The Pennsylvania State University

The Graduate School

Department of Business Logistics

WAREHOUSE PERFORMANCE AND SUPPLY CHAIN MANAGEMENT: CURRENT PRACTICES IN THE USE OF PERFORMANCE MEASURES

A Thesis in

Business Administration

by

Allen W. Kiefer

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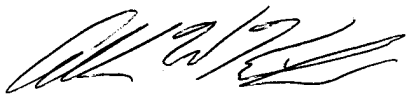

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Date of Signature

Robert A. Novack — 4-3-96

Robert A. Novack
Associate Professor of Business Logistics
Thesis Adviser

John J. Coyle — 4-3-96

John J. Coyle
Professor of Business Administration

Sean O'Keefe — 4/3/96

Sean O'Keefe
Professor of Business Administration

John C. Spychalski — 3 April 1996

John C. Spychalski
Professor of Business Logistics
Chair, Department of Business Logistics

ABSTRACT

This thesis addresses the question of how warehouses, which use a supply chain management logistics strategy, measure performance compared to companies with more traditional logistics strategies and how each of these two groups rate their performance measures in terms of effectiveness. Little research has been published in the area of warehouse performance measurements and this research provides exploratory information. In order to properly distinguish which companies use supply chain management versus companies which use a traditional logistics strategy, this study also provides a comprehensive literature review on supply chain management, to include company additional information on how a supply chain management strategy is developed, implemented, and the experience of companies that have adopted this strategy. A method of identifying which companies use supply chain management strategies is also used.

Upon determining warehouses that are and those that are not using a supply chain management strategy, the study analyzes the differences in the way the two types of companies measure performance to provide business with information on other company's practices and potentially improve their measurement programs.

The performance measures used are taken from recent literature on warehouse operations. Companies were surveyed to determine whether or not they are practitioners of a supply chain management strategy, how long the strategy has been practiced, measures used to evaluate warehouse performance, whether the warehouses believe them to be effective.

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Chapter 1

Introduction

Supply Chain Management (SCM) is the latest buzzword used by firms to describe their logistics operations and strategy. But what is SCM? What is a Supply Chain? Or, for that matter, what is logistics? There are several definitions and descriptions for all these terms. Regardless of how a company defines them the commonality between many companies is that : the effective and efficient management of logistics activities from the raw material source to the consumer and back again has become of importance to many companies that wish to remain competitive or that wish to gain a competitive advantage in their respective businesses. Harrington (1995) writes that logistics is the:

> Key facilitator in cross-functional efforts. Logistics activities touch virtually every activity in an organization and logistics managers have knowledge of how material and information flows through the supply chain. (p. 34)

Academic communities are also interested in the effectiveness of an SCM strategy and the changes that should be, or are, made when a company converts to SCM. Logistics has been described as "The last frontier for performance improvement and cost cutting." (Forbes 25 May 1992). Much has been said and written of SCM in journals, periodicals, and even newspapers, but little research has been conducted into what SCM really is, what it means to practice SCM, how to implement an SCM program, and

finally, how to measure the performance of the system in a manner that helps the firm become more efficient and effective.

The purposes of this thesis are: 1) to explore the many logistics related definitions used in today's business world; 2) to review the available literature in the area of SCM to determine why SCM should be used; 3) to examine how companies structure for SCM; 4) to determine how to successfully implement an SCM program; 5) to identify the barriers that make SCM difficult to implement; 6) to evaluate the measurement of performance in SCM; and 7) to generate the benefits of implementing an effective SCM program. Detailed research is conducted in the performance measurement of warehouse operations in an SCM strategy and a non-SCM strategy to determine the differences and the perceived effectiveness of the measurements.

Logistics Defined

The logistics business function is a relatively new one compared to the traditional business functional areas of marketing, finance, accounting, and manufacturing. Traditionally, logistics has been separated into two major areas, physical distribution and materials management, physical distribution is the outbound side of logistics and materials management is the inbound side. It is the coordinated management of these two basic activities that makes logistics. The first idea of coordinated management of these functions, mostly in the form of cost-service trade-off, was noted in 1844. A French engineer, Jules Dupuit, was the earliest known person to write about this concept without actually calling it logistics (Ballou 1992, p. 3). The first textbook to mention logistics as

a field of coordinated management of physical distribution and materials management was published in 1961. This recent date probably explains why a generally accepted definition of logistics is still being developed (Ballou 1992, p. 4).

In defining logistics the first logical place to begin is to check the dictionary definition. The dictionary definition is "The branch of military science having to do with procuring, maintaining, and transporting materiel, personnel, and facilities" (Guralink 1980). In fact, the military has been a practitioner of the concept of logistics since World War II. The idea of logistics as a business function has not caught on in the business community until recently, partly explained by the economic boom following World War II. Businesses were most concerned with increasing production and meeting customer demand rather than the efficiency and cost-effectiveness of distribution and material management systems. Today, now that the post-war economic boom is over, companies must look to other ways of increasing sales and market share as well as cutting costs in order to stay in business.

Another reason for the lack of concern in the logistics area was government regulation of the transportation industry. There was almost no flexibility in how companies could make agreements with carriers and almost no price and service competition between carriers. Deregulation of the transportation industry has provided the incentive for companies and carriers to integrate distribution and material management activities thus expediting the growth of the logistics function. The importance of logistics is evidenced by the large number of services now provided by carriers and the large number of third party logistics firms that exist today.

Logistics definitions have a very large range and scope. The most basic definition is in laymen's terms, "getting the right stuff, to the right place, at the right time" (Henkoff 1994, p. 64). There are also short, vague, business oriented definitions, "the management of the entire supply chain" (Horsley 1993, p. 42). There are narrow definitions based on the two traditional major functions within logistics, "the integration of Materials Management and Physical Distribution into a broader function" (Battaglia 1994, p.49) and "the melding of materials management and physical distribution" (Yanacek 1987, p. 30).

There are also definitions that describe logistics as a scientific discipline, "the science of moving goods from a manufacturer into a customer's hands in the most timely, efficient, cost-effective way" (Strom 1993, pp. D-1, D-2), and "the science which integrates all the activities required to move goods from the original sources of raw materials to the location of the ultimate consumer of the finished product" (Sussams 1994, p. 37).

Logistics is also defined in terms of a process. The Council of Logistics Management defines logistics as:

> The process of planning, implementing and controlling the efficient cost effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of conforming to customer requirements.

Another process oriented definition is "the process of strategically managing the movement and storage of material or products and related information from any point in the manufacturing process through consumer fulfillment and back" (Jenkins 1995, p. 71).

There are definitions that relate to profits and to managerial responsibility, "the profitable deployment and management of operating assets and personnel to move products, material, and information" (Rosenthal 1990, p. 20) and "the managerial responsibility to design and administer a system to control the flow and strategic storage of materials, parts, and finished goods inventory to the maximum benefit of the enterprise" (Williamson et al. 1990, p. 67).

The final definition could be categorized as one that is full of faddish terms within the business community "the coordinated effort between supply chain partners (suppliers, carriers, manufacturers, wholesalers, and customers) to dynamically respond to the needs of the end customer" (Greene 1991, p. 24).

To adequately define logistics as a legitimate business function on a par with marketing, finance, etc. The definition must be concise and use terms that are not in vogue, but are widely recognized, understood, common. I would propose the following as a definition:

> The business function responsible for integrating procurement, inventory management, distribution, and related information from the raw material source to the consumer and back in the most efficient, manner.

Supply Chain Defined

In order to properly examine supply chain management as a strategy the term "supply chain" must be defined. The term "supply chain" has also gone through an evolutionary period just as logistics has. Harrington (1995) has defined the supply chain through three periods in recent history:

> In the early 1980s the supply chain encompasses everything from sources of supply to customers, picturing a unidirectional flow from suppliers to customers and concentrating on physical activities. In the late 1980s the supply chain added emphasis on the importance of information flow but still focused on a self-contained company-centric chain and also focusing on interfaces with direct customers and suppliers.
> Today, supply chain is the product and information flow encompassing all parties beginning with the supplier's supplier and ending with the flows viewed as bi-directional. The formal definition is groups of enterprises (suppliers, customers, producers, and service providers) that link together to acquire, purchase, convert/manufacturer, assemble and distribute goods and services to the ultimate consumers or end users. (p. 30)

Other authors describe a supply chain as "a network of material processing cells with the following characteristics: supply, transformation, and demand" (T. Davis 1993, p. 37) or, "a network of entities through which materials flow, including suppliers, carriers, manufacturing sites, distribution centers and customers" (Hammel and Kopczak 1993, p. 65). There are those who describe a supply chain in terms of an actual chain. "The chain linking of each element of the production and supply processes from raw materials to the end customer" (Scott and Westbrook 1991, p.23), and "A series of linked processes which convert a raw material into a finished product delivered to the customer" (Vallely 1994, p.30). Another definition is "the connected series of activities which is concerned with planning, coordinating and controlling, material parts, and finished goods from supplier to customer. The two distinct flows in which a supply chain is concerned is material and information" (G. Stevens 1989, p. 3).

These definitions are either too complex or too vague to be of practical use. I propose to define a supply chain as:

All the entities that participate in getting a particular product or service from raw material to the end user.

An illustration of a supply chain is located at figure 1.

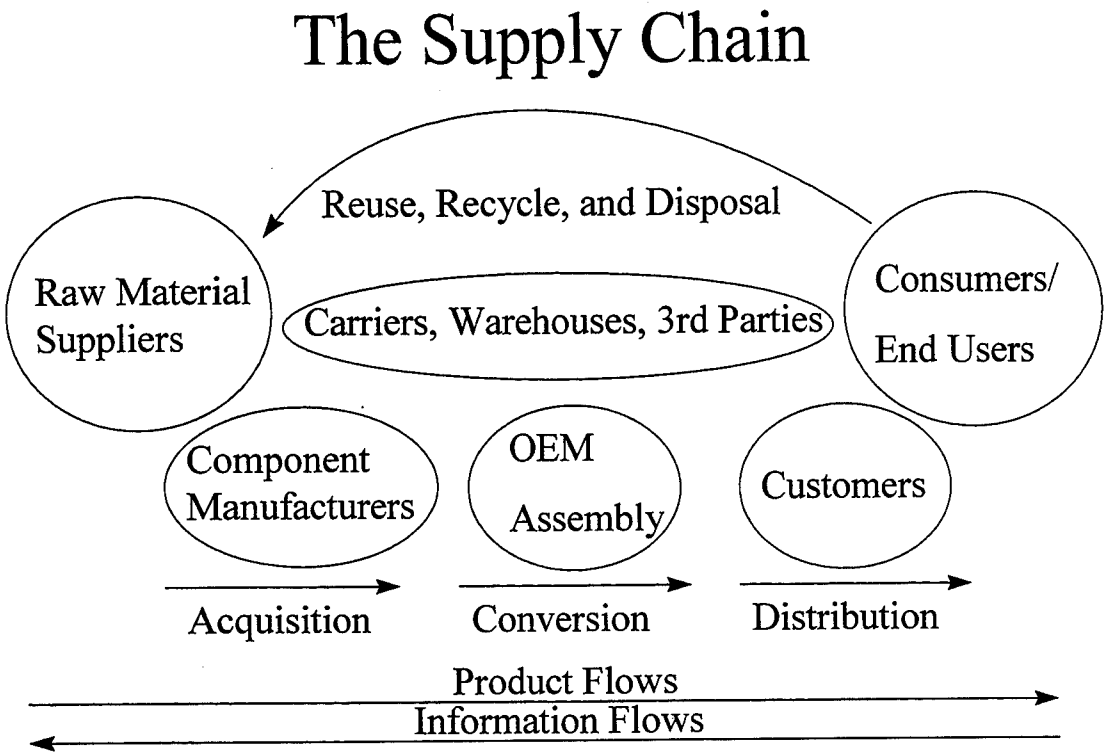


Figure 1

Supply Chain Management (SCM) Defined

Having defined both logistics and supply chain, it is now possible to define SCM. SCM is another term that has been defined extensively in recent logistics literature and is a current buzzword in business today. Many of the definitions I found have the same problems of vagueness and/or complexity as in the definitions of logistics and supply chain in the previous sections. Some of the simplest definitions describe SCM in layman's terms, "the sinuous, gritty, and cumbersome process by which companies move

materials, parts, and products to customers" (Henkoff 1994, p. 64), in terms of marketing, "A formal linkage among all levels of a marketing channel" (Turner 1993, p. 52), in concepts common to total quality management, "Paring down suppliers to a chosen few who work within strict rules laid down by the customer. These suppliers demand similar compliance from their own suppliers and so on down the line" (Vallely 1994, p. 30), and in management terms, "the management of the flow of goods and services to end customers to satisfy their requirements" (Harland et al. 1993, p.18).

SCM is also described as a concept, "a strategic concept that involves understanding and measuring the sequence of activities, that are often cross-functional, from supplier to customer that add value to the product supply pipeline" (Battaglia and Tyndall 1991, p. 42). T. Brown (1993) describes SCM in a manner that is far too narrow and restrictive to be of practical use to logisticians. He defines SCM as:

> a concept whereby a distributor allows his supplier to take responsibility for replacing (and managing) his inventory, the distributor accepts the notion of everyday low prices (EDLP) from suppliers, according to which, in theory, the distributor absorbs promotional markdown thereby eliminating wasteful forward buying, and the distributor uses Electronic Data Interchange (EDI) for all transactions between himself and his suppliers. (p. 23)

Planning and control is the central point of other definitions of SCM. "The planning and control of total materials flow from suppliers to end users" (T. Jones and Riley 1987, p. 94) and "taking control of all goods within the supply chain, all material no matter how awkward to handle or manage" (Grange 1994, p.43). Other definitions include: "the logistics strategy of continuous removal of obstacles and costs which inhibit the flow of goods and information required to compete profitably" (Rosenthal

1990, p.20), "aligning key business process goals and the performance of all supply chain participants to eliminate waste, maximize long-term profits, and add value to final customers" (Harrington 1995, pp. 30-31), and "an integrative philosophy to manage the total flow of a distribution channel from the supplier to the ultimate user" (Ellram 1994, p. 26).

Just as in the definition of logistics, supply chain management is also described as a process. Battaglia (1994) defines supply chain management as:

> an integrating process based on flawless delivery to customers of basic and unexpected services by optimizing information and product flows from the purchase of raw materials to the delivery and consumption of finished goods." (p. 49)

Another process related definition is "an integrating process used to create and sustain competitive advantage based on delivery to the customer of basic and unexpected services" (Muller 1993, p. 56). The most complex and detailed definition of SCM is offered by The Council of Logistics Management.

> An integrating process, used to build competitive position, based on the delivery to customers of basic and unexpected services. Led by line executives, supply chain management optimizes information and product flows from the purchase of raw materials to the delivery of finished goods with a vision of achieving significant strategic objectives involving productivity, quality, innovative services and alliances. Total supply chain management includes the implementation of sales and marketing activities to share the benefits with all the participants in the supply chain.

All of the previous definitions describe what SCM is in some portion or even more than is required. Many of the definitions also include the outcomes of SCM, such as adding value, competitive advantage for those companies which do SCM best, and

competing profitably. The definition of SCM, as in logistics and supply chain, must be concise and clearly understood.

Lalonde and Masters wrote that SCM is "expanding the integrated logistics concept beyond the corporate borders of the firm to include the logistics operations of vendors and customers" (Lalonde and Masters 1994, p.37). This is the best definition of SCM found in this research, however, I would argue based on my definition of logistics that the term "integrated logistics" is redundant and also that SCM is a strategy. Therefore I propose the following modification to Lalonde and Masters' definition for use in this thesis:

> The logistics strategy of expanding the concept of integrated logistics across company boundaries to optimize information and product flows from the purchase of raw materials to the delivery of finished goods or services to the final consumer.

A further simplification in defining SCM is to characterize it as inter-firm logistics.

Costs of Logistics

Why is the study of logistics and SCM so important? The answers to this question are both quantitative and qualitative. "American Companies spent $670 billion (10.5% of GDP) on logistics functions" (Henkoff 1994, p.64) is part of the answer. Companies have only begun to realize the importance of logistics since the early 1980s. Why it has taken so long for companies to realize can only be speculated about, but research into how much logistics related activities cost certainly has played an important part in the realization. Another factor towards realization is that "Whether

logistics costs are handled internally or outsourced they involve a large commitment of capital which requires board room level decisions" (Harrington 1995, p. 34). The grocery industry has indicated "they can wash $30 billion (10% of its annual operating costs) out of its system" (Henkoff 1994, p. 64) by making logistics more efficient and effective. "Order processing and order fulfillment functions are greater than 15% of sales" (Battaglia 1994, p. 49). "Logistics and distribution costs can be as much as 30 to 40% of total costs for some businesses" (T. Davis 1994, p. 46). A specific example is that Compaq Computer estimates that it lost between $500 million and $1 billion because its personal computers were not available when and where the customers were ready to buy them (Henkoff 1994, p. 64). In light of these statistics it is obvious why companies are trying new operating methods and innovative logistics strategy. Computer technology is now making it possible to replace people and inventory with information and creates enormous opportunities for companies to cut costs, improve service and increase profits. SCM, or inter-firm logistics, is the next step for a company to build or increase its competitive advantage once its internal logistics operations become fully integrated.

