sup>. One well-known example is the push-in system used by Proctor & Gamble (P&G) with Wal-Mart. The technique was first tried with P&G's diapers, one of Wal-Mart's high turn items. Under the push-in arrangement, when a shipment of diapers leaves Wal-Mart's warehouse, notice is sent to P&G. No order is transmitted, no delivery schedule is requested; P&G has a performance contract to make sure that the pipeline is full. This partnership is meant not to merely reduce inventories in the Wal-Mart's warehouse. Its intent is full-scale coordination: paperwork is significantly reduced on both sides (orders, quotes, complicated billing and so on), production schedules are more responsive and the two companies can trim their operations.<sup>61</sup>

Continuous Replenishment and Quick Response are variations of the push-in technique. Continuous Replenishment (CR) shifts the burden for inventory management and replenishment at the customer's warehouse back to the manufacturer. This approach generally involves higher transportation costs because the manufacturer must often ship more frequently. Benefits to the manufacturer include greater visibility of actual product usage. In the retail industry Wal-Mart has established the practice of CR, including supplier shelf management and simplified communications that have significantly influenced its suppliers including General Electric and Proctor & Gamble<sup>46</sup>, as mentioned above. Quick Replenishment (QR) is a somewhat similar technique where the customer retains responsibility for monitoring inventory levels and for replenishment decisions. Heard<sup>62</sup> discusses the need for QR techniques to be aligned with production and other areas throughout the supply chain. Cooke<sup>63</sup> discusses how KMart, Kodak and Lee have moved beyond QR and CR and are attempting to strike a balance between the costly small shipments of these methods and greater combined cost efficiencies for both companies.

Early visibility of demand refers to the gathering of information on product end-consumption and the use of this information to predict sales, schedule manufacturing and determine appropriate stock levels. This technique is particularly applicable in "ramp-up" channels, where new products move into and through the supply chain. One method to acquire and use early visibility of demand in the apparel industry is "accurate response". Fisher et al.<sup>64</sup> describe this particular technique as a new approach to the entire forecasting, planning and production process. Accurate response provides a way to both improve forecasts and redesign planning processes to minimize the impact of inaccurate forecasts. It entails figuring out what forecasters can and cannot predict well, and

then making the supply chain fast and flexible so that managers can postpone decisions about their most unpredictable items until they have some market signals, such as early season sales results, to help correctly match supply with demand. For example, through the use of accurate response Sport Obermeyer (a supplier in the fashion-ski-apparel business) restructured their production from traditional batch methods based on forecasts to a method of risk-based production sequencing which incorporates more of the demand uncertainty of highly volatile fashion items. The results were significant - Sport Obermeyer slashed its mismatch costs in half. Reducing mismatch costs also gives companies the option of taking a further action: lowering prices - since currently suppliers, distributors and retailers alike build mismatch costs into their prices, making customers pay more to cover the cost of inaccurate forecasts.

Another interesting approach to demand management is found in the example of Proctor & Gamble's pricing strategy. Doyle<sup>65</sup> describes the impact of the company's new pricing strategy which offers everyday low prices and eliminates dealer incentives. The elimination of dealer incentives greatly reduced unnecessary demand fluctuations previously experienced within the chain. Benefits of this new strategy include the ability to run a JIT supply schedule, the elimination of warehouses as well as the ability to deliver fresher products to their customers.

Integration with one's suppliers, looking back in the supply chain, also provides opportunities for process restructuring. In these types of supplier or purchasing alliances, the focus remains on improving product and information flows and reducing costs. As described by Byrnes and Shapiro<sup>4</sup>, specific techniques to achieve these goals include: shared forecasting, capacity purchase, integrated production, strategic postponement, satellite plants and multi-tiered purchasing.

In a shared forecasting arrangement, a company provides both a forecast of its future needs and a commitment to "take or pay", allowing its supplier to give that customer priority scheduling and committed capacity<sup>4</sup>. Gillette and Ford are cited as examples of companies which utilize shared forecasting arrangements. Gillette typically freezes its production schedule with key suppliers for a fixed period (e.g., 4 weeks) and forecasts its requirement subject to scheduling uncertainty for an additional fixed period (e.g., 12 weeks), but commits to take the entire period's production (e.g., 16 weeks). Ford gives Goodyear a 20 day forecast and 8 days' firm commitment for its heavy truck tires.

In capacity purchase, a customer obtains long-term production commitments from a supplier<sup>4</sup>. This technique enhances channel coordination because it enables a customer to assume the supplier's risk of capacity utilization in return for supply continuity and price stability. It is particularly useful in industries where capacity is scarce. For example, Hewlett Packard purchases semiconductor manufacturing capacity from some of its vendors.

In integrated production, a supplier's production is situated inside a customer's factory and managed by the supplier. Integrated production allows operational specialization while maintaining close coordination, reducing inventory costs and lowering the operating costs of both companies through the elimination of duplicate functions. For instance, PPG manages painting operations within certain General Motors factories.

Strategic postponement refers to the practice of stocking a product in a generic, uncompleted, form and delaying customization until the last minute so that the channel can respond quickly to market fluctuations. The postponement technique responds well to changes in product mix (rather than in overall volume). Two types of postponement are examined in the literature - supplier postponement and distribution postponement (addressed later in the section). In supplier postponement a company seeks to alter a supplier's production process so the supplier holds most goods in partially manufactured form which can be finished quickly to order.

One example of supplier postponement is found in the case of Benetton<sup>36</sup> and their suppliers. Traditionally, the manufacture of clothing starts with the dyeing of the yarn followed by the knitting of the garment. The problem with this sequence is that the knitting process is slow. Thus, in order to meet customer service expectations, high inventories of finished garments are required. Benetton challenged this traditional sequencing using the postponement technique. Their solution was to have their suppliers manufacture the garments from bleached yarn and delay dyeing until information on the preferred colors becomes available through EDI connections from their stores.

Another method to integrate suppliers is the establishment of satellite plants near a customer's factory. Often customers offer semi-exclusive contracts of guaranteed utilization in return for the supplier's commitment to build and operate a facility nearby. The practice of locating suppliers in

close proximity to automobile suppliers, common in Japan, has been replicated by Toyota in the U.S. When Toyota set up an assembly plant in Georgetown, Kentucky, roughly 90 suppliers followed the company to Kentucky<sup>66</sup>.

One example of a U.S. company requesting supplier satellite plants is Compaq<sup>52</sup>. In an effort to restructure their manufacturing, Compaq has recently cleared most of its parts inventories off the factory floor. Many pieces are now stored 12 miles away in a warehouse leased by 35 major Compaq suppliers. In addition, Houston-based Compaq convinced seven sheet metal suppliers to relocate to Texas. All these suppliers now truck the parts to Compaq exactly when and where the computer maker needs them. The supplier's cooperation was secured not by promising them an uninterrupted flow of business but by keeping them better informed about Compaq's production plans, thereby helping their suppliers to keep their own parts inventories under control.

The technique of multi-tiered purchasing refers to a company's involvement in raw material purchases for its suppliers to ensure low materials prices and supply continuity, where a company will directly purchase or commit to pay for a portion of its suppliers' raw materials. Several companies studied by Byrnes and Shapiro substantially reduced their suppliers' raw material costs, while ensuring availability in times of shortage. For example, Dunkin' Donuts purchases raw materials for its suppliers through a franchisee buying cooperative to facilitate product flow and lock in prices. In another example, Motorola-Codex has included suppliers on its raw materials plastics contracts in certain cases where the suppliers did not have sufficient volume to secure adequately responsive contract terms.

Supply chain process restructuring at the manufacturer/supplier interface not only involves better coordination for the flow of products but can include concurrent engineering and design, which often reduces time to market for new products. Kamath and Liker<sup>67</sup> discuss the Japanese practice of involving suppliers in product development and assert that among the big three U.S. auto makers, Chrysler most closely resembles Japanese efforts to involve suppliers early in the design process. Chrysler's automobile design process for their latest line of platform vehicles incorporates early and extensive involvement of their chosen suppliers. Selected Chrysler suppliers worked "elbow to elbow" with the designers and engineers on the platform team and in some cases played a significant role in solving some of the engineering challenges of the new cars. For

example, Chrysler's "cab forward" design meant the windshield would be one of the largest ever made for a passenger car. The windshield supplier, Guardian Industries, was called in during the clay model design stage and met daily with the Chrysler team to work out the design<sup>23</sup>. Overall, Chrysler compressed development time by 25% or more and produced world-class vehicles incorporating state-of-the-art components at considerably lower cost than its competitors did<sup>67</sup>.

