Supply Chain Management: A Strategic Perspective

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In order to respond to competitive pressures, managers need to know more about the strategic aspects of supply chain management. This paper addresses this need by critically reviewing the supply chain management literature and by suggesting a research agenda for the future. A conceptual model is provided which helps to identify certain assumptions made in the literature that must be challenged. The model also provides a tool for identifying the major contributions in the literature. Finally, a research agenda is developed.

Is the concept of supply chain management (SCM) important in today's business environment or is it simply a fad destined to die with other short-lived buzzwords?

Is the concept of supply chain management (SCM) important in today's business environment or is it simply a fad destined to die with other short-lived buzzwords? This question may be answered by looking at the list of firms embracing the concept including: Xerox, Hewlett Packard, AlliedSignal, Wal-Mart, and Toyota [1, 2]. Many of these firms are enjoying above average success.

Besides SCM there are concepts such as business ecosystems, business networks, and Keiretsu relationships that are being used to achieve higher performance. The business ecosystem concept [3] views businesses as organisms which can choose to either compete or co-evolve with competitors. New markets are continually being formed and transformed. Businesses can no longer be viewed as unique and immutable but rather must be seen as organic and ever changing interdependent organisms. Many leading firms achieve competitive advantage through cooperative co-evolving relationships rather than protection or exploitation of resources in an industry. SCM is similar to the business ecosystem concept since it looks at the interconnection between key processes both within firms and between firms. SCM crystallizes the business ecosystem idea by providing a process framework that enables firms to engage in co-evolvement rather than competition.

The concept of business networks [4] is described as relationships between businesses where the chain of connectedness is without limits and can span several relationships that are (indirectly) connected. What happens between two companies does not depend solely on the two parties involved, but on what is going on in a number of other relationships [5]. Harrison [6] and Best [7] describe a movement towards business networks especially in Japan and Italy where firms have pared down their activities, introduced collaborative manufacturing, and used more subcontractors, suppliers, and alliances. While networks have been used to broadly describe changes in countries and relationships among firms, little empirical testing or theory development has been done.

Finally, much has been written about Japanese Keiretsu relationships. Although Keiretsu relationships are popular in Japan, they are illegal in the United States due to antitrust laws. However, U.S. companies still strive to develop the tight, well structured (tiered) supplier relationships seen in Japanese Keiretsus. SCM provides a framework for attaining close, well tiered customer supplier relationships, without the large exchanges in equity characteristic of Keiretsus. While business ecosystems, business networks, and Keiretsus are valuable ideas for the reasons described, these concepts do not provide the depth, practicality, and realism provided by SCM.

SCM is poised to take firms in a new direction, but is this direction good? In firms where SCM is emphasized, managers pay attention to strategies such as partnerships

and strategic alliances, but they often ignore the underlying capabilities and competencies, which are also critical [8]. SCM is receiving increased attention in the literature. White [9] reported SCM as number three behind quality and customer service, of 10 key dimensions that define world-class performance. Several authors note that SCM is becoming a growing area of study [10,11,12]; and, that finding and building strong positions in carefully selected supply chains will become the focus for SCM, as firms strive for excellence in cost management and strategic planning [13].

SCM is becoming important in Europe as well. Hines [14] described the formation of supply chain research consortium consisting of three of the UK's leading academic centers in purchasing and logistics. While awareness of SCM is growing, there is a corresponding increase in confusion concerning the concept. Articles now appear addressing international supply chains [15] and SCM reengineering [16,17], but a key assumption is that industry professionals and academics clearly understand the definition and operationalization of SCM. The following analysis of the SCM literature shows that the term is often misused, and that few studies have demonstrated the usefulness of the concept.

Our objective is to analyze the literature from multiple disciplines. By seeing how the supply chain concept has evolved and changed, the reader will have a greater understanding of what SCM means and the key research issues that need to be tackled. First, we examine the definition of SCM and analyze the various schools of thought. The seminal ideas upon which the various schools were developed are highlighted. Then, a conceptual model is introduced and used to group and analyze the literature. The model provides a framework which identifies areas addressed, as well as, gaps in the literature. Finally, a research agenda is presented.

Definition and Schools of Thought

Implementation of JIT [18, 19], TQM [20], reengineering [21], and other manufacturing based programs of the 1980's and 1990's have achieved mixed success at best. The keys to long-term competitive advantage in today's marketplace are flexibility and customer response [22,23]. The problem with the programs mentioned is that while a certain functional area may benefit through optimization of inventory or other benefits, some non-targeted functional areas may be harmed. The net result could be negative for a company [24]. Academics and industry professionals now see that implementation of individual programs such as JIT and TQM often cause problems or involve tradeoffs [25]. One idea for linking various programs together into a single integrated concept is the concept of SCM.