History of Logistics Responsibilities

Traditionally, company logistics, or logistics related departments in companies without a logistics department, have been the stepchildren of companies. It is the place where people who could not succeed in other areas were sent as a last resort. Most manufacturers paid little attention to improving supply chain linkages and to coordinating the timing and quantity of product flows between locations in the supply chain. The

focus was on improving manufacturing and warehouses with each operation measured for performance on a local level. The major goals were increasing production efficiencies and flexibility, material handling and warehouse operations to reduce operating time and costs and to increase responsiveness. "In the 70's marketing was king and suppliers called the tune. Supply chain inefficiencies were overlooked and was ignored as a central part of the business" (Grange 1994, p. 43). The first employment of the logistics concept occurred during the 1970's. Lalonde and Masters (1994) noted:

> At this time many firms began to integrate the traditional business functions of traffic management, warehousing, inventory control, and in some cases, purchasing, into a single organizational entity so as to make appropriate trade-offs between the costs and benefits associated with the flow of material throughout the firm. In the 70's and 80's firms discovered that the movement of material throughout the firm could be managed in an organic and systematic way, and that by doing so, both the effectiveness and efficiency of the operation could be dramatically improved.

When reviewing the history of logistics responsibilities it is important to note the prevailing attitudes of business managers and executives about logistics as a field in recent history. It can be reasonably assumed that prior to this research that the percentages were less than those reported. In an attitude survey of businesses, Yanacek (1987) found that:

> Only 9 of 23 business functions were indicated as clearly logistics functions. The percentage of respondents that indicated clearly logistics is noted:
>
> 1. Outbound transportation 100%
> 2. Shipping 89%
> 3. Private trucking 89%
> 4. Inbound transportation 81%
> 5. Outside warehousing 78%
> 6. Receiving 70%
> 7. Inventory control 67%
> 8. Order entry/processing 63%

9. Lease/buy transportation 63%

In addition 14 were indicated as not predominantly logistics responsibilities but, logistics may have input on policies and decisions.

1. Customer service.
2. In-plant warehousing.
3. In-plant material handling.
4. Market areas.
5. Plant location analysis.
6. Pricing.
7. Inspection/quality.
8. Information systems.
9. Product mix.
10. Forecasting.
11. Purchasing.
12. Packaging.
13. Production scheduling.
14. Household goods moves.(p.32)

The results of this survey clearly show that, even as recently as 1987, attitudes about logistics as a function were quite narrow. It has only been in the last few years that logistics has come to the forefront of companies as a discipline that can integrate these functional areas and generate significant cost savings in operations as well as adding value to their products. The newness of the logistics function has left the door wide open to innovation in logistics. This is one of the probable causes for the emergence of SCM.

Trends That Are Making SCM Necessary/Possible

If SCM is such a great strategy than why has it taken so long for companies to embrace it? The reason is that the current business environment and technology improvements have created an environment that has made SCM possible. The current business environment includes an "increasing consumer driven nature of the market. We've gone from the market just wanting products to the market demanding more and

more variety" (Vallely 1994, p. 31). Customers now realize that they are in charge of the market and they are exercising their power to get what they want.

Manufacturing units are now maximizing productivity by concentration and making the marketplace global. Treaties are in place, or in negotiation, to eliminate economic barriers (tariffs and customs regulations) between nations that are allowing companies to concentrate manufacturing. This is providing companies with a greater ability to provide a competitive edge through quality of service, one of SCM's main objectives.

Another environmental factor is the recognition that centralizing logistics structures, by reducing depot networks and having a limited number of stockholding points, is more efficient and provides for better control of logistics. This is true for both inward and outward flows. This environment is allowing SCM to be implemented in a less painful manner because their are less entities in a company to integrate in the logistics system.

Other trends and technology improvements that have made SCM necessary and possible to provide a competitive advantage through quality of service to customers were noted by Horsley (1993):

> The development of large automated warehouses incorporating much more technically advanced systems: automated storage and retrieval, guided vehicles, sortation systems, etc. The concept of stockless depots. Global logistics as companies view their distribution on a worldwide basis. The integration of physical and informational support systems, such as the concepts of just-in-time, materials resource planning and distribution requirements planning. The development of sophisticated computer programs using the latest color graphic techniques for logistics and distribution simulation modeling. The use of paperless information systems for operational purposes. (p. 42)

These are not the only trends and technology improvements occurring. They do represent a cross-section of the transition that is occurring in business today from a manufacturing orientation to a customer, quality, and service orientation. These components are what the true logistics function does best.

Companies That are Using SCM

The introduction and implementation of a SCM strategy may take years before it is completed. Changes and improvements will be made continuously as companies fine tune their supply chain. Acceptance by companies of an SCM strategy has been slow with "only 11% of manufacturers well into their program" (Battaglia and Tyndall 1991, p. 45) as of 1991. The fact that as of 1990 "only 10% of North American companies were highly sophisticated in logistics" (Rosenthal 1990, p. 20) is a contributing factor in this slow process of SCM implementation. SCM requires a high level of logistics sophistication and understanding to properly and effectively implement. More recently, however, there has been an increase in the number of prospective practitioners. As of 1994, 33% of North American companies have begun integrating with their suppliers, 7% internally, and 29% with customers (Harrington 1995, p.31). This is a significant increase in the number of SCM practitioners and, as companies see the positive impacts on costs and profits form those that have pioneered the SCM strategy, the number of companies practicing SCM will continue to increase.

The companies that correctly implement an SCM program have noted dramatic improvements in some, or many, performance areas. Some of the most dramatic

improvements are as a result of inventory reductions. Compaq computer has implemented an SCM program that has helped to make it the number one producer of personal computers in the world. Compaq has quintupled productivity without increasing factory space by reducing inventory. Laura Ashley turns inventory 5 times faster than 3 years ago. Saturn turns inventory 300 times per year (Henkoff 1994, p. 64).

Among the most dramatic improvements in performance are Digital Equipment Corporation and Xerox. "Digital Equipment Corporation experienced a 37% inventory reduction, 55% increase in revenues per person, 25% reduction in cost per order, 50% reduction in overtime, and a 97% customer service level all while the volume of orders increased 20%" (Turner 1993, p. 54). Xerox, over 5 years, has reduced inventory by $750 million and annual operating expenses by $200 million while also showing an 8% gain in customer satisfaction (Hewitt 1994, p. 4) after adopting an SCM strategy.

Other improvements made, due to adopting SCM strategy, are in the areas of reduced design and manufacturing cycle time. Over 20 months, Motorola improved quality, took $1 billion out of its structure and reduced manufacturing cycle times by 50% (Harrington 1995, p. 31). Seiko watches can design and manufacture a new watch in eight hours when it used to take eight months. John Deere has brought its new equipment time to market from two and a half years to within seven weeks by increasing its ability to respond to customer demand shifts (Vallely 1994, p. 30).

Increased sales, reduced distribution costs and reduced delivery times were the result of National Semiconductors adoption of an SCM strategy. Delivery time was

reduced by 47%, distribution costs by 2.5%, and sales have increased 34% in 2 years (Henkoff 1994, p. 66).

Other practitioners that have had positive results from adopting an SCM strategy are Becton-Dickinson, Baxter Health Care, Tupperware Home Parties, and Phillips Consumer Electronics. In my review of the literature about companies that have implemented SCM, I found no evidence that the adoption of such a strategy has had a negative impact on the performance of any business over the long term.

Supply Chain Management By Other Names

While the term "Supply Chain Management" is relatively new and still little used in practice, their are many popular strategies with other names that have many of the same attributes of SCM. Among those attributes are; closely working with suppliers and customers, measuring performance across the supply chain, and the integration of all elements in the supply chain (e.g. manufacturing, distribution, purchasing).

Efficient Consumer Response (ECR) and Continuous Replenishment (CR)/Quick Response (QR) are logistics strategies used by the grocery industry and non-food retailers, respectively. These strategies are used primarily to cut down on inventories but, they also increase customer satisfaction and lower distribution costs. In order to do this, close work with suppliers and manufacturers is necessary, particularly in terms of information exchange.

Just-in-Time (JIT) delivery is term that is related to SCM. However, the JIT concept's focus is limited mainly to the inbound side of logistics. JIT requires complete

integration throughout the supply chain to ensure that deliveries arrive just-in-time. Complete and timely information exchange between suppliers, manufacturers, and customers in order to synchronize operations and is critical for a JIT program's success.

Other names for strategies that share the same attributes as SCM have been coined by numerous authors. These names include; "seamless distribution" (Rosenthal 1990, p. 20), "product channel management" (Yanacek 1987, p. 34), "channel integration" (Cooke 1992, p. 57), and "supply chain integration" (Harrington 1995, p. 30). Henkoff (1994) and Horsley (1993) refer to supply chain management simply as "logistics".

Chapter 2

Review of Literature

Why Use Supply Chain Management

In the previous sections the use of SCM was demonstrated to be effective in numerous organizations. There are several reasons why companies should consider using SCM, if their business environment allows for the proper implementation. The reasons are many and fall into one of four categories:

1) Market conditions.
2) Customer service, quality, and competitive advantage.
3) Operating efficiency/cost reductions.
4) Profitability.

Market Conditions

Today's market is the number one reason why SCM is possible and should be used. Producing high quality goods is required, but not enough. Today's customers want the products they purchase to be where and when they want them with perfect administration (e.g. billing). Customers reward suppliers that provide service above and beyond the basics. Scott and Westbrook determined that it is possible to compete on price, quality, delivery, lead-time, and reliability simultaneously (Scott and Westbrook 1991, p. 23) in today's market.

There are also a number of companies that are willing to enter into partnerships, alliances, and cooperative relationships, that SCM requires, in order to share in the benefits those type of relationships bring. In yesterdays market companies were not willing to provide sensitive and confidential information to others.

Finally, another change in the market that makes SCM useful is that "retailers are handling as much as four times the number of product they did a few years ago creating a far more complex logistics system" (Strom 1993, p. D2,D5). This volume of business virtually requires the close coordination and integration that SCM brings.

Customer Service, Quality, and Competitive Advantage

This category is of paramount importance to a successful enterprise. Companies that have difficulties in attaining excellent performance in this area are a particular target for SCM implementation. Today's company must "satisfy key customer needs of time and place utility while lowering the total amount of resources required to provide the necessary level of customer service" (T. Jones and D. Riley 1987, pp. 98-99). The importance of SCM in this category is best explained by Vallely (1994):

> If your supply chain isn't well managed than you will be busy making and stocking the wrong things. That means you won't be able to supply the demands of the customer, and your money will be tied up in the wrong place. Poor customer service and investing in the wrong activities will kill your company. (p. 30)

SCM allows a company to enhance service and compete based on customer service quality. Companies are being forced by competitive pressures to provide exceptional customer service, including quick, reliable delivery. Stevens (1989) noted:

> That SCM allows companies to synchronize the requirements of the customer with the flow of material from suppliers in order to effect a balance between what are often seen as conflicting goals of high customer service, low inventory investment and low unit cost. (p. 3)

Operating Efficiency/Cost Reduction

While market conditions and customer service requirements are very important, companies must also increase operating efficiency and reduce costs. SCM is key in because, "there is more opportunity to get cost out of the supply chain than out of manufacturing" (Henkoff 1994, p. 64), since manufacturing is traditionally where business has looked for operating efficiency. Cooper and Humphreys (1994) noted that with SCM, companies:

> Reduce waste, non-value-added activities by reducing the amount of handling and excess inventories (all types). Increase responsiveness, improve communication, (speed, timeliness of information, accuracy, and sharing). Reduce cycle time (new product development and order lead time) and improve coordination of efforts (continuous channel improvements and understanding). (p. 27)

Lalonde and Masters (1994) stated that:

> Even if each individual firm in the chain is performing integrated logistics management of its own internal operations, there still exists a great potential to increase the overall efficiency and effectiveness of the supply chain as a whole by practicing integrated logistics management on the total flow of material throughout the supply chain. (p. 38)

Since SCM hinges on the share of information and cooperation between supply chain partners, companies "can heighten this cooperation with suppliers, customers, and transportation providers thereby reducing costs using information exchange and

customized practices through SCM" (Rosenthal 1990, p.21). T. Davis (1993) found another reason why SCM should be used:

> The use of Supply Chain Management reduces the impact of uncertainties in operations. In the past the only recourse against vagaries in the supply chain has been a combination of intuition and experience because of a lack of insight into other processes in the supply chain. (p. 35)

Berry et al. (1994) stated that companies should use SCM because:

> Supply chain management is aimed at building trust, exchanging information on market needs, developing new products, and reducing the supplier base to a particular OEM (original equipment manufacturer) so as to release management resources for developing meaningful long-term relationships. (p. 20)

The current business trend toward a "reduction in depot networks with a limited number of stockholding points both for inward and outward flows" (O'Keefe 1993, p. 2) is another reason why companies should use SCM. SCM allows companies that are reducing their networks to better manage inventory, create a more streamlined and even flow of materials into the manufacturing process, manufacture products to meet demand, reduce cycle time, and create a true demand pull system (Harrington 1995, p. 31).

Profitability

Profitability is the final reason why companies should adopt SCM as their logistics strategy. This is also nearest to the businessperson's heart, because profitability is why companies are in business. Adopting SCM allows companies to "make permanent improvements in profitability" (Rosenthal 1990, p. p.21). Profit margins are suffering due to increased competition and those companies that enter a market with the first, the

most, and the best product will have a significant competitive advantage and therefore, more profitability. Turner found that "companies at the highest level of integration achieve the best financial results, higher customer service levels and the best ability to plan and make things happen" (Turner.1993, p. 53).

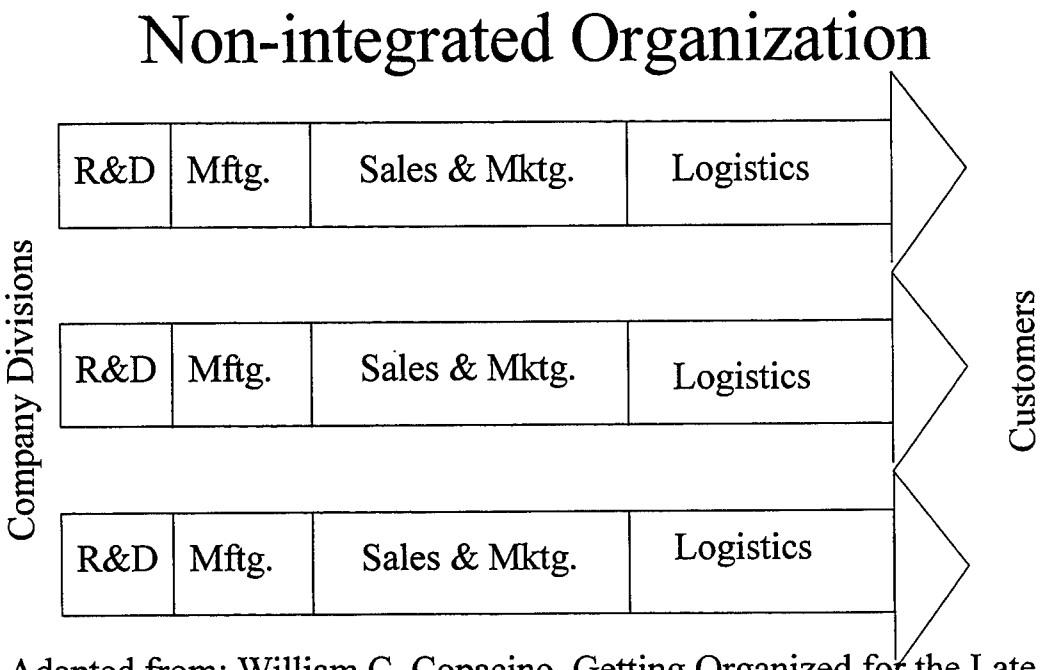
Supply Chain Management Organizational Structure Steps

The development of an organizational structure for SCM does not happen overnight. It may take years for a company to become fully integrated into SCM. Researchers have devised between four or five stages of SCM/logistics evolution.A company may be in one of the advanced stages when it begins the adoption of an SCM strategy and thus not have as far to go as a company which has not even thought of logistics as a competitive weapon. Copacino (January 1994) outlines four steps of organizational structure in a multi-divisional company:

1) Non-integrated. Operating functions (sales, manufacturing, logistics, etc.) operate separately in an uncoordinated way. In addition, each division operates independently, not leveraging logistics activities across divisions (figure 2).
2) Functionally integrated. This type of setup features close coordination and integration across operating functions. Each division, however, operates independently (figure 3).
3) Divisionally integrated. In this arrangement, designed to maximize cross-divisional synergy, logistics is coordinated across divisions, but remains unintegrated with other functions (figure 4).
4) Fully integrated. In this case there is close coordination and integration across operating functions and across divisions (figure 5). (p. 37)

Hewitt (1994) described the development of organizational structure as "stages of logistics evolution" and are shown in two forms at table 1 and table 2. Whether one

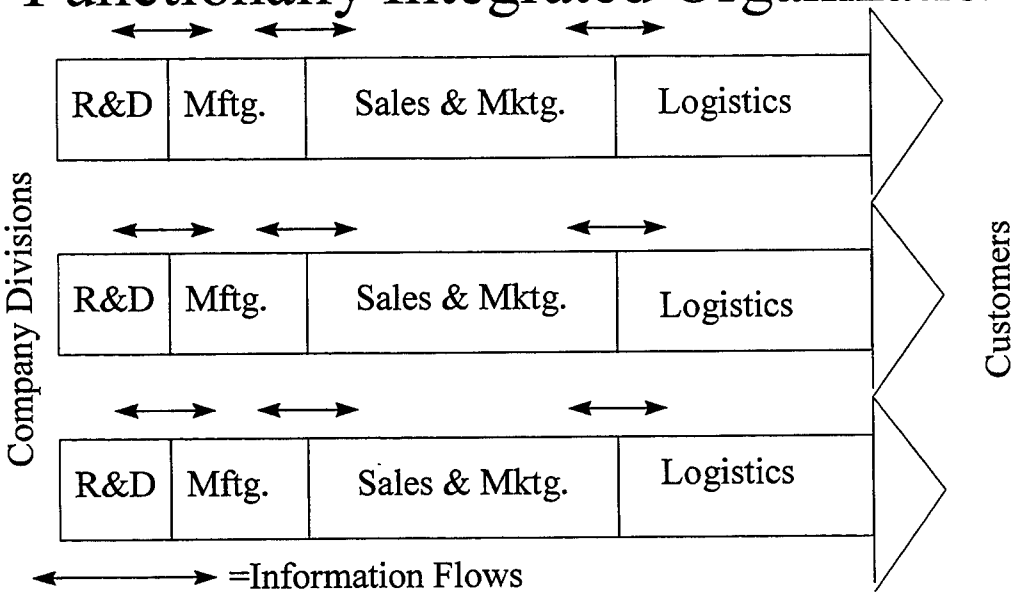
accepts the notion of the Copacino's four steps or Hewitt's four or five stages the last substep of full integration is to cross company boundaries with full integration.