Another technique for supplier management and integration is known as JIT II. This approach, which incorporates supplier representatives ("in-plants") onto the site of the manufacturer for coordination as well as concurrent engineering, was pioneered by Bose<sup>21</sup> and has subsequently been adopted by AT&T<sup>68</sup> and many other corporations. In practice, the supplier in-plant sits in the purchasing office, replacing the buyer and salesman. The in-plant is empowered to use purchase orders to place orders on himself, and is also empowered to practice concurrent engineering attending design engineering meetings involving his company product area. Host companies such as AT&T cite millions in savings from reduced inventory costs and distribution staffing. The selected suppliers also enjoy an enormous advantage over any other competing vendor who is standing outside, looking in. In some cases, adjustments are being made to the original JIT II technique. For instance, AT&T did not want to rely on one supplier for software and invited two to their JIT II program to increase the likelihood of more competitive pricing and service. Also, for their computer hardware, AT&T secured a commitment for first-class back-up support and training from the vendors who would be selling those products. Even with these adjustments to the technique, AT&T has been able to reduce the number of U.S. warehouses it maintained for such supplies from five to two, and it no longer carries the cost for that inventory.

Restructuring the shipper-carrier relationship can also provide significant benefits. Partnerships or alliances between shippers and carriers reduce the complexity of the traditional adversarial shipper-carrier relationship by eliminating steps from the logistics process which reduce costs and ultimately provide better service and improved quality. Examples of these new logistics partnerships are numerous and include Coors Brewing Company and Burlington Northern Railroad<sup>31</sup>, Lands' End and United Parcel Service<sup>28</sup>, Becton Dickinson and Preston Trucking<sup>69</sup>, and PPG Industries and Schneider Trucking<sup>70</sup>. Key to the benefits of these alliances is the reduction of the carrier base for the shipper and the reduction of the customer base for the carrier, improving management and control for both. Close coordination also reduces paperwork and related

administration tasks between the two partners. In some cases, carriers place representatives on-site with their partners, including Burlington Northern (at Coors) and Preston Trucking (at Becton Dickinson). This coordination brings benefits similar to those described in the JIT II technique above, and facilitates the maintenance and monitoring of the alliance relationship. Horsley<sup>71</sup> reviews similar process changes taking place in the British transport industry.

Further process restructuring is occurring as carriers have begun to provide inventory management and warehousing services as well as transportation. One example is the Saturn/Ryder partnership mentioned earlier in this section. Another is the National Semiconductor/Federal Express<sup>52</sup> example. National Semiconductor, the world's 13th-largest chipmaker, operated a complex logistics system with six warehouses around the globe. They drastically simplified their distribution system and hired Federal Express to take over both transportation and warehousing. Federal Express now runs all of National's storage, sorting and shipping activities out of a distribution center in Singapore. As a result, National cut its standard delivery time 47%, reduced distribution costs by 2.5% and increased sales 34% in two years.

Another technique for logistics process restructuring is "distribution postponement". In distribution postponement, a company's distributors or carriers perform the final stages of assembly or customization, often done in conjunction with installation. For example, Xerox uses distribution postponement for its final stages of assembly including accessory installation both in its sales subsidiaries and with Ryder System, its transportation/installation contractor<sup>4</sup>. Another example of distribution postponement by a U.S. computer peripherals manufacturer was described earlier as part of a product design discussion in Section 3.2.

Process restructuring which focuses on the flow of cash through the supply chain is also gaining recognition. Holland et al.<sup>34</sup> describe a restructured cash management process between several companies. In this example Motorola, with a goal of improving their cash management, effectively restructured their cash flow process with many of their suppliers and Citibank in order to achieve seamless collection and disbursement of cash payments between the organizations. The process was restructured using a currency netting model to reduce cash flows and foreign currency payments between Motorola and their suppliers. The approach also required that Motorola and Citibank effectively "mesh" parts of their organizations and information systems together to

provide a mechanism for the seamless collection and disbursement of these cash payments. As mentioned in Section 2.2, this improved process resulted in significant (transaction) cost reductions as well as improvements in the flow of cash.

### **3.4 MULTI-COMPANY CHAINS**

Examples of process restructuring over multiple companies are not as common, since most integration currently occurs on an inter-company basis. One example of a process restructuring technique encompassing multiple companies introduced earlier in Section 3.3 is accurate response<sup>64</sup>. The earlier example describes steps that Sport Obermeyer took to restructure their production from traditional batch methods to a method of risk based production sequencing which using accurate response techniques. Although Sport Obermeyer, its customers and suppliers may not be formally identified as a multi-company chain, the process restructuring did encompass multiple companies, a large portion of the supply chain from the fabric manufacturers to the retailers.

Other companies also taking a broader perspective on supply chain restructuring include Levi Strauss. Knill<sup>72</sup> describes the company's dissatisfaction with their current supply chain and their efforts to work toward higher degrees of process integration from suppliers to final customers, with the ultimate focus on increased customer service. These efforts include partnering with suppliers to speed up the delivery of fabric and sundries, team manufacturing for increased production flexibility, and the "regionalization" of distribution networks closer to customers. In addition, Levi's expects a shorter product development cycle by working with retail partners to more accurately capture consumer demands.

### **3.5 CLASSIFICATION OF PROCESS RESTRUCTURING EFFORTS**

Stepping back from review of the specific restructuring techniques, one can generally position supply chain restructuring improvements along a continuum between the extremes of "streamlining" improvements and "revolutionary" improvements. Streamlining improvements describe process improvements made by tuning the existing process, with no major changes to the basic process itself. Moving towards the middle of the continuum, process restructuring can be



described as “evolutionary”, where substantial improvements to processes are made without a fundamental change in the basic process structure. Evolutionary improvements often involve implementation of new technologies and coordination techniques with neighboring organizations within the supply chain. In terms of Exhibit 3, evolutionary process restructuring corresponds roughly to integration stages 2 through 4. At the far end of the continuum, process restructuring is described as revolutionary, where extremely large improvements are made. Often the process has undergone a complete transformation, almost unrecognizable from its earlier state. Other popular business terms which also imply complete re-invention of a process include process re-engineering and process innovation. Although benefits can be achieved by process restructuring efforts at all levels, revolutionary process improvements often provide more dramatic results and benefits. The ability to identify and implement revolutionary process changes is often hindered by the lack of analysis tools and models able to identify such opportunities.

## **CHAPTER SUMMARY**

This chapter addressed process restructuring which is at the core of supply chain integration. The chapter began with a conceptual introduction to process efficiency, followed by a discussion of process restructuring techniques for supply chain integration. The discussion of the wide range of process restructuring techniques began at the individual company level and proceeded along increasing levels of integration, finishing with the multi-company supply chain. Lastly, a discussion regarding the classification of process restructuring efforts was provided.

It is important to note that some techniques are suited for specific channel types and not for others. Specific process restructuring techniques should be applied only after a careful evaluation of the supply chain has been performed.

## **4.0 ORGANIZATIONAL ISSUES**

Supply chain integration is strengthened when accompanied by a re-alignment of the organizations within the chain. This third framework area addresses organizational issues which arise during supply chain integration at all levels. Issues include supply chain organizational forms, changing roles, behavior incentives and monitoring mechanisms both within and between organizations. The discussion below first examines these issues for individual companies, followed by inter-company ties and multi-company supply chains. The last section examines the relationship of supply chain organizations and Japanese keiretsu.

### **4.1 INDIVIDUAL COMPANIES**

Supply chain integration requires a basic departure from traditional adversarial relationships to associative relationships characterized by coordination. At the company level, adversarial relationships between functions need to be overcome to effectively support cross-functional integration and management. Organizational changes to support supply chain integration may include a new organizational structure, changes in functional and individual roles along with new behavior incentives.

Lack of organizational change is identified by Lee and Billington<sup>47</sup> as a common supply chain integration pitfall. Organizational barriers arise when elements of a supply chain belong to different organizations within a company, each organization having its own performance measures and evaluation criteria. Common barriers include disagreements on inventory ownership and unwillingness to commit resources to help someone else. To overcome these barriers companies may need to redesign their organization and develop new incentive systems and performance metrics. These metrics should consider, for example, inventory across the supply chain and total response time instead of individual lead times. Instead of each entity being responsible for its own set of metrics, all entities should take ownership of the supply chain metrics and be held accountable for overall company performance (or at least in part).