Definition

SCM is a relatively new concept that still lacks a clear definition (see Table 1). It is important to note that while many definitions of SCM exist, we will not attempt to create the best and latest definition of SCM. Rather, this paper will draw out the key processes and characteristics that are essential components of SCM.

SCM is a relatively new concept that still lacks a clear understanding among academics and industry professionals.

The supply chain concept originated in the logistics literature [26, 27, 28], and logistics has continued to have a significant impact on the concept. Initially, the emphasis was on facilitating product movement and coordinating supply and demand between a supplier and buyer. Logistics managers in retail, grocery, or other high inventory industries began to see that a significant competitive advantage could be derived through the management of materials through inbound and outbound channels. Since its introduction in the retail industry, the supply chain concept has spread to other industries such as computers [29, 30], copiers [31, 32], and chainsaws [33].

The following analysis of the SCM literature shows that the term is often misused, and that few studies have demonstrated the usefulness of the concept.

The Functional Chain Awareness School

The functional chain awareness school of thought recognizes the existence of a chain of functional areas. Several key points emerge from the functional chain awareness school definitions shown in Table 1. First, most of the definitions agree that the supply chain covers material flow from channel members or suppliers through end users [34, 35, 36, 37, 38, 39, 40, 41]. The emphasis is on including all chain members from beginning to end. Second, the definitions emphasize the flow of materials [42, 43, 44, 45]. The emphasis on material flow through

Table 1
Supply Chain Schools of Thought

Author(s)	Definition
	Chain Awareness School
Jones and Riley (1985)	"Supply chain management deals with the total flow of materials from suppliers through end users." (p. 19)
Houlihan (1988)	"Supply chain management covers the flow of goods from supplier through manufacturer and distributor to the end user." (p. 14)
Langley and Holcomb (1991)	"Supply chain management focuses attention on the interactions of channel members to produce an end product/service that will provide best comparative value for the end user." (p. 14)
Cavinato (1991)	"... the entire sourcing, value-added, and marketing activities of the overall link of firm up to final customers." (p. 32)
Novack and Simco (1991)	"Supply chain management covers the flow of goods from the supplier through the manufacturer and distributor to the end user." (p. 32)
Stevens (1990)	"Control the flow of material from suppliers, through the value adding (production) processes and distribution channels, to customers."
Lee and Billington (1992)	"Networks of manufacturing and distribution sites that procure raw materials, transform them into intermediate and finished products, and distribute the finished products to customers." (p. 65)
	Linkage/Logistics School
Scott and Westbrook (1992)	"...supply chain is used to refer to the chain linking each element of the production and supply process from raw materials through to the end customer." (p. 23)
Turner (1993)	"...technique that looks at all the links in the chain from raw materials suppliers through various levels of manufacturing to warehousing and distribution to the final customer." (p. 52)
	Information School
Johannson (1994)	"SCM is really an operations approach to procurement. It requires all participants of the supply chain to be properly informed. With SCM, the linkage and information flow between various members of the supply chain are critical to overall performance."
Towill, Naim and Wikner (1992)	"A supply chain is a system, the constituent parts of which include material suppliers, production facilities, distribution services, customers linked together via the feed forward of materials and the feedback flow of information." (p. 3)
Manrodt and Harrington (1995)	"Product and information flow encompassing all parties beginning with the supplier's suppliers and ending with customers or consumers/end users... flows are bidirectional."
	Integration School
Cooper and Ellram (1990)	"An integrative philosophy to manage the total flow of a distribution channel from the supplier to the ultimate user." (p.1)
Ellram and Cooper (1993)	"Supply chain management is an approach whereby the entire network from which suppliers through the ultimate customer, is analyzed and managed in order to achieve the 'best' outcome for the whole system." (p.1)
Hewitt (1992)	"Supply chain integration is only a natural result of redesigned business processes not realignment of existing functional organizations." (p.340)
	Future
Cavinato (1992)	"The supply chain concept consists of actively managed channels of procurement and distribution. It is the group of firms that add value along product flow from original raw materials to final customer. It concentrates on relational factors rather than transactional ones." (p. 285)
Farmer (1995)	"Instead of using the term supply chain management, we should use the idea of a seamless demand pipeline."

channels is no surprise since the seminal field of SCM is logistics. For each of the schools of thought an industry will be discussed to help clarifying perspective. An industry that is representative of the functional awareness school is the restaurant/foodservice industry. Firms such as McDonalds and Pepsi, have begun to realize the tremendous benefits available from reliable global suppliers as well as strong logistics systems which can provide a reliable flow of materials.