Adapted from: William C. Copacino, Getting Organized for the Late '90s, Traffic Management, January 1994, p. 37.

Figure 2

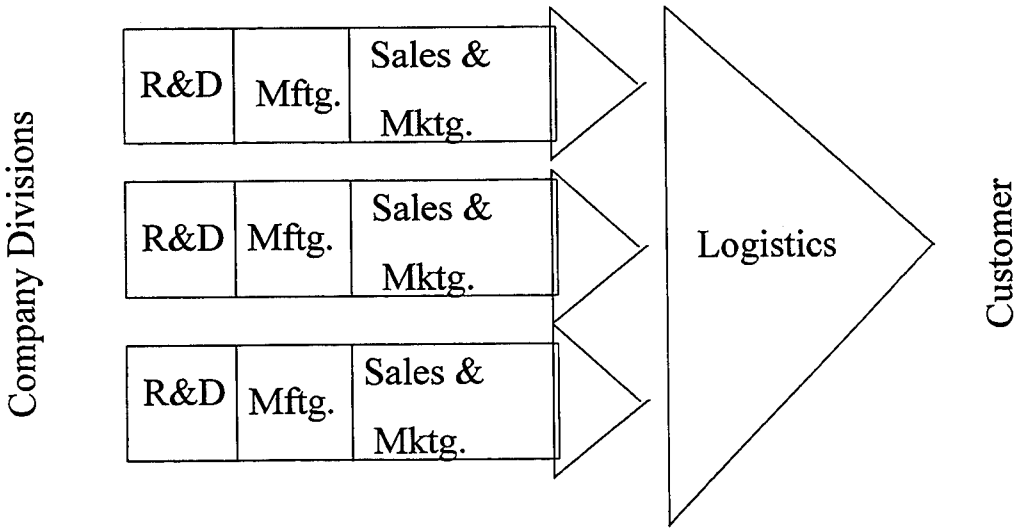
Functionally Integrated Organization



Adapted from: William C. Copacino, Getting Organized for the Late '90s, Traffic Management, January 1994, p. 37.

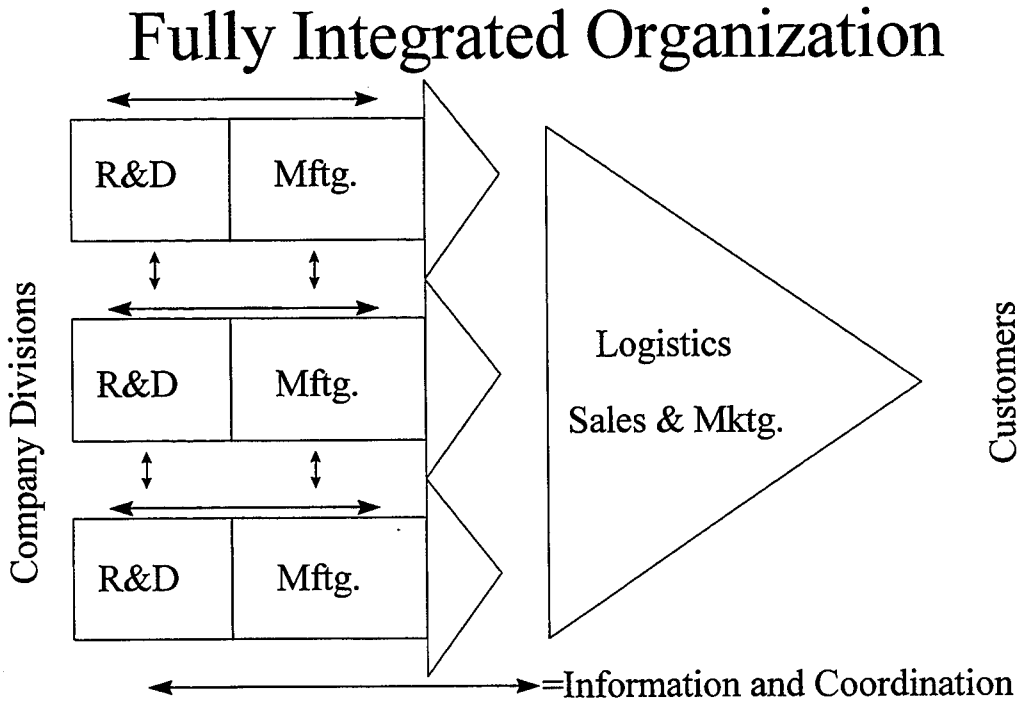
Figure 3

Divisionally Integrated Organization



Adapted from: William C. Copacino, "Getting Organized for the Late 90's," Traffic Management, January 1994, p. 37.

Figure 4



Adapted from: William C. Copacino, Getting Organized for the Late '90s, Traffic Management, January 1994, p. 37.

Figure 5

Table 1
Stages of Logistics Evolution

	Level of Integration	**Objective of Optimization Initiatives**
Stage I	Fragmented Technical Disciplines	Local Quick Fixes
Stage II	Functional Focus	Cost Reduction
Stage III	Broad Scope Logistics	Network Productivity Improvement
Stage IV	Links with Customers and Suppliers	Integrated Network Planning

Source: Seger and Best, Integrated Logistics Management, Chicago: A. T. Kearney, February, 1986, p. 6.

Table 2
Stages of Logistics Evolution (Alternative View)

	Level of Integration	Objective of Optimization Initiatives
Stage A	Fragmented Technical Disciplines	Local Operational Fixes
Stage B	Logistics Functional Integration	Logistics Network Cost Minimization
Stage C	Cross Functional Logistics Integration	Logistics and Asset Rationalization
Stage D	Inter-Company Logistics Coordination	Joint Enterprise Network Rationalization
Stage E	Integrated Intra-Company and Inter-Company Supply Chain Process Management	Total Business Process Efficiency and Effectiveness Maximization

Source: Fred Hewitt , "Supply Chain Redesign", The International Journal of Logistics Management, vol. 5, number 2, p. 4.

Keys to Supply Chain Management

In order for a SCM strategy to be successful there are certain criteria which a company must adhere to in order for the strategy to be successful. Hines (1994) offered an overall key to SCM:

> An awareness of what the complete value stream seeks to achieve, with a focus by all the individual companies on the demands and interests of the ultimate consumers of the products or devices produced. A dynamic transparency between the firms, so that each can proactively assist ant of the others, as well as reacting rapidly to others changing needs and circumstances. A range of new tools and techniques will be employed not just within or between pairs of companies but right along the value added chain, from raw material supplier to the ultimate point of consumption (and indeed beyond the

> point of recycling and reuse). A shared strategy that ensures that improvements are continuous and particularly focused where existing constraints and weaknesses exist, rather than on the parts that currently enjoy the best resources. As such, improvements are likely to be carried out not only within a single organization but also as part of inter-company cross-functional teams within a range of other value stream partners. (p. 30)

The ultimate key that lays separate from all the others and from which the other keys will focus on is that the companies in the supply chain "must recognize end-user customer service level requirements" (T. Jones and D. Riley 1987, p. 97). Without this all other efforts are destined to failure. The other keys to a successful SCM strategy fall into one of four categories:

1) Management and vision.
2) Cooperation.
3) Information and communication.
4) Performance.

Management and Vision

The management and vision keys to SCM are:

1) SCM must be "coordinated by a senior level executive who reports directly to the CEO or to the senior operating officer" (Battaglia 1994, p. 49).
2) Management must "develop appropriate policies and procedures for managing the supply chain as a single entity" (T. Jones and D. Riley 1987, p. 97).
3) All the entities in the supply chain must have a "shared vision of the organization, high quality relationships based on two pillars of communication

and a basis for evaluating trade-offs and accurate information" (Grange 1994, p. 43).

Cooperation

The cooperation keys to SCM are:

1) Retailers, manufacturers, and suppliers must maintain a high level of trust because of the sharing of confidential information (Cooke 1992, p. 59).
2) "Joint reduction of inventories, focus on channel wide cost efficiencies, long-term horizon, information sharing, coordination between levels of firms, joint planning, reduced supplier, distributor, and carrier base to improve coordination, channel leadership, shared risks and rewards, emphasis on speed and velocity of inventory, operations and information" (Cooper and Humphreys 1994, p. 27).

Information and Communication

The information and communication keys to SCM are:

1) Companies in the chain must have "data integration that allows for rapid retrieval and transmission of information" (Lee and Billington 1992, pp. 67-68).
2) "Each level within the chain must use consistent planning tools and processes, you must integrate higher level needs and lower level demands, communication must be effective and timely" (J. Turner 1993, p. 52).

3) The SCM structure must be able to handle speed. "Any supply chain enhancement will lead to a faster flow of information, materials or both. You must look at both information and material flows" (Scott and Westbrook 1991, p. 30).

Performance

The performance keys to SCM are:

1) Companies in the chain must "define where to position inventories along the supply chain and how much to stock" (T. Jones and D. Riley 1987, p. 97).

The other performance keys to SCM are stated by Lee and Billington (1992):

2) Companies must "understand the sources of uncertainties and the magnitude of their impact, such as transit times. Document and track these variables and eliminate root causes of problems."
3) "Hold company divisions to the same service standards for both internal and external customers."
4) "Realize that as uncertainties change, suppliers become more or less reliable as well as demand becoming more or less predictable."
5) "Take into consideration the impact of decisions on other operational factors (e.g. changing mode of transportation on inventory)." (p. 68) This impact must be considered across firm boundaries.

Implementing Supply Chain Management

When implementing an SCM strategy there are eight actions a company must perform to ensure the best possibility of successful implementation. The seven actions needed to implement an SCM strategy are:

1) Strategy.
2) Conceptual framework.
3) Implementation framework.
4) Change management plan.
5) Customer research.
6) Benchmark and reengineer processes.
7) Reorganization.
8) Establish performance measurements.

Strategy

To implement SCM a company must define its strategy, resolve how it wants to manage change and commit to work over a long period of time to achieve high levels of operational effectiveness (Battaglia and Tyndall 1991, p. 42). While doing this the company must establish a clear corporate mission statement to send the company in the right direction. The company must also determine how it will choose its partners in supply chain relationships.

Conceptual Framework

After the strategy for implementation has been devised the next step is to come up with a conceptual framework for the SCM strategy. Battaglia and Tyndall (1991) created an SCM "pyramid" based on the McKinsey's "7S" (i.e. shared values, strategy, structure, systems, staff, style, and skills) model to assist in corporate efforts to implement SCM. The pyramid consists of:

Shared Values
- Implement world class SCM

Measurements
- Supplier performance - Manufacturing performance - Capacity utilization
- Inventory investment - Cost effectiveness - Service levels
- Customer Satisfaction

Staff Skills/Style
- Assure adequate staff resources - Build required staff skills
- Create mulitfunctional integrated teamwork approach

Subsystems
- Forecasting - Capacity planning - Production and vendor scheduling
- Inventory status - MRP - Warehouse management
- Lead time management - Logistics maps - Order management

Master Systems
- Business planning systems - MRP systems - DRP systems
- Customer service systems

Structure/Information Technology
- Suppliers - Marketing - Logistics - Manufacturing - Transportation
- Internal distribution - Sales administration - Distributors

Policies/Objectives
- Inventory - Manufacturing - Purchasing - Distribution - Transportation
- Product handling - Service level

Strategies
- Customer and supplier alliances - Superior relative quality

- Productivity/cost effectiveness - Innovative products and services
- Best customer service in the industry

Basic Elements

- Develop and produce the products and services customers want
- Deliver these products and services on a timely basis (p. 43)

Implementation Framework

The company must have an implementation framework so as to know where to begin on the road to SCM. There is no standard model for the implementation framework. How a company develops an implementation framework is dependent on its business and circumstances. However, to develop the implementation framework the company must take into consideration the three stages of implementing SCM and the three perspectives of SCM. Turner (1993) described the three stages of SCM as:

> Stage I. Controlling finished goods transportation and warehousing, and piecemeal automation. Emphasis is on the importance of today's work.
> Stage II. Tactical approach - integration of finished goods distribution to satisfy customer demand. Integrate inbound transportation, customer service and order processing. Emphasis in this stage is increasing overall profitability.
> Stage III. Strategic approach - combine material management and physical distribution and integrate the entire process. Logistics interacts and supports other business functions and is fully incorporated into the company strategy. (p.53)

Some companies may begin in a more advanced stage than others. Therefore, it is important for the company to recognize what stage they are in before devising the implementation framework.

Stevens (1989) stated that the three perspectives of SCM are:

> Strategic perspective - Develop objectives and policies, shape the chain in terms of key facilities and their locations, the company's

competitive package detailing balances between availability, service, lead-time, technical support, and after sales support and an organization structure that bridges functional barriers.

Tactical perspective - To focus on the means by which strategic perspectives can be realized devising complimentary goals and objectives for each function to provide balance, also to determine tools, approaches and resources necessary to provide the information infrastructure.

Operational perspective - Detailed systems and procedures to ensure controls and performance measures are in place.

Change Management Plan

Since the adoption of SCM will undoubtedly require many significant changes in most companies, it is important that they recognize that change will occur and have some sort of a plan to deal with change. Of particular importance is that there must be a plan between supply chain partners to accommodate changes that are bound to occur during the normal cycles of business. "Changes must be planned into the network. Companies must study in advance the benefits or costs of changes. New policies may improve performance or reduce costs" (T. Davis 1993, pp. 36-37). Currently the most frequently adopted change platform is the practice of total quality management, although there are other approaches that can be used (Battaglia and Tyndall 1991, p. 34).

Customer Research

Before any physical actions can take place in adopting an SCM strategy, the company must determine the needs and desires of their customers. Customer requirements must be determined and the information found must be used to create a

common mission for all functions involved in the supply network. Internal objectives should not be allowed to dictate day to day operations (How Dupont Forged ...1991, p. 55). In other words, the "first thing is to ask yourself what are the needs of the customer? From there you can benchmark against your opponents" (Vallely 1994, p.31). The company also "must ensure that functional specialists are customer focused. Communication, cooperation, and coordination must improve between departments" (T.R. Davis 1994, p.49).

Grange (1994) added that in addition to directly determining customer requirements the company must also indirectly determine customer requirements by:

> Evaluating the contribution each product line makes to business profitability. The distributed product cost (DPC) represents the real cost to business of moving a product through the supply chain. Include storage, loading and administration and all other costs. Analysis of these costs along the axis of volume and margin shows where the greatest savings can be made to improve efficiency and reduce costs. (p. 44)

Improving efficiency and reducing costs will result an increase in both customer service and satisfaction.

Benchmark and Reengineer Processes

After a company has determined its customer requirements the next action is to benchmark its operations. "Benchmarking current performance will show what is possible given existing circumstances" (T. Davis 1993, pp. 36-37). Harrington (1995) states that when a company benchmarks it should:

> Identify current processes and benchmark performance and cost areas in the chain, understand barriers to change, operate under a higher level mandate, have broad knowledge of what competitors

> are doing/have done and their success/failure and clearly understand the goals and expected outcome of integration efforts and keep those in sight. (p. 34)

After completing the benchmarking the company should reengineer its processes so as to exceed the performance of its benchmarking partner(s). "Process reengineering will break down functional silos starting from the ground up using suppliers, customers, and third parties to achieve results" (Harrington 1995, p. 31). Process reengineering should also be used to help the company control uncertainties by understanding the impact of them thereby reducing or avoiding major problems.

Reorganization

Now that benchmarking and process reengineering is complete, the company has an idea of what type of performance to expect and an idea of how to get there. Reorganization to accomplish those goals is the next step in implementing SCM. Grange (1994) states that a company must:

> Introduce structure and discipline to supply processes, tighten up procedures and take control of all activities in the supply chain such as a structured replenishment system (JIT), service level management, volume related review frequencies, and buying quantities relating to efficiency and productivity criteria. (p. 34)

The company should also reorganize toward the principles of total quality management. Harrington (1995) recommends:

> Team based organization - restructuring toward self-management, the idea of competing through people with increased information sharing throughout the organization, customer oriented measures of results and finally leadership replaces management. New jobs for management and supervisors are to eliminate non-value added activities, build team competence and skills, educate and coach,

and define boundaries and linkages. (p. 31)

Reorganization should also include the financial and accounting areas through the use of activity based costing (ABC). The use of ABC determines the expense of everything done to a part as it goes through the supply chain to determine where and how much value is lost (Henkoff 1994, p. 74). Pohlen and Lalonde (1994) found that:

> ABC analysis allows managers to pinpoint the activities, products, services, or customers consuming overhead resources. Managers can examine techniques to reduce or eliminate resource consumption. Techniques can focus on improving activity efficiency by reducing the number of times the activity must be performed, eliminating unnecessary or redundant activities, selecting a less costly alternative, or using a single activity to accomplish multiple functions. (p. 8)

Establish Performance Measurements

Presumably, the company is ready to go out and provide world class products and service to their customers at the lowest possible cost and highest efficiency by this point. How does the company know that it is being successful? The answer, in addition to asking the customers on a continuous basis, is through the use of performance measurements and standards. On the surface, selecting and implementing performance measures would appear to be a simple task, but it is one of the most extremely difficult action to accomplish successfully. The key issues in the performance measurements area are:

1) What is going to be measured?