The traditional functionally-focused organization is not the ideal form to support supply chain integration. A variety of alternative supply chain organizational forms have begun to appear,

although there is no consensus as to which is the most effective. These range from process-focused horizontal structures to coordinated functional organizations.

Byrne<sup>73</sup> examines the trend towards horizontal organizations defined by (horizontal) processes rather than (vertical) functions. The key to this approach is that instead of creating a structure around functions or departments, the company is built around its “core processes” with specific performance goals. Examples of companies moving toward this horizontal model include AT&T Network Systems which reorganized its entire business around 13 core processes, each of which has an “owner” and a “champion”. While owners focus on the day to day operations of a process, the champions ensure that the process remains linked with overall business strategies and goals. In another example, Xerox employs what it calls “micro-enterprise units” of employees that have beginning to end responsibility for the company’s products. New Xerox products are developed through multi-disciplinary teams that work in a single process, instead of being handed off from function to function (or department to department).

Despite the movement towards horizontal organizations, most companies only implement these concepts to a limited extent, often retaining vertical functions in some form. This may be due to fear of losing functional excellence within the company if the vertical function structure is completely abandoned. This is a valid concern, and thus it is unclear whether a completely horizontal company structure is effective for supply chain integration.

The “lean enterprise” is an organizational form proposed by Womack and Jones<sup>74</sup> which incorporates both process and functional components. The lean enterprise is a group of individuals, functions and legally separate but operationally synchronized companies. The enterprise is defined by the notion of a value stream (the linking of individual value-creating activities). The group’s mission is to collectively analyze and focus a value stream so that it does everything involved in supplying a good or service in a way that provides maximum value to the customer. However, significant difficulties arise when trying to link these lean activities. Stiff resistance may arise from employees, functions, and from other companies in the stream, since each of these have legitimate needs that conflict with those of the value stream. Individuals on cross-functional teams may feel they are being asked to abandon their functional career path, while functions face the loss of power and importance. These are the very problems faced in the

horizontal corporation model described above. Thus, in addition to targeting the best opportunities for exploiting their collective competitive advantage, lean enterprises must also include a new element to complement and sustain the concepts of individual careers, functions, companies and shared enterprise.

At the company level, the lean enterprise attempts to solve some of these problems. To reassure the individual, career paths in the lean enterprise alternate between concentration on a specific value stream (a family of products) and dedicated, intense knowledge building within functions. The role of the function is also changed. In the lean enterprise, the functions serve as schools. As reasoned by Womack and Jones, when functions become support for value-creating process teams, every function has a deeper and more coherent knowledge base than was possible when it divided its attention between thinking and doing. Moreover, this knowledge base is more relevant to the company's long term needs because function members returning from value-creating assignments in the processes bring new questions for the functions to answer. Constantly applying knowledge in this way fights the tendency of all intellectual activities to veer off into abstraction when left in isolation.

Understandably, there are not yet examples of lean enterprises as envisioned by Womack and Jones since creating such an enterprise requires radical organizational changes. More typically, companies retain a functional structure and focus on methods to increase functional coordination in support of supply chain integration.

In considering organizational changes to increase functional coordination, the following basic issues need to be addressed for each function:

- Roles within the individual functions need to change in order to support necessary coordination within and outside of the company,
- New skills are needed for cross-functional management, and
- Behavior incentives (compensation, performance measurements) need to support functional coordination.

With these basic issues in common, each function undergoes distinct changes in order to support integration of the internal company supply chain. The following sections address these function-

specific changes, examining purchasing, operations, product development and design, logistics and human resources.

### Purchasing

Dion et al.<sup>75</sup> discuss the changing role of purchasing brought about by the particular integration technique of JIT. Historically the buyer's role has been to secure the maximum value from the supplier. This is still the case, but what has changed is the method used to secure that value. The change in the buyer's role can be summarized by stating that he or she becomes less concerned with "getting the best" of the supplier in each transaction and behaves more as a manager of long-term supplier relationships. Specifically buyers report spending less time in the details of specific procurement transactions such as expediting shipments and price shopping, while spending more time in the management of supplier partnerships.

Offodile and Arrington<sup>76</sup> also discuss the changing role of purchasing brought about by JIT, focusing on three main areas. First, purchasing's role in vendor evaluation, training and certification is increasing. Second, purchasing is increasingly involved in the integration of transport and manufacturing. Third, purchasing is playing an expanded role in product development.

In an effort to develop greater synergy in manufacturing, design engineers are seeking greater input from production, purchasing and suppliers. Because buyers are in constant contact with outside suppliers and the commodity markets, they can play an important role in informing design groups of the latest technologies and material applications. By including both buyers and suppliers early in the design stage, buyers and designers hope to benefit from better quality, better manufacturing and shorter lead times. One example of this is illustrated in the case of Chrysler's latest platform cars<sup>22,23</sup>. Sourcing for the cars began 180 weeks before "Job 1" (when the 1st car rolls off the assembly line). Normally, purchasing didn't begin to line up suppliers until about 80 weeks before the cars were scheduled to go into production. By then, suppliers could be little more than bystanders. In this case, however, purchasing buyers as well as selected suppliers worked "elbow to elbow" with the designers and engineers on the platform team. (Details of supplier involvement in the design process are provided in Section 3.3.) The result was that the platform cars were developed from scratch in the world class time of 39 months, and under budget.

In some cases, purchasing actually accommodates supplier representatives on-site for coordination as well as concurrent engineering as in the case of JIT II mentioned in Section 3.3. In these cases, the on-site supplier representative takes over many of the coordination responsibilities previously performed by purchasing.

### Operations

Armistead and Mapes<sup>77</sup> discuss the changing role of supply chain operations managers, identifying several important factors. As the use of cross-functional management increases, the operations manager's role demands a greater understanding of corporate strategy and skills in managing the business. No longer is it permissible for operations managers to defend their domain of responsibility, but rather it is necessary to contribute to the overall company objectives. Thus, instead of focusing on their particular piece of the supply chain, operations managers will need to work to eliminate bottlenecks throughout the product flow, and reduce system-wide inventory and throughput time. Another new challenge for the operations manager is how to minimize disruptions in the flow between manufacturing and other functions, particularly distribution. This puts great emphasis on the planning process and communication.

### Product Development and Design

As mentioned earlier in the Chrysler example, the roles of product development and design teams are changing in integrated environments. Designers now increasingly coordinate with cross-functional teams and suppliers early on in the design process. This cross-functional coordination is necessary in order to evaluate product designs not only on functionality and performance but also on the resulting costs and service implications throughout the product's supply chain. Two company examples of product design for the supply chain were discussed in Section 3.2.

### Logistics

Copacino<sup>78</sup> examines four types of organizational structures for the logistics function in a multi-divisional company setting. The first is the "traditional" company model featuring separate logistics operations in each division. This weakness of this model is that it misses the synergies between divisions. The second model, characterized by a centralized logistics capability, has allowed companies to capture synergies across divisions while still preserving their autonomy.

However, as customers' requirements extend beyond specific product and shipment specifications to a fuller set of value-added services, this model may fall short. The third option adds the service business unit (including logistics, customer service and administration) to the mix, allowing full integration of all "customer facing" activities while preserving the focus and management of control gained from product oriented divisions. The final model combines sales and marketing, customer service and logistics into account focused teams. Copacino observes that there is no best organization model for all companies at all times and that as the market changes, the organization of the company's logistics activities must also be dynamic, continually adjusting to these changes.

Stank, Daugherty and Gustin<sup>79</sup> address the topic of organizational structure and its influence on logistics integration, costs and information system performance. They examine and compare centralized and decentralized (referring to the location of decision making authority and control) organizational structures. Their findings suggest that centralized structures accommodate logistics integration better than decentralized structures and that centralized firms spend a lower percentage of net sales on logistics costs and information system support than decentralized firms. They assert that centralization of authority can result in better coordination between functional areas and generally more proactive, opportunity seeking behavior.

Bowersox and Daugherty<sup>80,81</sup> propose that successful logistics organizations of the future will focus on process rather than functional accountability, capitalize on their core competencies while improving their coordination with others in the chain, and shift to an information based organization structure in the future. Information technology will permit the separation of the strategic logistics planning from day to day functional execution. Day to day functional execution will be dispersed throughout the logistics organization within a highly formalized but decentralized network, while strategic logistics activities are centrally coordinated through information sharing. Flexibility to accommodate the dynamics of change is also identified as a desired characteristic of the logistics organization of the future.