The Linkage/Logistics School

The linkage/logistics school goes beyond recognizing that there is a chain from suppliers to end users and begins to address the material flows through this chain. The linkage/logistics school lays out the actual linkages among functional areas which usually include suppliers, production, and distribution [46,47]. A good way to distinguish between the chain awareness and linkage schools is to realize that the

functional chain awareness school simply recognizes that the functional areas of purchasing, manufacturing, and distribution form a sequence called the supply chain, which should be managed. The linkage school begins to investigate how linkages among the functional areas can be exploited for competitive advantage, especially in the areas of logistics and transportation. The emphasis on linkages focuses on smoothing the flow of materials between functional areas to reduce inventories [48,49]. The furniture industry is representative of the linkage/logistics school. As the industry has become more competitive, firms such as Herman Miller and Steelcase use sophisticated logistics and distribution systems to gain cost advantages.

The Information School

The information school emphasizes the flow of information between supply chain members. The flow of information is the backbone of effective SCM [50,51,52]. Not only is the unidirectional flow of information from buyer to supplier important, but also the bidirectional information flow [53]. Information does not flow from one chain member to the next, but all chain members need feedback on how their customers and end users perceive their performance [54]. An industry that represents the information school is the banking industry. The early 1990's brought tremendous change to the banking industry, as investment firms performed traditional banking functions (checking and providing cash) and banks provided investment options (purchase of stocks, bonds, and mutual funds) to companies. Companies that are prospering appear to be those taking advantage of information technology on several levels. Brokerage firms such as Charles Schwab are using information technology, such as the World Wide Web, to conveniently provide more services to customers. Banks have begun to use sophisticated technologies that transfer money faster and more accurately across international borders.

The Integration/Process School

The integration/process school focuses on integrating supply chain areas into a system defined as a set of processes [55] that strive for the best overall system [56], which adds value [57]. The difference between the linkage and integration schools is subtle but the implications are great. The linkage school assumes that functional areas appear in a sequence that cannot be changed. The goal is to gain as much efficiency as possible from this sequence of functions. The integration school implies that the emphasis is on customer satisfaction regardless of the configuration of the functional areas in the supply chain. The integrative philosophy, however, does not necessarily assume that the links of the chain are in any particular order or causality. The decision maker in the integration/process school is free to explore alternative configurations of the supply chain. These alternative systems may remove redundancies by performing certain activities simultaneously. Ellram and Cooper [58] acknowledge the integration concept by stating that SCM is an "approach whereby the entire network from which suppliers through ultimate customer... managed to achieve the 'best' outcome for the whole system." Hewitt [59] adds that the emphasis has moved away from efficiency of an assumed chain of events to effectiveness in meeting customer requirements, which may require radical change to the chain. The automotive industry best represents the integration school. Customers who are traditionally at the end of the supply chain are being used in coordination with suppliers to create better parts for vehicles.

Future

Two themes provide vision into the future of SCM. First, the SCM concept is becoming closely tied to the concepts of partnerships, strategic alliances, and other cooperative relations with supply chain members. Therefore, a greater emphasis exists on the relational as opposed to the transactional factors involved in SCM [60]. But, emphasizing relational factors is not the only important SCM requirement. The definition of SCM may change in a more fundamental way. Farmer [61], Nicosia and Harrington [62] describe the inadequacy of the term SCM. The term supply chain suggests that "supply" begins and drives the chain of activities. However, any chain must begin with a customer who demands a service or product [63,64]. A better term would be "seamless demand pipeline" where the end user and not the supply function

...emphasizing relational factors is not the only important SCM requirement.

drives the supply chain [65]. Figure 1 provides a graphic representation of the evaluation of the schools of thought on SCM.

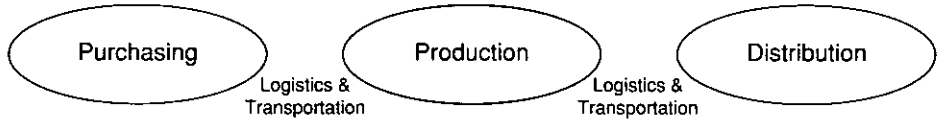
A Conceptual Framework

The different SCM themes in the literature are characterized into content and process areas and presented in Figure 2. The content areas of SCM address the issue of responsibility for attaining supply chain integration. This stream of literature has typically taken a functional view of responsibility for supply chain integration. For example, articles in the logistics literature are predominantly concerned with the content areas of distribution and the customer, thereby implying that the distribution function and the customer play an important role in SCM integration. The SCM literature has identified nine content areas that represent a comprehensive picture of the various functional areas of supply chain management (see Figure 2). The structure of the content areas follows the definition of the supply chain provided by Xerox Corporation. In a further refinement of