2) How is it going to be measured?

3) Who is going to measure it?

4) What is an acceptable performance level?

5) What unnatural behavior may be created in order to accomplish a performance level?

6) How can a performance measure be formulated to deter unnatural behavior?

After these issues are resolved there are certain areas of performance that must be addressed. Lee and Billington (1992) determined that companies:

> Must adequately define customer service and make complete measurements of customer satisfaction using line item fill rates, completed order fill rates, total order cycle time, total order response time, average backorder levels, average lateness or earliness and backorder profile (1 week, 2 weeks, etc.). (p. 67)

Barriers to Supply Chain Management

As with any innovation there will always be some amount of resistance to the change. A company's attempt to adopt an SCM strategy is no exception to the resistance rule. The basic barrier in changing to SCM is "a lack of belief that it can be done" (Scott and Westbrook 1991, p. 24). The first barrier to change relates to the historical attitude toward logistics. "Distribution and logistics are functions that many companies don't see as a source of competitive advantage, top management has a mental image of distribution and logistics as that of a warehouse where inventory is mislaid, products are inaccurately shipped and picked and half the warehouse operators time is wasted" (T.R. Davis 1994, p. 46).

Communication and information barriers exist as well. Companies have the perception that information disclosure is a loss of power (Chow et al. 1994, p. 22). Many

companies have "closed communication discouraging lower level involvement, breaking down functional barriers, and lining up different department MBO's" (T.R. Davis 1994, p. 46). Since communication and information are keys to SCM these barriers must be torn down.

Complexity of an SCM system creates another barrier. Lalonde and Masters (1994) stated that:

> New systems are much more complicated than the systems and procedures they replace. SKU level items flow across firm boundaries in near real time with great precision and reliability. Low inventory levels place the entire operation at risk to errors at any level of the system. High trust is required both within and outside the firm. SCM requires the sharing of highly sensitive sales data and given candid estimates of production schedules, shipping status and delivery dates. (p. 46)

"Establishing clarity about what is to be achieved and where to start and a lack of commitment and understanding by management and staff to make it happen" (Scott and Westbrook 1991, p. 24) provides another barrier. There are "difficulties in quantifying the benefits associated with change. Typical decision criteria like Net Present Value are not easily calculated forcing advocates to rely on qualitative arguments" (T. Davis 1993, p. 40). These two barriers dissuade prospective SCM implementers from acting.

Organization systems form the final barrier to the adoption of an SCM strategy. "Most organizational systems are designed to create winners and losers and do not reward working together for system optimization" (T. Davis 1993, p. 36). "Multiple managers, manufacturing, operations, logistics, material, distribution, and transportation have responsibility for different parts of the chain and product design process design

approaches that ignore implications in the supply chain" (Lee and Billington 1992, p. 65, 70) are other organization systems that impede the adoption of SCM.

Eliminating Barriers to Supply Chain Management

The numerous barriers discussed in the previous section should not dissuade companies from adopting SCM. There are ways and means for these barriers to be eliminated, although it will not always be easy. Logistics managers play the integral role in eliminating these barriers by first eliminating the stereotypes. "Logistics managers must push management to think in cross-functional, boundary spanning, integrated supply chain functions" (Copacino May 1994, p. 29). They must also provide to top management "comparisons with other organizations to provide proof that it can be done" (Scott and Westbrook 1991, p. 26).

In order to eliminate the other barriers companies must make all the current participants in the logistics structure, participants in the SCM structure. There should be "joint development of supply chain management between corporate headquarters, divisions, and plant management (shared value approach) and adopt Electronic Data Interchange (EDI) technology" (Battaglia and Tyndall 1991, p. 45).

Once top management gets interested, a cost study of the logistics function can be performed to show the magnitude and impact of logistics costs in the company. This should ensure top level commitment and continuous support for SCM. Following that the entire company can become committed by "aligning strategies and encouraging practices

that achieve common goals as well as physically redesigning the movement of goods to maximize value and minimize costs" (Jenkins 1995, p. 71).

Actions to Improve Supply Chain Performance

T. Davis (1993) found that there are numerous ways that a company can improve its supply chain performance. He divided these ways into three components; supplier performance, manufacturing, and customer demand. He further subdivided the three components into two subcomponents; product and process. The specific actions follow.

Supplier Performance

The product actions are:

1) Using common components and subassemblies in many products (to pool risk of stockouts).
2) Follow industry standards (to increase part availability).
3) Share information with strategic partners.

The process actions are:

1) Reward good performance (based on ship date, not delivery date).
2) Measure transportation performance separately.
3) Subcontract inbound freight handling.
4) Source locally (to shorten lead times).

5) Review stocks more frequently.

Manufacturing

The product actions are:

1) Lower tolerances.

2) Pool engineering change orders.

3) Use standard processes.

4) Promote DFM, DFA, etc.

5) Produce a generic product.

The process actions are:

1) Remove bottlenecks.

2) Size buffers appropriately.

3) Reduce setups.

4) Shorten cycle times.

5) Introduce self managed work teams.

6) Install buffer capacity.

Customer Demand

The product actions are:

1) Reduce product offerings and options.

2) Design for localization.

3) Manage delivery expectations (service requirements).

The process actions are:

1) Adjust finished goods inventory safety stocks.

2) Change transportation mode.

3) Implement better data systems.

4) Introduce improved forecasting techniques.

5) Subcontract distribution operations.

6) Build near customers. (p.45)

Benefits of Supply Chain Management

There are many benefits associated with a change to an SCM strategy. These benefits fall into the tangible and intangible category. The following sections summarize the benefits that have been reported by companies that have begun, or have made the change.

Tangible Benefits

Among the tangible benefits are "Improved customer service, minimization of stocks at all stages in the supply chain, no stockouts and a lower total cost to the business" (Horsley 1993, p. 42). Other benefits include reduced total costs, improved customer satisfaction, improved order fill rates, lower handling costs, lower transportation costs, lower production costs, increased sales, increased inventory turns. All of these benefits add up to increased profitability and strength for the company.

Intangible Benefits

The intangible benefits include "improved teamwork and cooperation among employees, especially those normally separated by either business function or geography and greatly improved customer focus" (T. Davis 1993, p. 35). Other reported intangible benefits are: better relationships with suppliers, improved agility to respond to demand pattern shifts, and a better allowance for postponement of processes for better customer service.

Measuring Supply Chain Performance

The final step in the implementation of an SCM strategy is to measure performance across the supply chain. Since SCM is a complex and different strategy from those used in the past, measuring the performance of the supply chain involves different measures used in different ways. Battaglia and Tyndall (1991) found through experience that:

> Traditional measures of departmental and functional activity, such as product cost of service, are not very meaningful in supply chain management. Supply chain management uses total cost savings, market share, cash flow, return on assets and service improvement (the key is to measure performance across all areas of the business). (p.44)

Caplice and Sheffi (1994) state that measures used to capture the performance of a transformational process fall into one of three primary dimensions: utilization, productivity, and effectiveness:

> Utilization is a measure of input usage and is usually presented as a ratio or percentage of the actual amount of an input used to some norm value. Productivity is a measure of transformational efficiency and is typically reported as the ratio of actual outputs

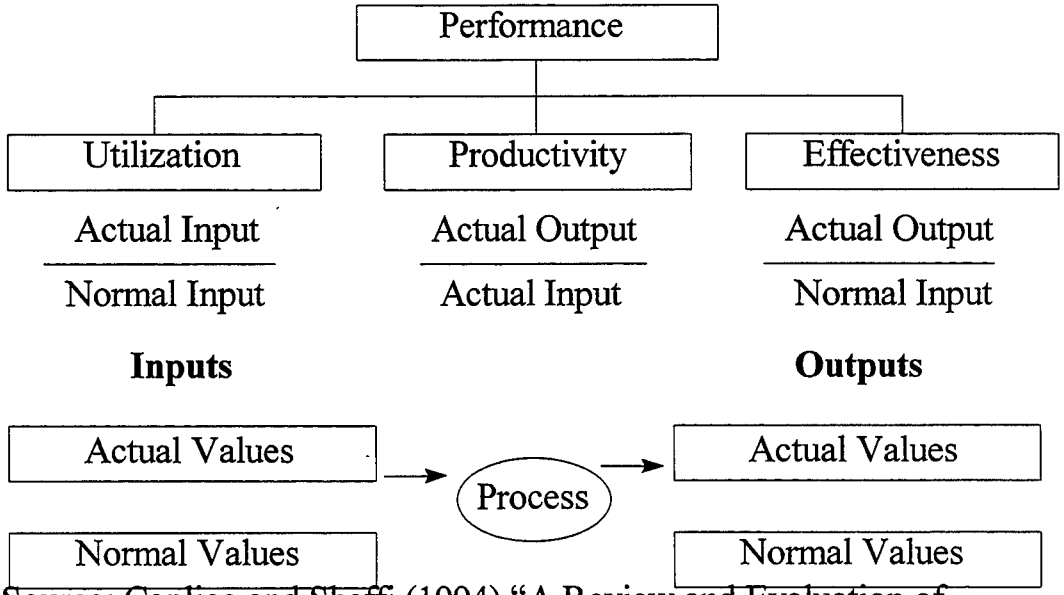
> produced to actual inputs consumed. Effectiveness is a measure of the quality of the process output and is typically reported as a ratio of actual output to a norm (predetermined or competitive standards) output. (p. 18)

Figure 6 illustrates how each dimension captures a unique aspect of the process, while together, they capture it all. Table 3 provides some examples of the dimensions in use.

Caplice and Sheffi (1994) also state that when modifying the performance measurements for SCM:

> A system should be developed to evaluate the usefulness of logistics performance metrics and to identify if any tradeoffs are present when using the metric. Use the system to classify and critique existing performance measures from a process rather than a functionality. There are four common problems with measurement criteria:
>
> 1) under determination - does not measure all aspects of the process.
> 2) comparability - not comparable across periods, shipments, or firms.

The Three Performance Dimensions



Source: Caplice and Sheffi (1994) "A Review and Evaluation of Logistics Metrics", The International Journal of Logistics Management, vol. 5, number 2, p. 19.

Figure 6

Table 3
Some Utilization, Productivity, and Effectiveness Metrics Used in Logistics Practice

Dimension	Form of Metric	Examples of Metrics
Utilization	Actual Input/Norm Input	Labor hours used/budgeted hours Area of warehouse occupied/total area Hours of machine use/machine capacity
Productivity	Actual Output/Actual Input	Ton-miles delivered/costs incurred Orders processed/# hours of labor # pallets unloaded/hour of dock time
Effectiveness	Actual Output/Norm Output	# items filled/# items requested # of shipments on time/# shipments sent # transactions w/o error/# transactions

Source: Caplice and Sheffi, "A Review and Evaluation of Logistics Metrics", The International Journal of Logistics Management, vol. 5, number 2, p.14.

3) measurement error - responsibility and causality are incorrectly assigned.
4) human error - where incentives harmful to the firm are created. (p. 11,14)

Evaluation criteria for individual performance measures are located at table 4.

Table 4
Definitions of the Eight Metric Evaluation Criteria

Criterion	Description
Validity	The metric accurately captures the events and activities being measured and controls for any exogenous factors.
Robustness	The metric is interpreted similarly by the users, is comparable across time, location, & organizations, and is repeatable.
Usefulness	The metric is readily understandable by the decision maker and provides a guide for action to be taken.
Integration	The metric includes all relevant aspects of the process and promotes coordination across functions and divisions.
Economy	The benefits of using the metric outweigh the costs of data collection, analysis, and reporting.
Compatibility	The metric is compatible with the existing information, material, and cash flows and systems in the organization.
Level of Detail	The metric provides a sufficient degree of granularity or aggregation for the user.
Behavioral Soundness	The metric minimizes incentives for counter-productive acts or game-playing and is presented in a useful form.

Source: Caplice and Sheffi, "A Review and Evaluation of Logistics Metrics", The International Journal of Logistics Management, vol. 5, number 2, p.14.

Pittiglio et al. (1993) concurred with Caplice and Sheffi's performance measurement from a process standpoint stating:

> Metrics must be process oriented, define the supply chain quantitatively and meet management needs (for balance). Companies should use standard metrics to;
> 1) avoid internal conflicts
> 2) clarify scope of supply chain processes and,
> 3) facilitate external benchmarking. (pp. 3,4)

When developing performance measures program for SCM Chow et al. (1994) found that companies must understand that:

> No one measure will suffice for logistics performance. Instead, the objectives for researchers and managers is to find a set of measures which collectively capture most, if not all, of the performance dimensions thought to be important, over both the long and short-term horizons. There are seven dimensions of what performance means: effectiveness, efficiency, quality, productivity, quality of work life, innovation and profitability/budgetability. (pp. 23-24)

A customer focus is of paramount importance when developing performance measures a company will use. "Measures should be dependent on end customer needs (based on what the critical success factors are for the customer)" (Harland et al. 1993, p. 22). "Metrics should be directly related to customer satisfaction, for example, use inventory turns as a measure of inventories as well as measuring response time and service fill rates to customers" (Lee and Billington 1992, p. 66). "Customer service goals form the basis of internal measurements (e.g. product availability, reliability) and external measurements (e.g. transportation performance (damage, on-time, etc.))" (How Dupont Forged a Quality Supply Chain 1991, p. 57). Customer focused performance measures that depend on customer demand are "the most difficult to manage, but customer demand uncertainty can be measured by knowing the average demand and the variability" (T. Davis 1993, p. 38). Not all measures for a customer focus are direct, such as order fill and on-time delivery, supplier and manufacturer frequency uncertainty can also play a role. T. Davis (1993) states customer focused measurements also:

> measure uncertainties of suppliers (on-time performance, average lateness and degree of inconsistency (standard deviation)) to tell you characteristics of suppliers and of manufacturing frequency of downtime (for the entire process), repair time and variation of repair time by focusing on the probability distribution of performance. The reliability of these two measures determines inventory investment. Suppliers performance and the factory's response determine

downstream customer service. (p. 38)

When performed properly, all of these considerations will lead to an effective performance measurement system. Once the effective performance system is established, the company can concentrate on making adjustments to the supply chain and fine tune performance. It is also important to note that performance measurement system review is an ongoing process. As customer requirements, technology and the company change, the performance measurement system must be reviewed and changed as needed.

Warehouse Performance Measures

In conducting this research, several sources were examined to determine as many common warehouse performance as possible. This was necessary to properly execute the survey research. Among the sources used are: Mentzer and Konrad (1991), Jenkins C. (1990), Caplice and Sheffi (1994), and "Integrated Supply Chain Performance Measurement" (1994). The measures used from the cited sources are mixed and matched based on the purpose of the measure, therefore it is impractical to cite sources for each individual measure. A listing of all the performance measures found in the literature is located at Appendix C.

Research Needs

The relevant literature makes several points that are especially important to this research. First, Battaglia and Tyndall (1991), and Chow et al. (1994) indicate that companies which use a supply chain management logistics strategy use different types of

performance metrics. These metrics evaluate performance across the company, break down functional activities, and recognize the value-add function of logistics to the company. Research is needed to determine the differences, if any, in performance measurement systems between those companies that use an SCM strategy and those that do not. Second, as noted by Harrington (1995), only a third of North American companies have begun integrating with their suppliers. This shows that even though many companies see SCM in a positive light, not many are implementing the strategy. Therefore, a more detailed analysis is required of where companies stand in the implementation of SCM.

Finally, there no research that indicates whether companies believe their measures of evaluating performance are effective or whether companies using an SCM approach believe their measures are more effective than the measures used in traditional logistics strategies. This would indicate whether further research is required to develop new types of measures.

The intent of this research is exploratory. It attempts to evaluate the extent of SCM implementation among companies which operate, own, and/or use warehouses in the their business. It also will determine the most widely used performance measures in warehouse operations and whether the executives in these companies believe their measures are effective in evaluating performance.

Chapter 3

Research Methodology

Introduction

This chapter details the research needs described previously and transforms them into research questions and hypotheses which can be evaluated through the use of data obtained through the use of a survey. It also describes how the survey was administered to the sample group and the construction of the survey. Finally, it describes the method of analysis used to evaluate the data obtained from the survey.

Research Questions and Hypothesis

Research Questions

The first purpose of this research is to determine the level of implementation of SCM in companies that use warehouses in their operations. Therefore, research questions one and two are:

Q1. What percentage of companies that use warehouses as part of their operations have implemented an SCM logistics strategy?

Q2. What percentage of companies that use warehouses as part of their operations are planning, or in the process of implementing, an SCM logistics strategy?

Since unit of measures are an important part of many individual performance measurements, the most widely used units of measure must be identified. Research question three is:

Q3. What are the most widely used units of measurement among warehouses in the aggregate, among SCM practitioners, and among those companies which use a more traditional logistics strategy?