### Human Resources

Although not directly linked to product and information flow, human resources provides the most critical element to any supply chain: people. As the roles of people within the company change to support integration of the supply chain, the role of human resources must also change.

Specifically, human resources must now focus on training employees to develop the skills necessary for supply chain integration and searching for employees with qualifications and skills useful in a supply chain environment. Coordination skills which facilitate integration are particularly critical. Rothwell<sup>82</sup> discusses the new training focus of human resources, citing the likely increase of training activities with employees, suppliers and customers to develop the skills necessary for supply chain integration. For instance, human resources may be involved in coaching purchasing managers in new interpersonal skills or working with them to develop training programs for suppliers.

## **4.2 INTER-COMPANY RELATIONSHIPS**

Inter-company integration also requires an adjustment from adversarial to coordinated and integrated relationships; traditional inter-company organizational roles and behavior incentives must also change. Drawing from experiences of more than forty companies, Byrnes and Shapiro<sup>4</sup> identify keys to successfully building inter-company operating relationships including project management and parallel change. They observe that inter-company project management, from design to implementation of company-specific arrangements, is a surprisingly long and complex process and that some of the most effective project management efforts have been lead by a “project champion” in each company.

Another key to inter-company operating ties is that both companies generally must undergo a set of internal changes in parallel with each another. Just as the initiating company must carefully manage its internal change process, its new partner must deliberately develop new organizational relationships and performance measures. For example, one company developed an effective coordinative arrangement involving postponement at the supplier level along with a commitment to purchase the supplier’s materials. Both companies had to make significant changes in their ordering, inventory, processing and purchasing procedures. Stock locations shifted in the channel from one company to the other. In the supplier, as well as in the customer firm, many jobs changed dramatically, so new inter-functional performance measures were developed and incentive compensation was adjusted in order to overcome internal resistance and induce cooperation.

Mitchell et al.<sup>25</sup> discuss the need for establishment of clear and comprehensive inter-company operating procedures since conflicts over accountability and responsibility may arise between the



two organizations. These guidelines are imperative to alleviate any ambiguities, and should explicitly demonstrate what tasks are expected of each partner and how to accomplish them. The key roles of each organization should be identified early in the process.

The issue of trust is often raised in the establishment of new inter-company operating ties. Byrnes and Shapiro<sup>4</sup> find that the conventional wisdom of establishing an atmosphere of trust before the partnerships can be put in place is not necessarily true. Particularly in channels that have long been characterized by adversarial tensions, channel members may enter into coordinative agreements for very selfish reasons: they recognize the mutual benefits and are particularly interested in the benefits that will accrue to them. For them “vigilant” trust is sufficient. Then, over time, deeper trust begins to develop as each party sees that there is in fact nothing to be gained in the long run from taking advantage of the other.

Another central issue for inter-company operating ties is that of benefit sharing. Inter-company operating ties offer significant cost reductions, increased sales and supply continuity and flexibility. When the benefits are properly distributed, both customer and supplier have a compelling incentive to ensure that the relationship continues. Byrnes and Shapiro<sup>4</sup> observe that there is a common understanding that the goal of benefit distribution is to create substantial gains for both firms, although there is not an equal sharing of benefits in every case. Often, the way benefits are split evolves naturally over time. For example, in many of their observations the customer initially takes the lion’s share of the benefits - immediate inventory reductions and reduced operating expenses. For the vendor there may be little initial immediate payback. Over time however, as more and more customers agree to adopt this new form of managing product flow, the vendor is able to decrease its inventory, reduce its operating expenses and push the benefits of decreased product fluctuations back into manufacturing and purchasing. Sales to these partners generally increase significantly, and after a few years, the vendor often gains the large share of the channel benefits. In the long run, they observe, the benefits of inter-company operating ties are so substantial that both customers and suppliers are much better off for having worked together.

Looking specifically at customer-supplier and shipper-carrier inter-company supply chain relationships, new issues of relationship form, establishment procedures and monitoring processes (performance measures and feedback mechanisms) come into play.

### Customer-Supplier Organizational Ties

There is a wide range of customer-supplier relationships - from traditional “arm’s length” to those which are closely integrated. Frameworks identifying and examining the range of these relationships are presented in several articles. Scott and Westbrook<sup>83</sup> examine customer-supplier relationships and find there are several factors determining these relationships including: the extent of the supplier’s dependence on the chain, longevity of the relationships, technological or process links, the existence of legal ties and the length and complexity of the chain. Of these factors, the most important perhaps is the extent of dependence on the chain. The proportion of a supplier’s business which is dedicated to the supply chain in question will clearly affect its attitude and commitment to collaborative improvement programs. Scott and Westbrook also develop a supplier-customer dependence grid plotting the range of relationships which focuses on two dimensions: the relative importance of the customer to the supplier’s order book and the relative importance of those suppliers to the customer’s purchased materials.

Burdett<sup>84</sup> examines the stages of development in customer-supplier alliances, taking into consideration dependence, integration and time span. He reviews critical issues for each stage of building alliances. Supplier certification is identified by Willis and Huston<sup>85</sup> as the culmination of the formal bond between customer and supplier. Willis and Huston assert the importance of supplier certification and provide a step-by-step certification procedure and a simple model for evaluating alternative supply sources. The importance of supplier feedback and periodic review is also stressed.

Ellram<sup>20</sup> also presents a normative guide for firms interested in developing purchasing partnerships to follow. In addition, Ellram discusses the long-term outlook for purchasing partnerships, asserting that as customers seek partnerships with suppliers, firms will risk losing attractive suppliers to the competition unless they form partnerships with those suppliers. Thus, hesitating to form these relationships could result in the erosion of a firm’s supply base for strategic components or goods.

McMillan<sup>86</sup> compares the incentive systems used by Japanese and U.S. firms to insure transactions are carried out as intended. He also discusses incentives for cooperation, contracting structures, multiple sourcing and the need for safeguards for specific investments.

### Shipper-Carrier Organizational Ties

Rinehart<sup>26</sup> examines how global logistics partnership arrangements are developed, providing a structure of the elements involved in their creation. Specifically, consideration is given to the unique global factors that impact on the environmental constraints, and the objectives and strategies that impact on the nature of the partnership agreement.

There is a wide range of logistics partnerships. As described by Bowersox<sup>24</sup>, the level of carrier involvement ranges from performance of routine services to complete responsibility for the customer's logistics requirements. These relationships also vary from informal "relationships" to long-term contractual partnerships. For instance, CenTra, Inc.'s Central Transport Division provides time-phased delivery of components and parts to General Motors's plants in Lansing, Michigan. No specialized equipment is needed and the arrangement is subject to annual review. At the other end of the spectrum in the long-term contract between NYK Line and Pioneer Electric, where NYK is handling all logistics aspects, from importing to customer distribution of mixed shipments and products from a network of warehouses.

Successful logistics alliances are characterized by joint improvement efforts, formal systems for measuring the performance of both parties and a mechanism for feedback between the two. One approach to these alliances which facilitates these practices is the placement of a carrier "in-plant" at the shipper's company. This practice is increasingly common. American President Lines and Roadway have both placed "in-plants" at Bose. Other examples of carriers who have placed representatives on-site with their partners, as mentioned in Section 3.3, include Burlington Northern (at Coors)<sup>31</sup> and Preston Trucking (at Becton Dickinson)<sup>69</sup>. This type of integration facilitates the maintenance and monitoring of the alliance relationship, providing a forum for problem resolution.

Although continuous improvement efforts may be facilitated by carrier in-plants, there are several examples of partnerships able to work towards continuous joint improvement without them. In the

partnership between computer manufacturer Unisys Corp. and Dart Transit Co.<sup>87</sup>, the partnership began by Unisys teaching Dart personnel about the computer industry, taking them around the country to each of their manufacturing sites and training Dart's drivers in proper packing and handling of computer equipment. For maintenance of the relationship, the two companies hold regular management meetings to discuss problems and evaluate performance. In addition, they hold twice yearly drivers' meetings, giving Dart's drivers a forum in which to meet with Unisys personnel from both headquarters and individual shipping sites to talk about problems and find ways to improve operations. In another approach, the partnership between Goodyear Tire & Rubber Company and Yellow Freight System<sup>88</sup> utilizes a joint operating committee as well as a joint executive steering committee, composed of both Goodyear and Yellow representatives. Monitoring of performance takes place at both companies, and the committees work together to identify opportunities for cost reduction and service improvement.

Examination of these alliance relationships is becoming increasingly popular. One recent study<sup>89</sup> examined three types of alliances (manufacturer-merchandiser, manufacturer-service supplier and manufacturer-material supplier) within the food industry, with the manufacturer as the common element. The study, drawn from three independent but related doctoral dissertations, provides a comparison and contrast of the three identified alliance types. A general alliance model was also established, providing managerial guidelines for building and maintaining alliances. This type of alliance research is bound to continue as inter-company ties become increasingly important competitive advantages.

### **4.3 MULTI-COMPANY CHAINS**

Tightly interconnected multi-company confederations may be emerging as the competitive unit of the early twenty-first century.<sup>4</sup> Looking particularly at the automobile industry, Dyer<sup>66</sup> asserts that competition occurs among production networks, or "value chains" and not simply among companies. Although this trend towards integration is strengthening, questions remain regarding the future organizational forms of these confederations.

Semich<sup>90</sup> espouses the benefits of the "virtual corporation". Virtual corporations generate ideas for products but rely on (often temporary) alliances with outside designers, suppliers, assemblers, packagers and distributors to actually manufacture and distribute products. To successfully create

a virtual company, businesses need to implement advanced supply chain management systems and software to coordinate the complex network of suppliers and assemblers manufacturing their products.

Another multi-company form introduced earlier in this section is the lean enterprise as envisioned by Womack and Jones<sup>74</sup>. The lean enterprise is a group of individuals, functions and legally separate but operationally synchronized companies. It differs from the “virtual corporation” whose members are constantly coming and going, which Womack and Jones characterize as an “unstable entity”. They assert that the virtual corporation cannot sustain the collaboration needed to apply lean techniques along an entire value stream. The lean enterprise recognizes that the member companies each have legitimate needs that conflict with those of the value stream, and attempts to balance these needs. They argue most companies today do too much and do much of it poorly. The narrower the scope of responsibility, the more easily a company can calculate costs and the benefits it generates and see the result of its improvement efforts. Thus, the companies in the lean enterprise will each tackle a narrow set of tasks that it can do well. At the same time, all companies will need to participate in several enterprises involving different sets of companies in order to obtain the stability that any one value stream, with its inevitable ups and downs, cannot provide. Womack and Jones also add that, stability aside, companies will want to participate in a range of streams involving a range of products or services in order to learn from companies that think in different ways.

Although there is no agreement on the best organizational form for a multi-company supply chain, there seems to be a consensus on the need for one company to take a leadership position. Womack and Jones identify the need for one company to lead each lean enterprise, orchestrating the decision to form an enterprise, pulling together the full complement of member companies and leading the joint analysis of the total enterprise team. Based on discussions with executives, Cooper and Ellram<sup>91</sup> also assert that channel leadership is a prerequisite for multi-company supply chains because there must be a “champion” for supply chain formation and coordination.

There are several cases of multi-company supply chains where one company takes on the leadership role. This arrangement is true of many retailers, including Target and Wal-Mart.

Benetton<sup>36</sup> is another example of a supply chain “leader”. As described in Section 2.4, Benetton coordinates 180 raw material producers, 450 manufacturers and 6,000 retailers.

In the future there may be new ways to approach the issue of organizational structure. Particularly, a working paper by Malone et al.<sup>49</sup> describes the efforts to create a process handbook capable of representing various organizational structures and able to help redesign processes by generating and analyzing possible organizational alternatives.

#### **4.4 SUPPLY CHAIN ORGANIZATIONS AND JAPANESE KEIRETSU**

Lastly, while considering new organizational forms for supply chain integration, it is helpful to examine the relationship of supply chain organizations and Japanese keiretsu. Keiretsu is a term used to describe Japanese business consortia which rely on cooperation, coordination and joint ownership and control to competitively position businesses and industries. Supply keiretsu are networks of firms linked along the supply chain and led by a major manufacturer.

Ellram and Cooper<sup>92</sup> discuss the many similarities between supply chains and keiretsu, as well as the fundamental differences. Both approaches are characterized by mutual sharing of information, coupled with joint planning and development involving multiple levels both within the firms and in the supply chain. In order for either keiretsu or supply chain management to be effective, a long-term strategy is required. In addition, both require compatible philosophies among member firms, a reduced network of participants in the chain, and strong leadership to provide overall direction.

The fundamental differences between the two include different historical backgrounds and social philosophies. Ellram and Cooper assert that supply chain management provides less control and participation is voluntary. There tends to be less commitment, less dependence and less strategic coordination in a supply chain versus a keiretsu network. Additionally, there is greater security in information sharing in keiretsu.

Investigation into these two organizational forms reveals a recent flurry of articles suggesting that the differences between Japanese and U.S. firms are not as large as popularly believed. For example, Presutti<sup>93</sup> examines U.S. and Japanese purchasing practices and suggests that the U.S.

and Japanese approaches to managing smaller supplier bases are converging and that a great deal of management practice is transportable despite the differences in the culture of the two countries.

In another article, Kamath and Liker<sup>67</sup> examine Japanese supplier relationships and assert that these relationships are often misunderstood. For example, contrary to popular belief, Japanese (automobile) manufacturers regard only a handful of first-tier suppliers as partners. There are indeed a range of supplier relationships from strictly contractual relationships (arm's length) to full-fledged partners. Kamath and Liker also refute the notion that Japanese customers and suppliers work together in free-flowing teams to develop new products. Rather, Japanese companies structure their development programs tightly and use targets and prototypes to keep suppliers in line.

In another article, Liker et al.<sup>94</sup> challenge the picture from existing literature of cooperative partnerships in automobile product development in Japan, predominantly among first-tier suppliers, versus adversarial relationships in the U.S. with suppliers brought on board after most product development is complete. U.S./Japan differences in supplier involvement in design are examined based on a survey of U.S. and Japanese automotive component suppliers, and little support is found for the expected differences. The survey results show that U.S. automakers have adopted many features of the "Japanese model" of supplier involvement in design and indicate that U.S. companies have levels of product development rivaling Japanese companies. In both countries there is a high level of supplier involvement in product development from the early stages of design, particularly among suppliers of major subsystems.

The survey also points to evidence that despite the early involvement of suppliers, U.S. companies are still weak on some of the underlying business infrastructure and technical processes that contribute to the Japanese automakers' success. In part, this seems to be the result of a poor internal infrastructure for handling the supplier role. There were significant communication problems between U.S. engineers working with outside suppliers on product development, problems that were clearly absent in Japan. There were also problems in getting timely, specific and stable requirements to suppliers. This reflects a lack of internal organization in the U.S. automakers to make decisions about requirements. The Japanese companies were much more effective in clearly defining their requirements and sticking to them. Liker et al. conclude that

while it is possible to imitate the structural features of the “Japanese model”, it is a greater challenge to emulate the efficient and effective execution of Japanese companies. In terms of supply chain integration, one might conclude from these findings that U.S. firms need to focus as much on integration of their internal supply chain as on integration with their suppliers.

## **CHAPTER SUMMARY**

This chapter reviewed organizational issues which arise during supply chain integration. These issues were first examined for integration within individual companies, followed by inter-company and multi-company supply chain integration. At the company level issues of new organizational forms, changing functional roles, necessary new skills and behavior incentives were addressed. Next, the variety of inter-company relationships were examined, and keys for successful inter-company relationships were identified including joint improvement efforts, formal systems for measuring the performance of both parties and mechanisms for feedback between the two. New organizational forms for multi-company supply chains were also discussed.

The last section examined the relationship of supply chain organizations and Japanese keiretsu. Several recent studies were reviewed which indicate that the differences between U.S. and Japanese approaches to supplier relationships are converging, however, U.S. companies do not seem to be able to coordinate their internal supply chain as well as their Japanese counterparts.



## **5.0 INTEGRATION ENABLERS**

The fourth piece of the framework addresses integration enablers. This term refers to supporting systems and tools whose use strengthens and supports supply chain integration. The categories of integration enablers discussed below are: 1) Information Systems and Technology, 2) Measurement Systems and Metrics (including appropriate costing methods) and 3) Supply Chain Analysis Tools and Models.