Since the literature supports the notion that performance measures used in SCM are different than those used in a traditional logistics strategy, it is important to identify the most widely used performance measures. Research question four is:

Q4: What are the most widely used performance measures in the aggregate, among SCM practitioners, and among those companies which use a more traditional logistics strategy?

The review of the literature presents several examples of how the implementation of an SCM strategy has benefited companies. It must be determined whether companies find their performance measures to be effective in assisting the management to make beneficial decisions for their company. Research question five is:

Q5. What are management's views regarding the effectiveness of the performance measurements used in their company in the aggregate, among SCM practitioners, and among those companies which use a more traditional logistics strategy?

The way that companies treat their warehouse operations, in financial terms (i.e. cost centers, revenue centers, etc.), is important in determining how a company views its logistics operations. Research question six is:

Q6: Do companies consider their warehouse operations to be profit centers, cost centers, revenue centers, investment centers, or some other type of financial center in the aggregate, among SCM practitioners, and among those companies which use a more traditional logistics strategy?

Research Hypotheses

Three hypothesis will be tested using the data obtained from the survey. The literature shows that an SCM strategy requires a different type and mix of performance measures than those used in traditional logistics strategies. The first hypothesis is:

H1: The most common performance measures will differ between SCM firms and traditional logistics strategy firms.

In an SCM strategy, companies view their logistics operations in financial terms rather than cost centers to show the value-added to the company by performing logistics functions. The second hypothesis is:

H2: The level of SCM implementation is related to whether warehouses are treated by their companies as cost centers, revenue centers, profit centers, or investment centers.

Because of all the accolades and evidence of increased performance in companies when adopting an SCM strategy it would seem that the level of effectiveness of the

performance measurement system would relate to the level of SCM implementation. It would also hold that companies which have adopted an SCM strategy would possess the level of effectiveness of their performance measurements at a higher level than companies using a traditional logistics strategy. Therefore, the following is proposed as hypothesis 3:

H3: A company's perception of effectiveness of its performance measures is related to level of implementation of an SCM strategy in the company.

Survey Construction

The survey was constructed in order to best identify the performance measures used by companies. A copy of the complete survey and cover letter are located in appendix A. The survey consists of common performance measures used in warehouses today obtained from Mentzer and Konrad (1991), Caplice and Sheffi (1994), Ackerman (1990), Jenkins, C. (1990), and Integrated Supply Chain Performance Measurement (1994). The Performance Measures are broken down into five categories:
1) order fulfillment; 2) storage; 3) receiving; 4) customer satisfaction; and 5) cost and earnings.

Order fulfillment is broken down into five subcategories: 1) labor and equipment productivity; 2) overall productivity; 3) labor, equipment and overall utilization; 4) labor and equipment performance; and 5) overall performance .

Receiving is broken down into two subcategories: 1) labor, equipment, and overall productivity; and 2) utilization and performance.

Many of the individual performance measures use a specific unit of measure. The first survey question asks to give the primary unit(s) of measure used in the respondent's system. This allowed for the survey to be significantly more brief and to obtain a higher response rates, while still obtaining the data necessary to complete the research. How warehouse space is measured is another question asked to allow for brevity in the survey.

The last portion of the survey consists of demographic data to conduct hypothesis testing and to conduct analyses on the extent of SCM implementation in warehousing. Demographic questions included: the position title of the respondent, the company's core business, the size of the company (in terms of annual revenue), the type of warehousing used (public, private, contract, and/or third party provider), and the way the company's warehouses are treated financially (cost centers, revenue centers, etc.). A portion of the demographic section also included four questions designed to determine the level of implementation of SCM in the company. These questions addressed the following key SCM areas: 1) overall implementation status; 2) integrated process implementation; 3) technology and information implementation; and 4) structure, people and culture implementation. The level of implementation of SCM was rated by the respondent on a scale of 0 (not planned) to 7 (fully implemented). These categories were selected based on research performed by Mercer Management Consulting.

Finally, since there may be performance measures or other terms used in different companies which are not included in the review of the literature, a write in "other" response was included in each section to ensure that all the relevant data is collected.

Survey Administration

In an attempt to establish content validity and to evaluate the organization of the survey, a pretest was sent to ten logistics executives. Because of the sophisticated nature of the audience, a large pre-test sample was not used, although the pre-test sample was chosen to represent the target population as closely as possible. A follow-up telephone call was made to all the pre-test survey recipients to clarify any comments that were made about the content and clarity of the survey. Nine of the pre-tests were returned. As a result of the pre-test very minor changes were made to the survey to confirm content validity and the pre-test responses were included in the overall data analysis. An initial mailing of the survey and a cover letter was sent to 982 logistics managers, supervisors, and executives working for companies that use warehouse operations. The sample was selected from the membership list of the Warehousing Education and Research Council (WERC) after screening out all academic institutions and consulting firms. A second mailing was sent in January 1996 to solicit more responses from the sample.

A total sample size of 992 was used in this research. The effective sample size was reduced to 980 because either the intended respondent left the firm, or the firm's business was not relevant to this research. The initial mailing produced 169 usable responses, and an additional mailing of the survey and cover letter produced an additional 13 usable responses, for a total of 182 responses. Thus, an overall responses rate of 18.6% was achieved. As of this writing, the number of response to the second mailing was too small to allow for non-response bias testing.

Method of Data Analysis

The data analysis was performed using basic statistics, factor analysis to determine SCM construct validity, Chi-square analysis to test hypothesis 2, and Canonical discriminant analysis to test hypotheses 1 and 3. These methods were applied using the SAS version 6.08 software on an IBM mainframe computer. The program considered all respondents that had a mean response of 4 or greater among the four SCM demographical questions (questions 23 through 26; see appendix A) to be a practitioner of an SCM strategy. Respondents with a mean response of less than 4 were considered in the process of implementing an SCM strategy and respondents with a mean response of zero had no plans to implement SCM. A factor analysis of the constructs was conducted to determine if the four items in this SCM construct are valid. The results of this analysis showed that the four SCM items loaded on one factor. The factor pattern for this analysis was .94202 for strategy, .93787 for integrated processes, .88617 for technology and information, and .92614 for structure, people, and culture. In addition to the factor analysis, correlation analysis using Cronbach's Alpha was used. The analysis yielded an alpha of .941949, indicating that the construct for determining the level of SCM implementation is valid. Any interpretations or conclusions made from the analysis of the sample data will be generalizable only to the WERC population, and not to warehouses in general.

Chapter 4

Results

Demographics

Table 5 shows the demographics for the respondent's description of their core business. The possible responses for this question are: manufacturing, non-manufacturing, wholesaler/distributor, retailer, public warehouse, contract warehouse, or other. Frequencies of the responses are listed in descending order from most to least frequently chosen. Manufacturers that operate warehouses were the most frequent respondents.

Table 5
Respondent Core Business

Response	Frequency	Percent of Respondents	Cumulative Percent of Respondents
Manufacturing	86	47.3	47.3
Wholesaler/Distributor	31	17.0	64.3
Public Warehouse	21	11.5	75.8
Retailer	18	9.9	85.7
Other	11	6.0	91.7
Contract Warehouse	10	5.5	97.2
Non-manufacturing	5	2.7	100

The next demographic question was to identify the type of position the respondents hold in their company. This question illustrates the level of involvement the respondents had in warehouse operations. The possible responses are: vice-president, director, manager, supervisor, and other. The large portion of the other responses were

company presidents. Table 6 lists the frequencies and percentages of each response in descending order from most to least frequent. Managers comprised the largest respondent category.

Table 6
Respondents Position/Title

Position/Title	Frequency	Percent of Respondents	Cumulative Percent of Respondents
Manager	90	49.5	49.5
Director	41	22.5	72.0
Vice-president	28	15.4	87.4
Other	16	8.8	96.2
Supervisor	7	3.8	100

Identification of the company size was the next demographic question. Size of the company was asked in terms of annual sales in dollars. Table 7 shows the frequency of each dollar sales category listed in descending order from greatest to least frequent. The most frequent response to this question was sales greater than $1 billion. Four respondents failed to answer this question.

Table 7
Respondent Company Size

Annual Sales	Frequency	Percent of Respondents	Cumulative Percent of Respondents
>$1 billion	61	34.3	34.3
<$100 million	57	32.0	66.3
$100-500 million	39	21.9	88.2
$500 million-$1 billion	21	11.8	100

The financial treatment of the company's warehouses was the next demographic question asked. This question was used to illustrate how companies view their

warehouse operations from a financial perspective. **Research question six** is answered by this question. The possible responses are: profit center, cost center, revenue center, investment center, and other. The frequencies of responses is shown in Table 8 and are listed in descending order from most to least frequent. Most of the "revenue center" responses were from public or contract warehouses. The most frequent response to this question was overwhelmingly "cost center". This may indicate that many companies do not take advantage of the value-add functions of logistics, or cannot quantify them. Therefore, the cost of the logistics is what companies tend to focus on.

Table 9 illustrates the comparison of warehouse financial treatment between SCM and traditional logistics companies. There appears to be no significant difference between the compared groups financial treatment of warehouses. The cause for this may be the inability to quantify the value-add of logistics as stated previously.

Table 8
Warehouse Financial Treatment
(Aggregate)

Financial Treatment	Frequency	Percent of Respondents	Cumulative Percent of Respondents
Cost Center	121	69.5	69.5
Profit Center	42	24.1	93.6
Revenue Center	7	4.0	97.6
Investment Center	3	1.7	99.3
Other	1	.7	100

The next area that was addressed in the demographic section was the type of warehouses used in the respondents operations. Possible responses to this question are: private, contract, public, and third party logistics provider. Respondents could select all

that applied to this question since many companies use more than one type of warehousing. Therefore, there are more responses than surveys returned.

Table 9
Warehouse Financial Treatment
(Traditional Logistics and SCM Comparison)

Financial Treatment	Traditional Percent Responses	SCM Percent Responses
Cost Center	68.3	72.2
Profit Center	25.0	22.2
Revenue Center	4.4	1.9
Investment Center	5.0	1.9
Other	0.0	1.9

Public and contract warehouses were not asked to respond to this question. In addition, there were 2 survey participants that did not respond to this question. Table 10 summarizes the frequency of positive responses and the percentage of total responses to this question from greatest to least for the type of warehousing used. The final column of this table shows the percentage of positive responses relative to the number of respondents (149) to this question. The most common type of warehouse used, in the sample, is private warehousing.

Table 10
Type of Warehousing Used

Type of Warehouse Used	Number of Positive Responses	Percentage of Positive Responses	Cumulative Percentage of Positive Responses	Positive Responses as a Percentage of Respondents
Private	120	52.0	52.0	80.5
Public	51	22.2	74.2	34.2
Contract	35	15.3	89.5	23.5
Third Party Logistics Provider	24	10.5	100	16.1

The Use of Supply Chain Management

This section answers **Research questions 1 and 2**, which identify the percentage of companies that either have implemented, or are planning/in the process of implementing an SCM strategy. The results of the data analysis for these research questions center around the four attributes that identify SCM practitioners. The four attributes are: 1) strategy; 2) integrated processes; 3) technology and information; and 4) structure, people and culture. For a complete description of the attributes, see appendix A, page 105.

The data analysis showed 31 of the 182 respondents (17%) had no plans to adopt an SCM strategy. This means that the value for the SCM construct was zero. The number of companies that are early in the process of adopting supply chain management total 96, or 52.7% of the respondents. This means that the value for the SCM construct was greater than zero but less than 4. This may indicate that supply chain management is becoming an established logistics strategy and is not simply a fad. The number of respondents with a mean score greater than 4, which implies greater than 60% implementation of SCM, among the four SCM indicators totaled 55, or 30.3%. This is an indicator that many companies are well on their way to fully implementing SCM in their companies and are current practitioners of SCM. Table 11 illustrates the mean results for the companies that are in the process of implementing or have implemented SCM.

Four additional indications may be drawn from this data. First, companies appear to be placing their greatest emphasis on information and technology. Second, company strategy follows closely behind information and technology in the level of emphasis

placed by companies on their operations. Third, people, structure, and culture may be receiving the least amount of emphasis as companies move toward SCM and improving their execution of logistics. Fourth, in companies that have adopted SCM, the tighter standard deviation fit of the mean responses may imply the order of implementation of the four SCM construct items.

Table 11
Level of Implementation of Supply Chain Management
(1=planned, 7=fully implemented)

Category	Mean Response	Standard Deviation
Companies in the process of implementing SCM:		
Technology and Information	2.72	1.34
Strategy	2.33	1.48
Structure, People, and Culture	2.12	1.36
Integrated Process	2.06	1.28
Mean of All Four Attributes	2.31	1.04
Companies that have implemented SCM:		
Technology and Information	5.11	1.10
Strategy	5.04	0.92
Integrated Process	4.80	1.18
Structure, People, and Culture	4.73	0.92
Mean of All Four Attributes	4.92	0.70

Units of Measure

The first question in the survey asked the participants to identify the units of measure that their companies use for measuring performance. The participants were permitted to select as many of the choices as applied to their companies. Tables 12,13, and 14 illustrate the response frequency and percent of respondents for each unit of measure in the aggregate, by traditional logistics, and by SCM, respectively. Each of

these three tables are listed from most to least frequent responses. In the aggregate, and for traditional logistics strategy companies, the top three most used units of measurement are: units/pieces; dollar value; and cartons. The top three units for SCM companies are: dollar value; units/pieces; orders. Table 15 depicts a comparison between the aggregate, traditional, and SCM companies on a percentage basis. It shows that more emphasis is placed on orders and dollar value as units of measure than for traditional logistics companies which emphasize units/pieces. This may be an indicator that SCM companies are more focused on value-added activity and customer service, in terms of their performance measurements, than non-SCM companies.

Table 12
Units of Measure
(Aggregate)

Unit of Measure	Frequency	Percent of Respondents
Units/Pieces	97	53.3
Dollar Value	79	43.4
Cartons	65	35.7
Orders	63	34.6
Lines	58	31.9
Weight	47	25.8
Pallets	46	25.3
Other	17	9.3
Invoices	12	6.6

Table 13
Units of Measurement
(Traditional Logistics)

Unit of Measure	Frequency	Percent of Respondents
Units/Pieces	69	54.3
Dollar Value	48	37.8
Cartons	44	34.7
Orders	40	31.5
Lines	40	31.5
Weight	33	26.0
Pallets	33	26.0
Invoices	9	7.1
Other	7	5.5

Table 14
Units of Measurement
(SCM Companies)

Unit of Measure	Frequency	Percent of Respondents
Dollar Value	31	56.4
Units/Pieces	28	50.9
Orders	23	41.8
Cartons	21	38.2
Lines	18	32.7
Weight	14	25.5
Pallets	13	23.6
Other	10	18.2
Invoices	3	5.5

Table 15
Units of Measure
(Traditional Logistics and SCM Comparison)

Unit of Measure	Aggregate Percentages	Traditional Percentages	SCM Percentages
Units/Pieces	53.3	54.3	50.9
Dollar Value	43.4	37.8	56.4
Cartons	35.7	34.7	38.2
Orders	34.6	31.5	41.8
Lines	31.9	31.5	32.7
Weight	25.8	26.0	25.5
Pallets	25.3	26.0	23.6
Other	9.3	5.5	18.2
Invoices	6.6	7.1	5.5

Performance Measures

Order Fulfillment Measures

The first section of the survey asked the participants to identify those performance measures that their companies use in the decision making process in order fulfillment. This section was subdivided into five areas: 1) labor and equipment productivity; 2) overall productivity; 3) labor, equipment, and overall utilization; 4) labor and equipment performance and; 5) overall performance. Participants were asked to check all the measures that applied to their companies.

Table 16 shows the aggregate frequencies and percentages of participants selecting metrics which measure labor and equipment productivity in the order fulfillment process. The responses are ranked from most to least frequently. Table 17 compares responses for traditional logistics and SCM participants.

Table 16
Labor and Equipment Productivity in Order Fulfillment
(Aggregate)

Measure	Frequency	Percent
Total (unit of measure) picked/total labor hours	115	63.2
Total (unit of measure) picked/total labor hours picking	108	59.3
Other	30	16.5
Total value-added/payroll for warehouse employment	25	13.7
Total (unit of measure) picked/total equipment hours	18	9.9
Total value-added/total warehouse employment	15	8.2
Vehicles loaded per door per labor hour	11	6.0
Vehicles loaded per equipment hour	7	3.8

It appears from the data in table 17 that SCM companies tend to focus mainly on labor productivity from a picking perspective. Equipment productivity measurement in order fulfillment appears to not be as important to SCM companies in comparison to traditional logistics companies. Overall, companies seem not to measure equipment productivity in order fulfillment and concentrate mainly on measuring labor productivity. Furthermore, a modest number of all companies (16.5%) have developed some other form of labor/equipment productivity in order fulfillment measure.

Table 17
Labor and Equipment Productivity in Order Fulfillment
(Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
Total (unit of measure) picked/total labor hours	55.9	80.0
Total (unit of measure) picked/total labor hours picking	54.3	70.9
Other	16.5	16.4
Total value-added/payroll for warehouse employment	14.2	12.7
Total (unit of measure) picked/total equipment hours	14.2	0
Total value-added/total warehouse employment	8.7	7.3
Vehicles loaded per door per labor hour	6.3	5.5
Vehicles loaded per equipment hour	3.9	3.6

The next area in order fulfillment metrics that was addressed was overall productivity in order fulfillment. Table 18 depicts the aggregate frequency and percent of positive responses for each overall productivity in order fulfillment measure. The responses are listed from most to least frequently selected.