### **5.1 INFORMATION SYSTEMS & TECHNOLOGY**

Information is widely recognized as one of the most important enablers for supply chain integration. Benefits of supply chain integration are based on coordination, the basis of which is information sharing. Even within a well-organized supply chain, disruptions and inefficiencies can result from inadequate information sharing. Both information technology and integrated information systems play significant roles in coordination of the supply chain.

Information technology advances have profoundly changed business practice and continue to transform the nature of processes, companies, industries and competition itself. Today's customers want reliable, efficient, top-quality service and information, fast. These expectations have been prompted by the ability of information technologies to deliver data quickly and accurately. Common technologies which have greatly improved supply chain efficiencies include bar codes, electronic data interchange and continuing improvements in computer processing ability. Radio frequency and satellite tracking are two additional technologies growing in popularity. Although the quick and efficient transfer of data is facilitated by information technologies, the rapid transfer of data by and of itself is not the key factor for success.

More important than specific technological advances is the ability to support the transfer of useful information (versus volumes of data) throughout a supply chain. Integrated information systems are thus needed to coordinate the movement of information throughout the supply chain. In fact, lack of adequate information systems is cited as a common supply chain integration pitfall<sup>47</sup>.

Traditional organizational structures do not typically support the efficient sharing of information within or between companies. Integrated supply chains, on the other hand, operate more efficiently

precisely because there is increased coordination and information sharing between the chain members. Supply chain integration is most efficient when members have access to information pertinent to the conduct of their business. This does not, however, imply that all information needs to be available to all members. Within the firm there should be free and open exchange of all relevant information between the functions. Where separate firms are involved there may not be complete sharing of all information, but enough information such that participants can optimize their own operations in the context of the chain. Information systems are needed to provide the supply chain members with the necessary information so that the decisions made at each link are consistent with the overall objectives of the chain.

The power of integrated information systems is illustrated in the example of Benetton<sup>36</sup>. As mentioned in Section 2.3, Benetton links 180 raw material suppliers, 450 manufacturers and 6,000 retailers to deliver 60 million garments a year to customers in 83 countries. Coordination of the entire system is possible through a global EDI network, where EDI allows Benetton's agents in each country to regularly transmit orders to Benetton's head office in Italy. The key is not simply the rapid transfer of data to Benetton but rather the coordination of this data through Benetton's information systems. This market knowledge is updated every 24 hours and allows Benetton to carefully track and react to demand by manufacturing only those garment styles, colors and sizes required.

As illustrated in the example above, integrated information systems permit coordination of a decentralized network, a particularly valuable ability given the increasingly global business environment. The ability to connect pieces of a supply chain electronically is quickly becoming a requirement in competitive markets. As technology capabilities increase, a variety of information systems architectures which facilitate efficient information flow throughout the supply chain become possible.

Braithwaite<sup>95</sup> recommends one such information system architecture for global supply chains. First, the need for centralized coordination as well as local functionality within a global business environment is identified. Based on this, Braithwaite presents four key principles of global information systems architecture: 1) standard track 2) modularity ("plug and play") 3) local functionality - global execution and 4) layers of business control.

The first principle of a standard track refers to the network structure where each function on the network has equal importance. The functions coexist on the network and have a basic responsibility to meet their own obligations to serve the network with information specific to their processes on which others are also dependent. In the same way, they are located on the network to receive such information from others.

The second key principle is that of modularity. Software functionality should be implemented on a site-by-site basis to reflect the business needs of the site. This means that elaborate software harmonization projects across global corporations are not needed and management can focus instead on maintaining the track and interfaces and ensuring integrity and quality across the network.

The third principle is that of local functionality with global execution. Local functionality must be maintained to support the individual operation. A fresh layer of systems which enable global execution are needed. These systems would encompass supply chain integration and seek to serve business units, finance, materials management and manufacturing.

The fourth basic principle is layers of business control. The system should support several layers of business control such as financial control, strategy, business unit and customer service and flow and process control. These layers within the information system should be equal but discrete, existing on the same network and utilizing the same basic data. For example, financial control can pull data from across the chain and compile it to address the needs of business groups, product groups and specific functional areas. These layers should be designed using relational database techniques. Although this is only one approach to information systems architecture, it illustrates the variety of issues which need to be addressed when designing these systems.

As information systems coordinate increasingly global supply chains, issues of how to interpret information outside of its local context become more important. For example, confusion regarding the currency units of a particular price may arise when working within a global supply chain context. This issue of context identification is being addressed by the Productivity from Information Technology group (PROFIT) at M.I.T.. Details of the group's progress in developing a system to perform efficient context interchange are provided in several PROFIT papers<sup>96,97,98</sup>.

As the sophistication of information technology continues to increase, the design and implementation of integrated information systems for the supply chain can be a significant challenge. Two alternatives to designing such a system in-house are gaining momentum: 1) the use of commercially available software packages, and 2) outsourcing the information technology function.

The use of specific supply chain management software is growing in popularity. As described by Semich<sup>90</sup>, supply chain management software lets manufacturers better integrate their customers' operations with their own, then ties it all into their suppliers. The goal is to integrate individual systems so that, for example, a single purchase decision in a retail store can generate a virtually instantaneous series of domino-like responses all the way down the supply chain. These software packages require that the organizations within the supply chain have integrated time-phased inventory management software, like manufacturing resource planning (MRPII) and the more recent enterprise resource planning (ERP) technology in place, as well as systems that translate and integrate higher business needs (sales transactions) into lower level activities and demands (such as production processes and materials orders). The available supply chain management software packages differ in some respects. Some are tightly integrated single-vendor systems which are more effective at giving users control of the overall business process, however, they require that all organizations in the supply chain install the same integrated software. To get around that limitation, several integrated single-system vendors are seeking to open up their applications to other vendor's systems, allowing users plug-in capability for competing products. According to Semich, distributed-computing and communications technologies necessary to make supply chain management software work have only recently matured and become sophisticated enough to support the complex systems required to coordinate and manage instant transactions across the whole supply chain.

One single-vendor supply chain software package is in use at Bell Canada<sup>99</sup>. The company uses the package to manage the complex flow of materials through the telephone company. Of particular importance is the ability for the software to handle the "reverse flow" of materials into their supply chain, as refurbishable equipment is returned from rental customers. The decision support software package is able to work with the company's current transaction based systems, and allows users full visibility into enterprise-wide demand and distribution requirements. For

specific software details, an annual compilation of logistics software is published by Anderson Consulting for the Council of Logistics Management<sup>100</sup>. Stenger, Dunn and Young<sup>101</sup> provide an empirical assessment of commercially available applications for “Integrated Logistics Management” based on a recent version of this publication.

As an alternative to performing the information function in-house, companies are increasingly outsourcing information technology. As explained by McFarlan and Nolan<sup>102</sup>, integrated information systems allow supply chains to compete more flexibly in the global market. This integration is putting extraordinary pressures on firms that are trying to keep the old services running while developing the interconnections and services demanded by the new environment. Under these pressures, outsourcing has become a viable alternative for those firms to get access to appropriate skills and to speed up the transition reliably and cost effectively. McFarlan and Nolan discuss the recent explosion of information technology outsourcing across the global corporate landscape, citing Xerox, Delta Airlines, and the Internal Revenue Service as the latest examples of these mega-alliances.

It is clear that information is a key enabler for supply chain integration. As information technology and integrated information systems become more powerful, companies will be able to coordinate more efficiently with their supply chain counterparts. At the same time however, these systems are becoming more difficult to design and maintain, driving outsourcing of the information function either through the purchase of software packages or by alliances with information providers.

## **5.2 MEASUREMENT SYSTEMS AND METRICS**

The old adage “you can’t manage what you can’t measure” also holds true for supply chains. In addition to managing the supply chain, explicitly measuring the benefits of supply chain integration is essential to gaining and keeping support for integration efforts within and between companies. Traditional functional performance measures do not provide an accurate measure of overall supply chain performance and can greatly understate the system-wide benefits of supply chain integration.

Measurement of the benefits of supply chain integration is particularly difficult because products as well as information cross functional and company boundaries. In fact, lack of adequate supply chain metrics is identified as a common integration pitfall<sup>47</sup>. The challenge is significant; develop a

set of metrics which effectively measure performance of the entire supply chain without becoming too general, and that are specific enough to retain usefulness for decision making purposes.