Table 18
Overall Productivity in Order Fulfillment
(Aggregate)

Measure	Frequency	Percent
Total (unit of measure) picked/total picking costs	91	50.0
Other	44	24.2
Total (unit of measure) loaded/total loading costs	27	14.8
Total number of orders entered/total order entry cost	24	13.2
Total number of invoices processed/total invoice processing cost	19	10.4
Vehicles loaded/total loading cost	13	7.1
Total numbers of orders scheduled/total order scheduling cost	9	4.9

As in the labor and equipment productivity measures, it appears in the aggregate, that companies overall tend focus performance measurement efforts on picking and associated costs than on the other measures. Also, a large percentage of companies have developed additional measures that are not documented in the current literature. Table 19 compares the responses of traditional logistics versus SCM companies.

Table 19
Overall Productivity in Order Fulfillment
(Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
Total (unit of measure) picked/total picking costs	44.1	63.6
Other	23.6	25.5
Total (unit of measure) loaded/total loading costs	14.2	16.4
Total number of orders entered/total order entry cost	6.3	29.1
Total number of invoices processed/total invoice processing cost	7.1	18.2
Vehicles loaded/total loading cost	8.7	3.6
Total numbers of orders scheduled/total order scheduling cost	2.4	10.9

From the comparison table it appears that SCM companies focus more of their performance measurement efforts in overall productivity on order fulfillment rather than on traditional logistics companies. SCM companies also appear to place more emphasis on productivity in order scheduling and order entry that could indicate an increased customer focus of SCM practitioners, since these areas are measured as opposed to only talking about customer focus.

The next area of order fulfillment measures examined is labor, equipment, and overall utilization. Table 20 illustrates the aggregate most frequently used performance measurements in this area by frequency and percent of positive responses.

As in the previous sections, it appears that companies tend to focus measurement efforts towards labor rather than equipment. The majority of companies has not developed measures for this category. Companies appear to use only labor hours and total volume to measure this area.

Table 20
Labor, Equipment, and Overall Utilization in Order Fulfillment
(Aggregate)

Measure	Frequency	Percent
Labor hours picking/labor hours worked	101	55.5
Total volume picked per day/picking capacity per day	70	38.5
Equipment hours used picking/equipment hours available	21	11.5
Average weight per movement/maximum weight capacity per movement	16	8.8
Total equipment downtime in hours/total equipment hours possible	15	8.2
Other	12	6.6

Table 21 illustrates the percentage comparison between traditional logistics and SCM users. From the comparison, it appears that SCM companies place more emphasis in this area overall. The comparison also seems to indicate that SCM companies also place more emphasis on equipment utilization, although only a relatively small amount of companies use equipment utilization measures.

Table 21
Labor, Equipment, and Overall Utilization in Order Fulfillment
(Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
Labor hours picking/labor hours worked	44.1	81.8
Total volume picked per day/picking capacity per day	35.4	45.5
Equipment hours used picking/equipment hours available	13.4	7.3
Average weight per movement/maximum weight capacity per movement	5.5	16.4
Total equipment downtime in hours/total equipment hours possible	6.3	12.7
Other	6.3	7.3

The next area of order fulfillment measures surveyed is labor and equipment performance. In this area, the literature provided only three specific measures to examine. Table 22 illustrates the aggregate use of these measures listed from most to least frequently used by frequency and percentage of positive responses. As in the previous areas, the data indicates that companies place a greater emphasis on labor than on equipment measurements. However, the emphasis seems to be to a lesser degree than previous areas.

Table 22
Labor and Equipment Performance in Order Fulfillment (Aggregate)

Measure	Frequency	Percent
Actual (unit of measure) per labor hour/a standard (unit of measure) per labor hour	97	53.3
Actual equipment cost/budgeted equipment cost	40	22.0
Other	11	6.0
Actual equipment downtime/a standard equipment downtime	10	5.5

Table 23 illustrates the comparison of responses from SCM versus traditional logistics companies on a percentage of positive response basis. The data in this comparison seem to indicate that SCM practitioners use this category of measures to a greater extent than traditional logistics companies. SCM companies also appear to place a greater emphasis on equipment performance measures. The measurement of equipment downtime, as it relates to order fulfillment performance, also appears to be an area of non-emphasis.

Table 23
Labor and Equipment Performance in Order Fulfillment
(Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
Actual (unit of measure) per labor hour/a standard (unit of measure) per labor hour	48.0	65.5
Actual equipment cost/budgeted equipment cost	19.7	27.3
Other	6.3	5.5
Actual equipment downtime/a standard equipment downtime	6.3	3.6

The final section of order fulfillment measures pertains to overall performance measures. The literature yielded 14 measures for this area. Table 24 displays the aggregate positive response rate for these measures listed from most to least frequently selected. Percentage of positive responses are also included in the table.

Table 24 indicates, in the aggregate, that companies use many of these measures. This also may be an indicator that companies need more focus on the customer in this area based on the large number of positive responses to measures which do not involve customer feedback. In this area, of the 4 most frequently used measures, 3 do not involve the customer.

Table 24
Overall Performance in Order Fulfillment
(Aggregate)

Measure	Frequency	Percent
Total number of (unit of measure) shipped per day	100	54.9
Number of incorrect orders/total number of orders	96	52.7
(unit of measure) shipped on time/total (unit of measure) shipped	79	43.4
Total number of (unit of measure) processed per day	74	40.7
Percentage of complete orders received on or before original		

committed date	69	37.9
Number of perfect orders (on time, accurate documentation, no damage)/total number of orders	67	36.8
Lead time from order release to order ready for ship	62	34.1
Number of orders with damages/total number of orders	62	34.1
Lead time from customer order to customer acceptance	59	32.4
(unit of measure) filled from stock/total (unit of measure) requested	59	32.4
Lead time from order entry to order release	44	24.2
Lead time from ready to ship to customer acceptance	27	14.8
(unit of measure) damaged per order	20	11.0
Total value-added per period	11	6.0
Other	11	6.0

Table 25 presents a comparison of overall performance in order fulfillment measures, on a percentage basis, between SCM and traditional logistics companies. In this measurement area, it appears that SCM companies tend to use these measures more frequently and use more measures which require customer feedback. SCM companies also appear to make extensive use of measures which cross company boundaries, such as lead time from customer order to customer acceptance. This may indicate that SCM companies are not only attempting to cross functional and company boundaries, but are also attempting to measure the performance of cross-functional and cross-company activities from the total supply chain perspective.

Table 25
Overall Performance in Order Fulfillment
(Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
Total number of (unit of measure) shipped per day	49.6	67.3
Number of incorrect orders/total number of orders	47.2	65.5
(unit of measure) shipped on time/total (unit of measure) shipped	37.0	58.2
Total number of (unit of measure) processed per day	34.7	54.5
Percentage of complete orders received on or before original committed date	31.5	52.7
Number of perfect orders (on time, accurate documentation, no damage)/total number of orders	34.7	41.8
Lead time from order release to order ready for ship	32.3	38.2
Number of orders with damages/total number of orders	26.8	50.9
Lead time from customer order to customer acceptance	22.8	54.5
(unit of measure) filled from stock/total (unit of measure) requested	28.4	41.8
Lead time from order entry to order release	20.5	32.7
Lead time from ready to ship to customer acceptance	12.6	20.0
(unit of measure) damaged per order	9.5	14.5
Total value-added per period	5.5	7.3
Other	6.3	5.5

Storage Measures

Section 2 of the survey instrument focused on performance measures in the storage area of warehouses. The literature produced very few measures in each of the areas of productivity, utilization, and performance. Therefore, all the measures were combined into a single multi-part question. Table 26 illustrates the aggregate frequency and percentage of use for each measure from most to least frequent. The aggregate data possibly indicates that the measures found in the literature are sufficient to effectively manage the storage area because of the low "other" number of responses. More evidence

to support this possibility is the large number of companies using one or more of these measures. Further evidence may be found later in this research where effectiveness answers are analyzed.

Table 26
Facility and Overall Productivity, Utilization, and Performance in Storage (Aggregate)

Measure	Frequency	Percent
Physical inventory accuracy	116	63.7
Inventory turns	112	61.5
Cycle counting accuracy: number of good counts/total counts	95	52.2
Storage locations used/storage locations available	78	42.9
Actual storage cost/budgeted storage cost	68	37.4
(unit of measure) of inventory per sq./cu. Ft.	59	32.4
Storage costs per unit (cwt., lb., kg)	53	29.1
Average inventory/cost of goods sold	47	25.8
(unit of measure) of inventory/total storage cost	44	24.2
(unit of measure) used per sq./cu. Ft. available	33	18.1
Actual cube utilization/actual cube available	32	17.6
(unit of measure) throughput per sq./cu. Ft.	22	12.1
Other	6	3.3

Table 27 illustrates the comparison of storage performance measures between SCM and traditional logistics companies on a percentage basis. From the comparison it appears that the mostly widely used measures are the same for both SCM and traditional logistics companies. However, as in previous observations, SCM companies appear to make more extensive use of the available performance measures.

Table 27
Facility and Overall Productivity, Utilization, and Performance in Storage (Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
Physical inventory accuracy	60.6	70.9
Inventory turns	55.1	76.4
Cycle counting accuracy: number of good counts/total counts	45.7	67.3
Storage locations used/storage locations available	37.0	56.4
Actual storage cost/budgeted storage cost	33.9	45.5
(unit of measure) of inventory per sq./cu. Ft.	29.1	40.0
Storage costs per unit (cwt., lb., kg)	23.6	41.8
Average inventory/cost of goods sold	18.1	43.6
(unit of measure) of inventory/total storage cost	21.3	30.9
(unit of measure) used per sq./cu. Ft. available	14.2	27.3
Actual cube utilization/actual cube available	16.5	20.0
(unit of measure) throughput per sq./cu. Ft.	7.1	23.6
Other	3.2	3.6

Receiving Measures

Section 3 of the survey instrument addressed the receiving area of warehouse operations. This section consisted of two parts: 1) labor, equipment, and overall productivity; and, 2) utilization and performance. Table 28 illustrates the frequency and percentage of positive responses from most to least frequent. From the data it appears that productivity measures in receiving are not extensively used. The degree of effectiveness may be a cause for the lack of use. Effectiveness of these measures is examined later in this research. In receiving, as in order fulfillment, it appears the most frequently used measures focus on labor and, to a much lesser extent, equipment.

Table 28
Labor, Equipment, and Overall Productivity in Receiving
(Aggregate)

Measure	Frequency	Percent
(unit of measure) received per labor hour	101	55.5
(unit of measure)/total receiving costs	42	23.1
Vehicles unloaded per labor hour	36	19.8
(unit of measure) per equipment hour	16	8.8
Total vehicles received/total receiving costs	13	7.1
Total equivalent vehicles received/total receiving costs	12	6.6
Other	12	6.6
Equivalent vehicles unloaded per dock door per labor hour	3	1.6

Table 29 illustrates the comparison, in percentages, between SCM and traditional logistics companies. From the survey responses received it appears that both SCM and traditional logistics companies use the same types of performance measures in this area. SCM companies also appear to use these measures more extensively, but not much more than traditional logistics companies.

Table 29
Labor, Equipment, and Overall Productivity in Receiving
(Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
(unit of measure) received per labor hour	52.0	63.6
(unit of measure)/total receiving costs	19.7	30.9
Vehicles unloaded per labor hour	19.0	30.9
(unit of measure) per equipment hour	11.5	9.1
Total vehicles received/total receiving costs	6.3	9.1
Total equivalent vehicles received/total receiving costs	7.3	9.1
Other	6.3	7.3
Equivalent vehicles unloaded per dock door per labor hour	0.8	3.6

The second part of this area is illustrated in the aggregate in table 30. The utilization and performance measures are listed from most to least frequent by both frequency and percentage. It appears from the data that these measures are not frequently used. The causes may be the same as those discussed in the first part of receiving performance measures. Once again, equipment based measures appear to be relegated to the lower end of frequency of performance measurement use.

Table 30
Utilization and Performance in Receiving (Aggregate)

Measure	Frequency	Percent
Labor hours receiving/labor hours worked	75	41.2
Actual (unit of measure) received per labor hour/a standard (unit of measure) per labor hour	57	31.3
Total volume received/total receiving capacity	38	20.9
Actual receiving costs/budgeted receiving costs	34	18.7
Actual equipment cost/budgeted equipment cost	23	12.6
Actual vehicles unloaded per labor hour/a standard number of vehicles unloaded per labor hour	18	9.9
Other	9	4.9
Equipment hours used in receiving/equipment hours available	7	3.8
Actual equipment downtime/a standard equipment downtime	5	2.7

SCM and traditional logistics company's use of these measures is compared in table 31. Appearances regarding the comparison between SCM and traditional logistics companies in these measures are the same as those of the productivity measures in receiving. The exception to the previous statement is that the labor hours receiving/labor hours worked appears to be used extensively relative to all the other receiving measures.

Table 31
Utilization and Performance in Receiving
(Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
Labor hours receiving/labor hours worked	37.0	50.9
Actual (unit of measure) received per labor hour/a standard (unit of measure) per labor hour	29.2	36.4
Total volume received/total receiving capacity	15.8	32.7
Actual receiving costs/budgeted receiving costs	15.0	27.3
Actual equipment cost/budgeted equipment cost	11.8	14.5
Actual vehicles unloaded per labor hour/a standard number of vehicles unloaded per labor hour	10.3	9.1
Other	3.9	7.3
Equipment hours used in receiving/equipment hours available	3.2	5.5
Actual equipment downtime/a standard equipment downtime	1.6	5.5

Customer Satisfaction Measures

Section 4 of the survey instrument addresses customer satisfaction measures. This section contains one multi-part question on different customer satisfaction measures. Table 32 illustrates the number of positive responses, by frequency and percentage, listed from most to least frequently selected.

It appears that, overall, a large number of companies use one or more of the customer satisfaction measures and that these measures adequately measure performance, because of the low number of "other" responses relative to the stated measures. Effectiveness perceptions of these measures will be specifically addressed later in this research. It also appears that companies rely on customer perceptions to measure

customer satisfaction, rather than using only internal measures. This section contains more positive responses than any other section.

Table 32
Customer Satisfaction Measures
(Aggregate)

Measure	Frequency	Percent
Customer perception of perfect order fulfillment (on time, no damage, accurate documentation)	120	65.9
Number of customer complaints/number of orders	91	50.0
Customer perception of order fill cycle time	90	49.5
Customer perception of order fill rate	72	39.6
Customer perception of order status and inquiry response	67	36.8
Number of damaged items/total number of items	67	36.8
Number of customer returns/number of orders	61	33.5
Average customer inquiry and response time	49	26.9
Other	12	6.6

Table 33 illustrates a comparison, on a percent usage basis, between SCM and traditionally managed companies. From the table it appears that this set of performance measures is widely used by both SCM and traditional logistics companies. SCM companies, however, appear to have a higher usage rate than traditional logistics companies.

Table 33
Customer Satisfaction Measures
(Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
Customer perception of perfect order fulfillment (on time, no damage, accurate documentation)	59.1	81.8
Number of customer complaints/number of orders	48.8	52.7
Customer perception of order fill cycle time	48.0	52.7
Customer perception of order fill rate	32.3	56.4
Customer perception of order status and inquiry response	31.5	49.1
Number of damaged items/total number of items	31.5	49.1
Number of customer returns/number of orders	30.7	40.0
Average customer inquiry and response time	26.0	29.1
Other	7.1	5.5

Cost and Earnings Measures

The final performance measure section of the survey (section 5) dealt with cost and earnings performance measures. Table 34 illustrates the responses in the aggregate for the sample. Costs are listed by frequency and percent selected from most to least frequent followed by earnings measures. The earnings measures are also ranked from most to least frequent. The majority of companies appear to use cost as a percent of sales for the total warehouse. Return on assets appears to be the most frequently used earnings measure, with earnings per labor hour a close second. Management appears to emphasize costs more than earnings. This is consistent with responses to the financial treatment of warehouses question, in which the majority of warehouses appear to be treated as cost centers.

Table 34
Costs and Earnings Measures
(Aggregate)

Measure	Frequency	Percent
Cost as a percent of sales for:		
Total Warehouse	117	64.3
Freight	82	45.1
Payroll of labor	71	39.0
Warehouse space	61	33.5
Distribution services (labeling, packaging, etc.)	57	31.3
Order processing	53	29.1
Material handling	51	28.0
Inventory reporting and control	44	24.2
Damage	35	19.2
Management reporting	27	14.8
Cost of capital	29	15.9
Shrinkage	26	14.3
Order Scheduling	12	6.6
Duty	6	3.3
Return on assets	44	24.2
Earnings per labor hour	42	23.1
Earnings per sq./cu. ft.	15	8.2
Other	7	3.8

Table 35 compares the responses of SCM to traditional logistics companies by percentage of positive responses to each measure. The comparison appears to show that SCM and traditional logistics companies use the same measures with almost the same frequency, with one exception. The exception is the appearance that SCM companies pay greater attention to order processing costs as a percent of sales in their measures. This may indicate that SCM companies place more emphasis on the improvement of order processing in both efficiency and effectiveness than traditional logistics companies.