Billington<sup>1</sup> examines the issue of metrics and asserts that traditional functional metrics applied without considering the total supply chain often results in lower profitability, higher cost and lower customer service. One example mentioned in Section 1.2 describes the actions of a manager at a chip fabrication facility who increased capacity to improve responsiveness although later analysis showed that these chips rarely caused late shipments of the printed circuit assemblies. So even though the chip manager's reliability increased and she improved her local metrics, delivery performance to the supply chain's customer did not improve. The cost of the total supply chain increased with no improvement in customer service. Another example provided by Lee and Billington<sup>47</sup> describes an Indiana component manufacturing plant of an automobile manufacturer which started aggressively cutting inventory, since its performance was explicitly determined by its inventory. As a result, the plant's response times to the final assembly plants and the spare parts distribution centers became longer and highly erratic. This resulted in the need for the final assembly plants and the parts distribution centers to keep inventory high to give their customers reasonable service, thus increasing the cost of providing service. Effective supply chain metrics need to ensure that decisions made locally to improve local performance actually improve the overall performance of the supply chain from the customer's perspective.

Using a set of tools with which to evaluate and select individual performance metrics for use in a performance measurement system, Caplice and Sheffi<sup>103</sup> examine the difficulties in establishing a set of supply chain metrics. Three primary forms of measurement used to capture process performance (utilization, productivity and effectiveness) as well as eight selected evaluation criteria of individual metrics (validity, robustness, usefulness, integration, economy, compatibility, level of detail and behavioral soundness) are identified. Two primary trade-offs within the set of evaluation criteria are discussed in the context of establishing supply chain metrics systems. The first is a trade-off between usefulness and integration - the more a metric promotes coordination, capturing performance across different functions or firms, the less guidance it will provide for the particular function or company managers. The second trade-off is between validity and robustness - the more specific aspects of a process are captured in a metric, the less comparable it is. Detailed

and complete metrics come at the price of lowered comparability. This is an important aspect when trying to benchmark processes across different organizations or industries.

Resolving these two primary tradeoffs can cause a great amount of difficulty, particularly when designing benchmarkable supply chain metrics. Recent efforts by various consulting, manufacturing and academic roundtables and consortiums have been grappling with these tradeoffs. Decisions over which business processes to include in the metrics, what metrics to consider core (for external benchmarking) and secondary (for internal benchmarking), and how much detail to include within each metric are all different facets of these two primary tradeoffs.

One such consortium has proposed a common set of critical supply chain performance metrics as well as a comprehensive metric framework. The consortium, including industry and academic participants as well as an operations consulting firm, achieved consensus to select only the most critical supply chain metrics in each framework category<sup>10</sup>. The framework, shown below in Exhibit 7, categorizes the selected set of metrics in two dimensions: as outcome or diagnostic measures, as well as by particular metric focus. Outcome metrics are results-oriented measures of the ultimate capability of the supply chain. Diagnostic metrics assist management in understanding how the capabilities can be improved or what is driving outcomes' performance. The four metric focus categories include customer satisfaction/quality, time, costs and assets.

| <b>EXHIBIT 7</b>                     |   |  |
|--------------------------------------|---|--|
| <b>PROPOSED SUPPLY CHAIN METRICS</b> |   |  |
| <i>Metric Type</i>                   | <i>Outcomes</i>   | <i>Diagnostics</i>   |
| <i>Customer Satisfaction/Quality</i> | 1. Perfect Order Fulfillment<br>2. Customer Satisfaction<br>3. Product Quality    | 9. Delivery-to-Commit Date<br>10. Warranty Costs, Returns & Allowances<br>11. Customer Inquiry Response Time |
| <i>Time</i>                          | 4. Order Fulfillment Lead Time  | 12. Source/Make Cycle Time<br>13. Supply Chain Response Time<br>14. Production Plan Achievement              |
| <i>Costs</i>                         | 5. Total Supply Chain Costs   | 15. Value-Added Productivity   |
| <i>Assets</i>                        | 6. Cash-to Cash Cycle Time<br>7. Inventory Days of Supply<br>8. Asset Performance | 16. Forecast Accuracy<br>17. Inventory Obsolescence<br>18. Capacity Utilization                              |

Source: Multi-Industry Consortium Recommendation, Council of Logistics Management, 1994.<sup>10</sup>

The issue of appropriate supply chain metrics raises the question of how supply chain costs are allocated. Generally, supply chain costs are allocated at the individual function level, while allocation of costs at the customer product or channel level is uncommon. The danger in using these traditional cost allocations lies in the potential for distorted cost information.

Distorted cost information is the result of sensible accounting choices made decades ago when costs of direct labor and materials were the most important production factors and could be traced to individual products. Distortions from allocating factory and corporate overhead by “burden rates” for direct labor were minor. Today, product lines and marketing channels have proliferated.

Direct labor now represents a small fraction of corporate costs, while expenses covering factory support operations, marketing, distribution, engineering, information processing and other overhead functions have exploded.<sup>104</sup> Accurate allocation of these costs is critical in order to identify the profitability of customers and products. Distorted product costs could drive unprofitable supply chain decisions, leading managers for example, to de-emphasize and overprice products that are highly profitable, while expanding commitments to complex, unprofitable lines.<sup>105</sup>

Activity-based costing (ABC) more accurately allocates the direct and indirect costs to the activities and the customers or products consuming the organization’s resources. As explained by Cooper and Kaplan<sup>105</sup>, different products, brands, customers and channels make different demands on a company’s resources. Activity-based costing enables managers to slice business costs in many different ways - by product, product group, customer or distribution channel - and allocate costs based on the particular focus. The main benefits of ABC include more accurate cost information by product and customer, in support of decision making.

Specifically, activity-based costing within a supply chain attempts to identify all of the costs associated with moving product to market, including all of the activities spanning the supply chain. Application of ABC may identify opportunities for cost reduction through the elimination of unnecessary activities or by shifting the activities to firms which can most efficiently perform them. Potential benefits<sup>106</sup> of supply chain ABC costing include:

- Evaluation of alternative supply chains - how different supply chain structures effect corporate profitability or marketplace costs



- Activity analysis across a supply chain - resulting in a sustainable competitive advantage by lowering costs or differentiating services
- Focusing on redundant or non-value-added activities between firms
- Performing cost trade-offs across an entire supply chain to determine how to reduce overall costs and which channel member can most efficiently perform specific activities
- Assessing the performance of other supply chain members using direct and indirect costs.

In summary, supply chain metrics are key enablers for supply chain integration and management, and are important to identify integration benefits. Development of a set of supply chain metrics presents a challenge since traditional functional performance measures do not provide an accurate measure of overall supply chain performance. Activity-based costing is recommended in order to accurately assess product and channel costs.

### **5.3 SUPPLY CHAIN ANALYSIS TOOLS & MODELS**

Lastly, there are specific analysis tools and models which support supply chain analysis. As with metrics, these tools and models need to encompass the entire supply chain while at the same time retaining enough detail to remain useful. This section examines both basic supply chain analysis techniques and several recently developed supply chain models.

#### Supply Chain Analysis Techniques

There are many analytical techniques, from a variety of academic disciplines, which focus on particular supply chain aspects. The two identified here, channel mapping and pipeline mapping, are more general in scope and helpful in understanding the supply chains at a basic level. These fairly intuitive approaches to supply chain analysis are often able to provide valuable insights into the nature of product consumption and flow throughout the supply chain as well as the supply chain structure.

Channel mapping considers a broad view of underlying consumption patterns, channel operating structure and actual channel performance by tracking product flow through the channel from point

of origin to point of consumption. As described by Byrnes and Shapiro<sup>4</sup>, a channel map has three components: 1) a diagram of information and product flow, activity by activity, at each channel stage, 2) a quantitative analysis and representative model of product accumulation and movement over a typical time period and 3) rough estimates of the costs at each stage. During the channel mapping process it is helpful to determine whether each stage of the process is “broad” or “narrow” - whether a company can tie with competitors of a chosen channel partner, or whether it must form exclusive relationships. With the understanding that a channel map provides, a company can identify its most basic channel characteristics, and the most important obstacles to efficient product flow.

Scott and Westbrook<sup>83</sup> recommend pipeline mapping techniques for basic supply chain analysis. Pipeline mapping captures both time in the supply chain as well as the pipeline volume. Although in practice most supply chains are more complex than a straightforward sequence of processes, it is frequently helpful to single out the critical path (i.e., the pipeline with the longest overall length or volume) to highlight areas for potential improvements. Additional insights can be obtained by identifying cumulative inventory costs and added-value.