Table 35
Costs and Earnings Measures
(Traditional Logistics and SCM Comparison)

Measure	Traditional Percent Usage	SCM Percent Usage
Cost as a percent of sales for:		
Total Warehouse	62.2	69.1
Freight	44.1	47.3
Payroll of labor	38.6	40.0
Warehouse space	33.1	34.5
Distribution services (labeling, packaging, etc.)	30.0	34.5
Order processing	22.8	43.6
Material handling	24.4	36.4
Inventory reporting and control	21.3	30.9
Damage	18.9	20.0
Management reporting	12.6	20.0
Cost of capital	14.2	20.0
Shrinkage	11.0	21.8
Order Scheduling	6.3	7.3
Duty	2.4	5.5
Return on assets	22.1	29.1
Earnings per labor hour	24.4	20.0
Earnings per sq./cu. ft.	12.0	5.5
Other	3.9	3.6

Measurement Effectiveness

This section addresses **research question 5**. This question is designed to identify the perceptions of effectiveness for each of the areas of measurement and any differences among the perceptions between SCM companies and traditional logistics companies. This question will be addressed in depth in the hypothesis testing section in this research.

Hypothesis Testing

Common Performance Measurements

This section discusses the results of the hypothesized differences **(Hypothesis 1)** between SCM and traditional logistics companies. The top 10 overall most common performance measures, with a comparison between SCM and traditional logistics companies, are depicted in table 36. An overall analysis of the top 10 appears to indicate that all companies tend to emphasize labor measures to a large extent. This would seem contradictory to total quality management (TQM) principles. TQM emphasizes employee empowerment, yet companies appear to measure their employees to a greater extent than other areas, for example, equipment or customer satisfaction. Another possibility for this difference could be that as companies continue to implement the principles of TQM and SCM, they want to intensively manage the change to ensure that the program is indeed working. From the table it appears that there is a difference in the measures used between the two logistics strategies. SCM companies appear to use performance measures more extensively than traditional logistics companies and the rankings between the two strategies also differ.

In addition to the basic percent analysis, a canonical discriminant analysis was conducted between the measures used by SCM and traditional logistics companies. The model, SCM, traditional logistics (1,0, Q19B, Q21A14, Q13I, Q3B, Q13K, Q3A, Q7A, Q15A, Q11K, Q9A, CLASS SUM)=10 measures, yielded an F statistic of 3.9082 with a

probability > F of .0001. This result is significant and it can be concluded that there is a difference between the two types of firms.

Table 36
Most Frequently Used Performance Measures in the Aggregate with Usage Data for SCM and Traditional Logistics Companies

Measure	Aggregate Percent Usage	SCM Percent Usage	Traditional Logistics Percent Usage
Customer perception of perfect order fulfillment (on-time, no damage, accurate documentation)	65.9	81.8	59.1
Cost as a percent of sales for the total warehouse	64.3	69.1	62.2
Physical inventory accuracy	63.7	70.9	60.6
Total (unit of measure) picked/total labor hours	63.2	80.0	55.9
Inventory turns	61.5	76.4	55.1
Total (unit of measure) picked/total labor hours picking	59.3	70.9	54.3
Labor hours picking/labor hours worked	55.5	81.8	44.1
(unit of measure) received per labor hour	55.5	63.6	51.9
Total number of (unit of measure) shipped per day	54.9	67.3	49.6
Actual (unit of measure) per labor hour/a standard (unit of measure) per labor hour	53.3	65.5	48.0

Warehouse Financial Treatment

This section addresses **hypothesis 2,** the hypothesized relationship between SCM and traditional logistics companies as to their treatment of warehouses as cost centers, profit centers, revenue centers, or investment centers. This hypothesis was tested using chi-square analysis between SCM and traditional logistics companies. The sample data for each type of logistics used was separated into two groups, cost center and other than

cost center. This was necessary because there were an insufficient number of other than cost centers (revenue center, profit center, or investment center) to conduct a statistical analysis of the data for hypothesis testing.

The chi-square analysis yielded a value of .268 with a probability of .605. This result was not significant and the null hypothesis could not be rejected. This result could be caused by one of three reasons. First, logistics professionals at SCM companies have not yet fully realized the advantages of SCM's value-adding principles and possibilities in the supply chain. This is probably not the case since the literature published by logistics professionals involved with SCM have demonstrated and agree with the value-add potential of an SCM strategy. Second, logistics professionals at SCM companies have been unable to convince finance professionals at their respective companies of the benefits of SCM and that logistics can be a revenue/profit producing activity. This may be the case at some companies, depending on the management climate. Third, logistics professionals have not been able to quantify the revenue and/or profit generation that SCM creates. This appears to be the case, since the review of the literature has shown numerous attempts at quantifying the value of SCM and logistics, yet none have been widely put into practice by companies.

Performance Measure Effectiveness

This section addresses the hypothesized relationship **(hypothesis 3)** between how companies perceive the effectiveness of their warehouse performance measures and a company's level of SCM implementation. The initial testing of this hypothesis was to

analyze all companies means and standard deviations for the survey questions that addressed measure effectiveness. Table 37 illustrates responses to the effectiveness questions in the aggregate listed from the highest to lowest mean. From an aggregate standpoint, it appears that it may be necessary to develop additional performance measures in the receiving area of warehouse performance measures due to the low relative rating in the effectiveness of these measures.

Table 37
Perceptions of Measurement Effectiveness
(Aggregate)

Measurement Area	Mean Response (1=low, 7=high)	Standard Deviation
Overall performance in order fulfillment	5.0935	1.2614
Facility and overall productivity, utilization, and performance in storage	4.9702	1.2688
Customer satisfaction	4.9125	1.4336
Costs and earnings	4.8313	1.2945
Labor and equipment productivity in order fulfillment	4.8198	1.1983
Labor, equipment, and overall utilization in order fulfillment	4.7556	1.2605
Overall productivity in order fulfillment	4.6950	1.3144
Labor and equipment performance in order fulfillment	4.6349	1.3121
Labor, equipment, and overall productivity in receiving	4.5113	1.3120
Utilization and performance in receiving	4.3413	1.2722

Table 38 compares the mean and standard deviation of the SCM company's responses to that of the traditional logistics companies. The data in this table appear to show that companies using SCM rate the effectiveness of their performance measures

higher than that of traditional logistics companies in all measurement areas. Six of the areas show at least one-half of a point difference.

Table 38
Perceptions of Measurement Effectiveness
(SCM and Traditional Logistics Comparison)

Measurement Area	SCM Mean Response	SCM Standard Deviation	Traditional Logistics Mean Response	Traditional Logistics Standard Deviation
Overall performance in order fulfillment	5.4074	1.1899	4.8068	1.2582
Facility and overall productivity, utilization, and performance in storage	5.2963	0.9443	4.8315	1.3836
Customer satisfaction	5.3200	1.3316	4.6667	1.4085
Costs and earnings	5.1132	1.1874	4.5882	1.2845
Labor and equipment productivity in order fulfillment	5.0943	1.0426	4.5422	1.2027
Labor, equipment, and overall utilization in order fulfillment	4.9200	1.2752	4.5373	1.2102
Overall productivity in order fulfillment	4.9592	1.2741	4.3768	1.2379
Labor and equipment performance in order fulfillment	4.6512	1.1929	4.4923	1.3821
Labor, equipment, and overall productivity in receiving	4.6809	1.1249	4.3382	1.3779
Utilization and performance in receiving	4.6222	1.1373	4.0625	1.2956

The differences are illustrated in Table 39 listed by performance measurement areas from greatest difference to least difference in effectiveness ratings and also include a percent difference between the effectiveness ratings. From the data in table 39 it appears that SCM companies rate their measurement effectiveness especially higher in measurement areas concerning customer satisfaction and order fulfillment. This is

consistent with SCM's concentration on the improvement of the overall order fulfillment process and improved customer service. Companies must be able to effectively measure what is occurring in order to improve a process and it would appear that SCM companies have put an increased emphasis on the above named areas relation to traditional logistics companies.

Table 39
Differences in Effectiveness Ratings
(SCM and Traditional Logistics Companies)

Measurement Area	Effectiveness Rating Difference	Percent Difference
Customer satisfaction	.6533	9.33
Overall performance in order fulfillment	.6001	8.57
Overall productivity in order fulfillment	.5824	8.30
Utilization and performance in receiving	.5597	8.00
Labor and equipment productivity in order fulfillment	.5521	7.89
Costs and earnings	.5250	7.50
Facility and overall productivity, utilization, and performance in storage	.4648	6.64
Labor, equipment, and overall utilization in order fulfillment	.3827	5.47
Labor, equipment, and overall productivity in receiving	.3427	4.90
Labor and equipment performance in order fulfillment	.1589	2.27

In addition to the mean and standard deviation visual analysis, canonical discrimination analysis was conducted on the relationship between the effectiveness ratings of the two groups. The model SCM, traditional logistics (1,0 EFFECT3, EFFECT5, EFFECT7, EFFECT9, EFFECT11, EFFECT13, EFFECT15, EFFECT17, EFFECT19, EFFECT21, CLASS SUM) = 10 measures yielded an F statistic of 1.4606

with a probability > F of .1830. This result was not significant and the null hypothesis could not be rejected, therefore, the visual observations of the means and standard deviations of each of the groups could not be statistically proven. The inability to reject the null hypothesis does not necessarily indicate that there is no relationship, especially considering the visual analysis results, only that further research is necessary in an attempt to confirm this relationship using different techniques and/or measures.

Chapter 5

Conclusions and Recommendations for Further Research

This research is based on the premise that an SCM strategy can be beneficial to many companies and that the companies which have adopted such a strategy have made changes to their performance measurement systems, in particular warehousing, which they find more effective than a traditional logistics company's use of performance measures. This research explores the use of warehouse performance measures among these two types of companies with emphasis on: 1) identification of the companies that are in the progress of adopting, or have adopted SCM; 2) the types of warehouse performance measures used; 3) the measures which are most commonly used; 4) the effectiveness of the performance measures; and 5) if SCM influences how management views the financial treatment (e.g. cost center, profit center, etc.) of warehouses in companies.

Conclusions

The research conducted indicates that 30.3 % of companies which use warehouses are over 60% complete in adopting a SCM strategy. In addition, 52.7% of the companies surveyed are in the early stages of implementation and 17% have no intent of adopting the strategy. The limitation to the indication that a large majority of companies are adopting SCM as their logistics strategy is that, although the attributes had construct validity through factor analysis, there is a possibility that one or more other attributes

were not identified in this research. This could be a cause for the inability to reject the possibility that SCM companies do not differ in their perceptions regarding the effectiveness of their performance measures as compared to traditional logistics companies.

The data also allows for the conclusion that SCM companies use different performance measures than traditional logistics companies. In addition, SCM companies appear to use performance measures to a greater extent than traditional logistics companies. The concentration of these measures is in the order fulfillment and customer satisfaction areas. This may be due to the complex nature of integrating the entire supply chain, which requires greater management coordination and information. This may justify the use of more performance measures to better manage the supply chain.

The conclusion reached from the most frequently used performance measures is that, overall, companies tend to use measures which involve labor to a large extent. This indicates a potential problem in that companies may not pay enough attention to measuring areas other than labor. The large number of positive responses in the order fulfillment customer satisfaction areas indicates that companies are paying attention to customer service and customer needs from the customer's perspective. A possible confirmation of this is that the most commonly used measure is customer perception of perfect order fulfillment. The lack of positive responses in the receiving measurement section, coupled with the indication that the receiving measures section had the lowest effectiveness rating among the sample, could be a sign that the available measures are inadequate to make management decisions.

The visual analysis of effectiveness perceptions for the performance measure areas indicates the possibility that SCM companies rate their performance measures higher than traditional logistics companies. This could not be confirmed through statistical analysis. The confirmation of this analysis is a subject for further research. If this relationship can be confirmed, traditional logistics companies could benefit by the sharing of information with SCM companies about their measurement programs and alter their own programs accordingly.

Finally, it could not be confirmed through statistical analysis how a warehouse is treated financially (cost center, profit center, etc.) is related to the level of SCM implementation. This could imply that there are inadequate means to measure profit and/or revenue contribution of warehouse operations causing companies to look to warehouses only for cost cutting instead of potential for revenue generation. Another possible implication is that companies are not aware of the revenue generating possibilities warehouses can provide to their business.

Implications for Companies and Recommendations for Further Research

The implications for companies are threefold. First, companies must pay close attention to their warehouse performance measurement program to ensure that critical areas are adequately measured. Measurement programs provide management with the information needed to make good decisions and are not an area to be taken for granted. Second, companies should examine the performance measures used by SCM companies in those areas that were ranked highly effective to determine if these measures should be

added to their programs. Finally, companies must take a close look at the revenue generation possibilities of warehouse operations through value-adding processes to ensure that potentials are taken advantage of to the fullest extent possible.

The following five recommendations are made for further research by academics. These recommendations can be applied to warehouse performance or to other performance measurement areas where there is insufficient research. First, more research can be conducted on measures, other than those examined in this study, in order to improve the overall pool of measures that businesses can use. Included in this recommendation is research to develop new measures. This is especially true for those areas rated low in effectiveness and/or are not used frequently. Second, research should be conducted to determine what constructs make measures more frequently used than others. This can be important in the development of new and improved measures. Third, research can be conducted which examines total performance measurement programs in detail to find the mix of measurements that form superior programs. This would be of invaluable assistance to improving a company's operations by identifying areas that have shortfalls. Fourth, research can be conducted to determine if the financial treatment of warehouses, as other than cost centers, is justified. There may be sufficient cause to treat warehouses only as cost centers. Finally, because it appears that SCM companies use more measures than traditional logistics companies and may rate their measures effectiveness higher, research can be conducted to determine if the use of more measurements is better in a company's measurement program.

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Appendix A
Survey Instrument Used and Cover Letter

Listed below are a number of different types of performance measures warehouses and their parent companies may use to measure performance. Please indicate with a check mark or X the measures you use, or closely resemble the measures you use. After each section, please circle, on a scale of 1 to 7, how effective you feel your measures are. If you do not use any of the measures in a particular section, circle NA. A rating of 7 (high) should be reserved for the section(s) that you feel are highly effective and would cause you to reevaluate company policy and procedures and operations if the measure shows inadequate performance.

Supply Chain Management is defined as the logistics strategy of expanding the concept of integrated logistics across company boundaries to optimize information and product flows from the purchase of raw materials to the delivery of finished goods or services to the customer.

Value-added is defined as total revenues (net of discounts) less the value of resources (labor, equipment, materials, etc.) used to generate the revenue.

1. My company's primary unit of measurement in warehousing is: (check all that apply)

a. Dollar Value	_____	d. Pallets	_____	g. Invoices	_____
b. Cartons	_____	e. Weight	_____	h. Orders	_____
c. Units	_____	f. Lines	_____	i. Other (specify)	_____

2. My company measures warehouse space by: (check all that apply)

a. square feet _____
b. cubic feet _____
c. other(specify)_____

Section 1: Order Fulfillment Measures
The following questions are with respect to the order fulfillment process in your warehouse.

Labor and Equipment Productivity in Order Fulfillment

3. My company measures labor and equipment productivity by: (check all that apply; if none used go to question 5)

a. Total (refer back to question 1) picked / total labor hours picking _____
b. Total (refer back to question 1) picked / total labor hours _____
c. Vehicles loaded per door per labor hour _____
d. Total value-added / total warehouse employment _____
e. Total value-added / payroll for total warehouse employment _____
f. Total (refer back to question 1) picked / total equipment hours. _____
g. Vehicles loaded per equipment hour _____
h. Other (specify) _____

Level of Effectiveness

	None						High	
4. Assess the level of effectiveness of your measures in question 3.	1	2	3	4	5	6	7	NA

Overall Productivity in Order Fulfillment

5. My company measures overall productivity by: (check all that apply; if none used go to question 7)

a. Total (refer back to question 1) picked / total order picking costs _____
b. Total number of orders entered / total order entry cost _____
c. Total number of orders scheduled / total order scheduling cost _____
d. Total number of invoices processed / total invoice processing cost _____
e. Vehicles loaded / total loading costs _____
f. Total (refer back to question 1) loaded / total loading costs _____
g. Other (specify) _____

Level of Effectiveness

	None						High	
6. Assess the level of effectiveness of your measures in question 5.	1	2	3	4	5	6	7	NA

Labor, Equipment, and Overall Utilization in Order Fulfillment

7. My company measures labor, equipment and overall utilization by: (check all that apply, if none used go to question 9)

a. Labor hours picking / labor hours worked _____
b. Equipment hours used picking / equipment hours available _____
c. Average weight per movement / maximum weight capacity per movement _____
d. Total equipment downtime in hours / total equipment hours possible _____
e. Total volume picked per day / picking capacity per day _____
f. Other (specify) _____

Level of Effectiveness

	None						High	
8. Assess the level of effectiveness of your measures in question 7.	1	2	3	4	5	6	7	NA

Labor and Equipment Performance in Order Fulfillment

9. My company measures labor and equipment performance by: (check all that apply, if none used go to question 11)

a. Actual (refer to question 1) per labor hour / a standard (refer to question 1) per labor hour _____
b. Actual equipment downtime / a standard equipment downtime _____
c. Actual equipment cost / budgeted equipment cost _____
d. Other (specify) _____

Level of Effectiveness

	None						High	
10. Assess the level of effectiveness of your measures in question 9.	1	2	3	4	5	6	7	NA

Overall Performance in Order Fulfillment

11. My company measures overall performance by: (check all that apply, if none used go to question 13)

a. Lead time from customer order to customer acceptance _____
b. Lead time from order entry to order release _____
c. Lead time from order release to order ready to ship _____
d. Lead time from ready to ship to customer acceptance _____
e. Percentage of complete orders received on or before original committed date _____
f. Number of orders with damages / total number of orders _____
g. Number of incorrect orders / total number of orders _____
h. (refer back to question 1) filled from stock / total (refer back to question 1) requested _____
i. (refer back to question 1) damaged per order _____
j. Total number of (refer back to question 1) processed per day _____
k. Total number of (refer back to question 1) shipped per day _____
l. Total value added per period _____
m. (refer back to question 1) shipped on time / total (refer back to question 1) shipped _____
n. # of perfect orders (on time, accurate documentation, no damage)/ total # of orders _____
o. Other (specify) _____

	Level of Effectiveness							
	None						High	
12. Assess the level of effectiveness of your measures in question 11.	1	2	3	4	5	6	7	NA

Section 2: Storage Measures

The following questions are with respect to the storage process of your warehouse.

Facility and Overall Productivity, Utilization, and Performance in Storage

13. My company measures facility and overall productivity, utilization and performance by: (check all that apply, if none used go to question 15)

a. (Refer back to question 1) of inventory per (refer back to question 2) _____
b. (Refer back to question 1) of inventory / total storage cost _____
c. (Refer back to question 1) used / (refer back to question 2) available _____
d. Storage locations used / storage locations available _____
e. Actual cube utilization / actual cube available _____
f. Average inventory / cost of goods sold _____
g. Storage costs per unit (cwt, lb., kg) _____
h. (Refer back to question 1) throughput per (refer back to question 2) _____
i. Physical inventory accuracy _____
j. Cycle counting accuracy: # of good counts / total counts _____
k. Inventory turns _____
l. Actual storage cost / budgeted storage cost _____
m. Other (specify) _____

Level of Effectiveness

14. Assess the level of effectiveness of your measures in ques. 13. None 1 2 3 4 5 6 7 High NA

Section 3: Receiving

The following questions are with respect to the receiving process of your warehouse.

Labor, Equipment, and Overall Productivity in Receiving

15. My company measures labor, equipment and overall productivity by: (mark all that apply, if none used go to question 17)

a. (Refer back to question 1) received per labor hours _____
b. Vehicles unloaded per labor hour _____
c. Equivalent vehicles unloaded per dock door per labor hour _____
d. (Refer back to question 1) per equipment hour _____
e. (Refer back to question 1) / total receiving costs _____
f. Total equivalent vehicles received / total receiving costs _____
g. Total vehicles received / total receiving costs _____
h. Other (specify) _____

Level of Effectiveness

16. Assess the level of effectiveness of your measures in question 15. None 1 2 3 4 5 6 7 High NA

Utilization and Performance in Receiving

17. My company measures utilization and performance by: (mark all that apply, if none used go to question 19)

a. Labor hours receiving / labor hours worked _____
b. Equipment hours used in receiving / equipment hours available _____
c. Total volume received / total receiving capacity _____
d. Actual vehicles unloaded per labor hour / a standard vehicles unloaded per labor hour _____
e. Actual (refer to ques. 1) rec'd per labor hour / standard (refer to ques. 1) rec'd per labor hour _____
f. Actual equipment downtime / a standard equipment downtime _____
g. Actual equipment cost / budgeted equipment cost _____
h. Actual receiving costs / budgeted receiving costs _____
i. Other (specify) _____

Level of Effectiveness

18. Assess the level of effectiveness of your measures in question 17. None 1 2 3 4 5 6 7 High NA

Section 4: Customer Satisfaction

The following questions are with respect to customer satisfaction with your warehouse operation.

19. My company measures customer satisfaction by: (mark all that apply, if none used go to question 21)

a. Customer perception of order fill cycle time _____
b. Customer perception of perfect order fulfillment _____
c. Customer perception of order status and inquiry response _____
d. Average customer inquiry and response time _____
e. Number of damaged items / total number of items _____
f. Number of customer complaints / number of orders _____
g. Number of customer returns / number of orders _____
h. Customer perception of order fill rate _____
i. Other (specify) _____

	Level of Effectiveness							
	None						High	
20. Assess the level of effectiveness of your measures in question 19.	1	2	3	4	5	6	7	NA

Costs and Earnings

The following questions are with respect to the costs and earnings of your warehouse.

21. My company measures costs and earnings performance by: (mark all that apply, if none used go to question 23)

a. Costs as a percent of sales for:
   1) Order processing _____
   2) Order scheduling _____
   3) Management reporting _____
   4) Material handling _____
   5) Warehouse space _____
   6) Distribution services (labeling, packaging, etc.) _____
   7) Inventory reporting and control _____
   8) Freight _____
   9) Duty _____
   10) Cost of capital _____
   11) Shrinkage _____
   12) Payroll _____
   13) Damage _____
   14) Total warehouse _____
b. Earnings per labor-hour _____
c. Earnings per (refer back to question 2) _____
d. Return on assets _____
e. Other (specify) _____

	Level of Effectiveness							
	None						High	
22. Assess the level of effectiveness of your measures in question 21.	1	2	3	4	5	6	7	NA

Section 6: Demographics

Please take a moment to fill out the following demographic questions. These will be used as the basis to aggregate your responses to this survey.

For questions 23-26 use the following descriptions:

Strategy - Aligning supply chain strategy with business goals, senior management commitment to supply chain management, a total system approach, customer service strategy to meet different customer requirements, procurement strategy for different supplier requirements, establishing strategic alliances with key suppliers, and outsourcing non-core, non-strategic supply chain activities.

Integrated Processes - Use of cross functional teams for process design and improvement, use of process owners, use of life cycle management into supply chain processes, integrating manufacturing, customers and suppliers into design process, utilizing total corporate leverage in procurement, shifting functions to the most efficient provider, monitoring supplier performance, integrate and balance supply, demand, and financial plans and objectives, delivery systems with tailored service, jointly manage inbound and outbound transportation, and regular monitoring of customer satisfaction levels with feedback to all supply chain processes.

Technology and Information - Aligned with key business processes, minimal data redundancy visible to all, availability of a data warehouse that is widely available, enterprise wide planning systems, institutionalized sharing of technology assets across divisions, use of EDI between company, customers and suppliers, system for demand forecasting, distribution planning, production planning, and material planning that are highly integrated, and manufacturing execution systems to track material flow and production costs as well as providing order status information to customer service.

Structure, People, and Culture - A clearly formulated and communicated vision of supply chain management to each player, removing disincentives to teaming, protection of innovation from short term profit pressures, training in the required skills for supply chain management, performance measurements that enforce supply chain management performance, regular examination for performance gaps and root cause analysis, inclusion of customers and suppliers in performance measurement, and existence of a plan to measure change.

	Not Planned							Fully Implemented
23. My company's status of implementation toward a Supply Chain Management logistics strategy	0	1	2	3	4	5	6	7
24. My company's status of implementation of integrated process towards Supply Chain Management.	0	1	2	3	4	5	6	7
25. My company's status of implementation for technology and information. toward the use of Supply Chain Management.	0	1	2	3	4	5	6	7
26. My company's status of implementation of structure, people and culture towards the use of Supply Chain Management.	0	1	2	3	4	5	6	7

27. My company's warehouse operations are: (mark all that apply)(If you are a public or contract warehouse, go to question 28)

Private_____ Public_____ Contract_____ Third Party Logistics provider_____

28. My company's warehouses are operated as: (mark one)

Profit centers _____
Cost centers _____
Revenue centers _____
Investment centers _____
Other (specify) _____

29. My position title is: (mark one)

a. Vice President _____
b. Director _____
c. Manager _____
d. Supervisor _____
e. Other (specify) _____

30. My company's core business is: (mark one)

Manufacturing _____
Non-manufacturing _____
Wholesaler/distributor _____
Retailer _____
Public Warehouse _____
Contract Warehouse _____
Other (specify) _____

31. My company has annual sales of: (mark one)

< $500k ____
$500k-$1 million ____
$1 million-$50 million ____
$50-100 million ____
$100-500 million ____
$500 million - $1 billion ____
>$1 billion ____

32. Would you like a copy of the results of this survey? Yes _____ No _____
If yes, please write in your mailing address below or include a copy of your business card.
If you prefer, call Allen Kiefer at (814) ***-**** or include a self-addressed envelope with this survey for a copy of the results.

20 December 1995

Mr. John Doe
Director
ABC Products
1234 Main Street
Anywhere, USA 12345

Dear Mr. Doe,

In conjunction with the Pennsylvania State University Master of Science degree in Business Logistics program, a study is being conducted to evaluate the differences in the use and effectiveness of performance measurements in warehouse operations for those warehouses operating in a Supply Chain Management logistics strategy and those warehouses operating in traditional strategies. This study is being conducted as part of graduate research at the Pennsylvania State University with the knowledge and support of the Department of Business Logistics. The results of this study will be made available to the Warehouse and Education Research Council and the Smeal College of Business Center for Logistics Research.

Enclosed is a survey designed to gather data on the features of your performance measurement program. It is requested that the survey be completed by someone knowledgeable about your program and general demographic questions about your business. This survey is brief and should take less than 30 minutes to complete.

The data obtained from this survey will be used to determine differences in performance measurement systems of Supply Chain Managed warehouses and traditionally measured warehouses and the perceptions of the effectiveness of the measures. Each survey is coded to determine the submitting company, but individual respondents will <u>not</u> be identified in the study in any way.

A self addressed and stamped envelope is provided for returning the survey.

Completion of this survey is voluntary. However, a high rate of return on the surveys is critical to making this a worthwhile study, so your completion of the survey is important. Since timing is an important issue in this study, your response is requested by 12 January 1996. Your assistance in this study is valuable, appreciated and will be of benefit to the industry. If you have any questions about the survey or this study, please call me at (814) ***-****, send me E-mail at ******@psu.edu, or FAX me at (814) ***-****.

Sincerely,

Allen W. Kiefer

Enc.

Appendix B
Warehouse Performance Measures

Order Fulfillment Measures

Labor Productivity Measures

1. Total dollar value picked/total labor hours picking
2. Total weight picked/total labor hours picking
3. Total orders picked/total labor hours picking
4. Total lines picked/total labor hours picking
5. Total units picked/total labor hours picking
6. Total $ value of orders entered/total # of labor hours
7. Total # of orders entered/total # of labor hours
8. Total # of lines entered/total # of labor hours
9. Total # of orders scheduled/total # of labor hours
10. Total # of invoices produced/total # of labor hours
11. Total # of orders processed/total # of labor hours
12. Total # of orders picked/total labor hours used
13. Total lines picked/total labor hours used
14. Vehicles unloaded per door per man hour
15. Total value added/total warehouse employment
16. Total value added/payroll for total warehouse employment

Equipment Productivity Measures

1. Total dollar value picked/total equipment hours
2. Total weight picked/total equipment hours
3. Total orders picked/ total equipment hours
4. Total lines picked/ total equipment hours
5. Vehicles unloaded per machine hour

Overall Productivity Measures

1. Total weight picked/total order picking costs
2. Total lines picked/ total order picking costs
3. Total units picked/total order picking costs
4. Total # of orders entered/total order entry cost
5. Total # of orders scheduled/total order scheduling cost
6. Total # of invoices processed/total invoice processing cost
7. Vehicles loaded/actual loading costs
8. Pieces loaded/actual loading costs

Labor Utilization Measure

Labor hours picking/labor hours worked

Equipment Utilization Measures

1. Equipment hours used picking/equipment hours available
2. Actual weight per movement/maximum weight capacity per movement
3. Total order entry equipment downtime in hours/total order entry equipment hours available

Overall Utilization Measure

Total volume picked per day/total picking capacity per day

Labor Performance Measures

1. Actual weight picked per labor hour/standard weight picked per labor hour
2. Actual orders picked per labor hour/standard orders picked per labor hour
3. Actual lines picked per labor hour/standard lines picked per labor hour
4. Actual units picked per labor hour/standard units picked per labor hour

Equipment Performance Measures

1. Actual equipment downtime/standard equipment downtime
2. Actual equipment cost/budgeted equipment cost

Overall Performance Measures

1. Actual picking cost/total order picking costs
2. Perfect Order Fulfillment = number of perfect orders/total number of orders
   - delivered complete within 1 day early tolerance
   - Documentation complete and accurate (packing slips, BOL, invoice, etc)
   - Perfect condition (no damage)
3. Total order fulfillment cycle time

lead time from order signature to customer delivery

Broken down by:

   - customer signature to order receipt
   - entry to release
   - release to shippable
   - shippable to customer receipt
   - receipt to customer acceptance

4. Percentage of complete orders received on or before original committed date

5. # of orders with damages/total # of orders
6. # of incorrect orders/total # of orders
7. Orders filled from stock/total orders requested
8. Total line items not filled/total lines requested
9. Orders with no damaged line items/total line items shipped
10. Line items damaged per order
11. Number of orders shipped on time/ total number of orders
12. Total number of orders processed per day
13. Total number of lines processed per day
14. Total number of orders shipped per day
15. Value added: revenue generated from outbound goods - cost of inbound goods
16. Orders shipped on-time/total orders
17. Orders received by customer on time/total orders

Storage Measures

Facility Productivity Measures

1. Dollar value of inventory per square foot
2. Dollar value of inventory per cubic foot
3. Weight of inventory per square foot
4. Weight of inventory per cubic foot
5. Units of inventory per square foot
6. Units of inventory per cubic foot
7. Dollar value of inventory/total storage cost

Overall Productivity Measures

1. Dollar value of inventory/total storage cost
2. Weight of inventory/total storage cost
3. Units of inventory/total storage cost

Facility Utilization Measures

1. Square feet of storage used/square feet of storage space available
2. Cubic feet of storage space used/cubic feet of storage space available
3. Storage locations used/storage locations available
4. Actual cube utilization/theoretical cube utilization

Facility Performance Measure

Actual storage occupancy/standard occupancy goal

Overall Performance Measures

1. Inventory days of supply: average inventory/cost of goods sold
2. Storage costs per unit (cwt./lb./kg.)
3. Units throughput per square(cubic) foot
4. Weight throughput per square(cubic) foot
5. Lines throughput per square (cubic) foot
6. Orders throughput per square (cubic) foot
7. Dollars throughput per square (cubic) foot
8. Physical inventory accuracy
9. Cycle counting accuracy: good counts/total counts
10. Inventory turns
11. Actual storage cost/budgeted storage cost

Receiving Measures

Labor Productivity Measures

1. Dollar value received/labor hour
2. Vehicles unloaded/labor hour
3. Equivalent vehicles unloaded/labor hour
4. Weight received/labor hour
5. Cartons received/labor hour
6. Pallets received/labor hour
7. Lines received/labor hour
8. Units received/labor hour
9. Weight unloaded per dock door/labor hour
10. Equivalent vehicles unloaded per dock door/labor hour

Equipment Productivity Measures

1. Dollar value received/equipment hour
2. Weight received/equipment hour
3. Units received/equipment hour

Overall Productivity Measures

1. Total dollar value received/total receiving costs
2. Total equivalent vehicles received/ total receiving costs
3. Total weight of received/ total receiving costs
4. Total pallets received/ total receiving costs
5. Total cartons received/ total receiving costs
6. Total lines received/ total receiving costs

7. Total units received/ total receiving costs

Labor Utilization Measure

Labor hours receiving/labor hours worked

Equipment Utilization Measures

1. Equipment hours used in receiving/equipment hours available
2. Actual weight per movement/maximum weight per movement

Overall Utilization Measure

Total volume received/total receiving capacity

Labor Performance Measures

1. Actual equivalent vehicles unloaded per labor hour/standard equivalent vehicles unloaded per labor hour
2. Actual weight received per labor hour/standard weight received per labor hour
3. Actual lines received per labor hour/standard lines received per labor hour

Equipment Performance Measures

1. Actual equipment downtime/standard equipment downtime
2. Actual equipment cost/budgeted equipment cost

Overall Performance Measure

Actual receiving costs/budgeted receiving costs

Customer Satisfaction Measures

1. Customer perception of order fill cycle time
2. Customer perception of perfect order fulfillment
3. Customer perception of order status and inquiry response
4. Average customer inquiry response and resolution time
5. Number of damaged items/total number of items
6. Number of customer complaints/number of orders
7. Number of customer returns/number of orders

Costs/Earnings

1. Costs as a percent of sales:
   a. Order processing
   b. Order scheduling
   c. Management reporting
   d. Material handling
   e. Warehouse space
   f. Distribution services (labeling, packing, etc.)
   g. Inventory reporting and control
   h. Freight and duty
   i. Cost of capital
   j. Shrinkage
   k. Insurance and taxes
   l. Obsolescence
   m. Payroll
   n. Damage costs
   o. Total warehouse
2. Earnings per man-hour
3. Earnings per square foot
4. Return on assets

PENNSTATE

Appendix C

(814) 865-1775
Fax: (814) 863-8699

Senior Vice President for Research and
Dean of the Graduate School
Office for Regulatory Compliance

The Pennsylvania State University
212 Kern Graduate Building
University Park, PA 16802-3301

November 22, 1995

Allen W. Kiefer
1356 University Drive
State College, PA 16801

Re: Proposal for Use of Human Subjects in Research - Exemption (**#951565-00**)
Approval Expiration Date: November 22, 1996
"Use of Performance Measures in Warehousing"

Dear Mr. Kiefer:

Your proposal for use of human subjects in your research has been reviewed and **approved for a one-year period**. Subjects in your research are at minimal risk.

By accepting this decision you agree to notify this office of (1) any additions or changes in procedures for your study that modify the subjects' risks in any way and (2) any events that affect the safety or well-being of subjects.

The University appreciates your efforts to conduct research in compliance with the federal regulations that have been established to ensure the protection of human subjects.

Sincerely,

Karen J. English
Research Coordinator

cc: R. Novack
J. Spychalski
K. Lusht