Tools to develop a general understanding of supply chain concepts and dynamics are also being developed. One such computer-based tool, “The Supply Chain Game”, was developed by a British consulting group to allow teams of managers to experience the management of a multi-level supply chain<sup>107</sup>. The game involves the management of a product through the (three-level) supply chain over a simulated three year period and to use different methods of management. Decisions at each level of the chain are required to run it. Similar supply chain teaching tools are also being developed within individual companies<sup>108</sup>.

### Supply Chain Models

As supply chains increase in complexity, basic channel mapping as described above may not be sufficient for analysis. More sophisticated analytical models are needed to make sense of the complex supply chain relationships and provide insight into decisions affecting the efficiency of the chain. A variety of supply chain models are described below, including examples of both general and company-specific models.

Graves, Kletter and Hetzel<sup>109</sup> present a new model of the requirements planning process in multi-stage production-inventory systems with applications for supply chain optimization. The mathematical model captures some of the key dynamics in the planning process, and uses a model for a single production stage as a building block for modeling a network of stages (multi-stage supply chain). The model is used as a tool to determine inventory placement across a multi-stage supply chain. Application of the model to a supply chain study demonstrates the value of a system-wide perspective for optimizing the supply chain, illustrating the underlying concept that looking at one stage in the supply chain in isolation is inherently sub-optimal.

Towill, Naim and Wikner<sup>8</sup> present industrial dynamics simulation models to facilitate the supply chain design and performance evaluation. Using dynamics analysis techniques, a simulation model of proposed supply chain strategies can be compared and costed. The purpose of supply chain dynamic design is to minimize the demand amplification within the chain while avoiding excessive stock level swings throughout the chain. The authors assert that these supply chain simulations are invaluable for prioritizing or choosing between various strategies for improving supply chain performance.

Arntzen et al.<sup>45</sup> describe the model Digital Equipment Company (DEC) uses to evaluate global supply chain alternatives and determine worldwide manufacturing and distribution strategy. The Global Supply Chain Model (GSCM) was developed jointly over the last 7 years by DEC and Insight Inc.. The model is a large, mixed-integer linear program, exhibiting comprehensive detail vital for modeling international manufacturing and distribution. A review of a number of earlier supply chain model developments, many of which have been incorporated into their model, is also provided.

The GSCM is able to simultaneously balance the multiple, conflicting attributes of manufacturing and distribution: time, cost and capacity. The comprehensiveness of the GSCM in considering a wide range of factors with objectivity has provided the analytical means and credibility to stabilize decision making at DEC. Specifically, the GSCM recommends a production, distribution and vendor network which minimizes cost and/or weighted, cumulative production times subject to meeting estimated demand, local content, offset trade, and joint capacity restrictions for multiple products, echelons and time periods. Cost factors include fixed and variable production charges,

distribution expenses via multiple modes, taxes, duties and duty drawback, and inventory charges. In general terms, the model decides what products to build at each location and how to distribute products to and service products for customers in nearly every location in the world. According to the article, supply chain restructuring assisted by the recommendations of this model have saved over \$100 million for DEC.

The GSCM is a deterministic model of global supply chains and is used at DEC for nearly all supply chain design studies. These fall generally into three categories: new product pipeline analyses, commodity supply base analyses and company-wide or division-wide supply chain studies. GSCM is applicable to other firms involved in multi-stage, multi-product manufacturing and is now commercially available.

Hewlett Packard (HP) has also been developing several supply chain models in the last several years. Much of their work focuses on addressing uncertainty within HP's supply chain. Davis<sup>110</sup> describes the framework HP has developed to address the uncertainty that plagues the performance of suppliers, the reliability of manufacturing and transportation processes and the changing desires of customers. The model representation of HP's supply chain is structured from node-based units. The units capture the salient features of nodes in the supply chain, carefully accounting for the upstream and downstream effects of uncertainty introduced at the node. Using this node unit as a basis, HP is able to model its complete supply chain network as a series of production sites, each stocking inventory stock keeping units (SKUs) to supply customer/downstream sites.

Davis also describes a decision support system tool HP developed that allows it to model supply chains analytically. The tool captures the spirit of the model characteristics as described above, and measures the benefits (or costs) of changes in supply chain policy. Specifically, the tool can analyze the inventory requirements of a given supply chain, given the appropriate operating conditions and customer service objectives. Again, uncertainties throughout the supply chain are accounted for, and stockpiles are sized and valued accordingly. Billington<sup>1</sup> describes the real value of the HP models as their ability to help quantify objectively supply chain challenges, ending the turf battle between functional managers. The models also help to clarify negotiations and make global collaboration easier between individual managers.

HP has evolved its supply chain models from relatively simple simulations into complex nonlinear stochastic mathematical programming models. The specific mathematical details of the latest model are given by Lee and Billington<sup>111</sup>. This particular supply chain application was developed to model decentralized supply chains and allows for 1) a generalized network structure, 2) uncertainties in supply, demand and internal processes, 3) simplicity and tractability for computation and 4) capacitated production systems. Again, the complete supply chain network is modeled as a series of production sites (nodes). Application of the model to the new product development project of the DeskJet printer supply chain is examined. Lee and Billington also review relevant literature, some of which forms the basis for their model.

Although there are certainly other models which focus on particular aspects of the supply chain, this section has focused primarily on models embracing a broader supply chain concept. As enablers, these models are able to make sense of complex supply chain relationships, providing insight into supply chain decisions. The development of supply chain models is likely to continue as companies struggle to compete in the increasingly complex global business environment.

## **CHAPTER SUMMARY**

This chapter addressed three categories of integration enablers: 1) Information Systems and Technology, 2) Measurement Systems and Metrics (including appropriate costing methods) and 3) Supply Chain Analysis Tools and Models. The distinct ability of each to facilitate supply chain integration as well as issues specific to each category were discussed.

## 6.0 SUMMARY & CONCLUSIONS

This thesis has provided a general introduction to supply chain integration, including a definition and discussion of the concept development. A framework was developed which divides supply chain integration issues into four basic categories: 1) strategic, 2) process restructuring, 3) organizational and 4) integration enablers. Using this framework, this thesis reviewed each category of issues in detail, incorporating references to recent supply chain literature where appropriate.

The aim has been to provide a broad overview of supply chain integration and a framework within which supply chain integration issues can be considered. As such, it reflects the broad dimensions of supply chain integration rather than the specifics of implementation. Although these categories of issues are addressed in this thesis independently, a balanced approach combining these is critical. Supply chain integration needs to be recognized and approached as a multi-dimensional project. In terms of the framework areas identified in this thesis, supply chain integration efforts should concurrently and explicitly address the first three framework areas (strategic issues, process restructuring and organizational issues) while making use of the enablers from the fourth.

Actual implementation of supply chain projects represents another significant challenge. Although outside of the scope of this thesis, change management throughout the integration process is crucial. Organizational and cultural changes are particularly challenging and require a great deal of attention.

Finally, it is important to emphasize that there is no one supply chain solution for all situations. As stressed above, the specific integration approach for each situation must be determined by careful consideration of the four framework areas. Furthermore, integration of one's supply chain should not be viewed as a one time fix. The business environment is constantly changing; businesses must be prepared to adapt to these changes to remain competitive. What works well as a strategy today may not be appropriate in 5 or 10 years. Thus, it is important to frequently re-evaluate supply chain integration strategy and adapt when necessary.

## **APPENDIX 1: LITERATURE DATABASE DESCRIPTION**

The literature base consists of supply chain focused articles (and books) published from January 1990 to approximately March 1995 and covers a broad range of topics. Some of the articles do not specifically mention supply chain integration per se but have been included due to the relevance of the subject matter.

Each article is entered into a database to facilitate management of the literature. Pertinent bibliographic information as well as a brief article summary is provided for each record. The database also contains several descriptive fields for further categorization of the articles. These additional fields include one for framework area in addition to fields for companies mentioned in the article. If the article addresses a particular framework area, a descriptive phrase or two is entered in the appropriate framework field. Since the pieces of the framework are so closely related many articles touch on several of the framework areas at once. However, if the article only addresses an area of the framework in passing or without much emphasis, no notes are entered into the framework field.

A listing of this database is available on the World Wide Web under the M.I.T. Center for Transportation Studies' homepage (<http://web.mit.edu/cts/www>).

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## CHAPTER 2 STRATEGIC ISSUES

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