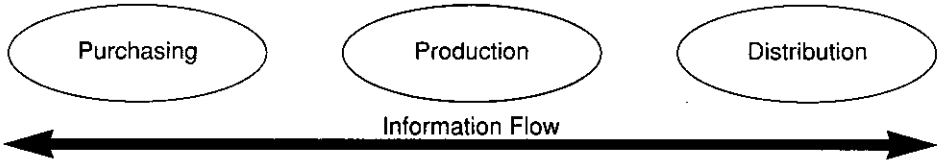
Figure 1
Supply Chain Management Schools of Thought

Chain Awareness School: There is a chain from supplier to end user through which materials flow.

Linkage/Logistics School: Emphasis is on linkages between functional areas where logistics and transportation are the focus.

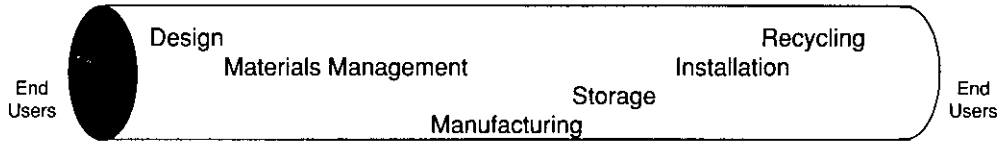


Information School: Emphasis is on information flow among chain members which can be bidirectional.



Integration School: Emphasis is on processes not functions and systems thinking.

The Future: A demand driven seamless pipeline emphasizing relations as well as transactions.



this view, Xerox extended the supply chain concept to include recycling and state that their chain goes from "earth to earth"[66]. In other words, managers at Xerox were interested in monitoring operations from sourcing of raw materials to recycling or safe disposal of the unused materials.

The process areas of SCM depict the different enabling factors for achieving supply chain integration. For example, information technology has been offered as a key enabling factor for supply chain integration. In all, five process areas were discerned from the literature (see Figure 2). The content and process areas are interrelated and should be considered together. They have been shown separately merely for the ease of discussion. The details of arriving at Figure 2 are provided in the Appendix which reflects the key areas (in either the content or process area) addressed by each article or book as an abbreviated summary of each.

Analysis of the Content Literature

Analysis of the content areas of the SCM literature depicts three broad trends. First, the functional areas of purchasing, manufacturing, and distribution are the most common in the supply chain literature. Since these SC areas were the foundation of the SCM literature [67,68], this is not a surprise. The areas of design, recycling, and installation are mentioned less because they are newer and have less functional presence in organizations. The second trend is the conjoint use of two functional areas to achieve supply chain integration. For example, the integration of the distribution function and customer, involving localization of generic products, has been discussed by Davis [69]. Similarly, the concept of "channel integration" in which the retailer provides sales data information directly to the manufacturer, thereby linking the manufacturer and retailer, has been mentioned in the literature. Thus, there appears to be an increasing emphasis on integrating "contiguous" functional areas.

Last is the trend of the diffuse and imprecise role of the customer in supply chain integration. While several authors mention the customer, little agreement exists on the role that the customer should play in SCM. Several articles treat the customer as the end link [70,71,72,73] in the supply chain, while others describe how the customer is linked to various parts of the chain [74, 75]. New SCM models are beginning to reflect the role of the customer as the starting point as well as the endpoint. As the customer plays an increasingly important part in various roles, supply chain research must shift focus and discuss these different roles. A distinction must be made between customer and end user. A customer is the next functional area or party that will use a part or service; and, a customer can be internal or external to a firm. The end user is the final user of a product, which is almost always external to a company [76].

The customer is beginning to play a role as an information source for various points in the supply chain.

The customer is beginning to play a role as an information source for various points in the supply chain. Traditional supply chain models begin with the design of the product and end with distribution. New technologies such as ECR, EDI, and quick response logistics are providing customer sales information not only quicker, but also to different members of the supply chain. Traditional supply chain relationships capture sales data, and based on these data, place orders with their suppliers, manufacturers, or distributors. New technologies such as EDI and ECR enable customer related information to be sent directly to suppliers, distributors, and manufacturers who can use this information to respond instantaneously to changing inventory levels. This represents the beginning of a SCM revolution which will capture and diffuse customer trends and preferences deep into supply chain member companies.

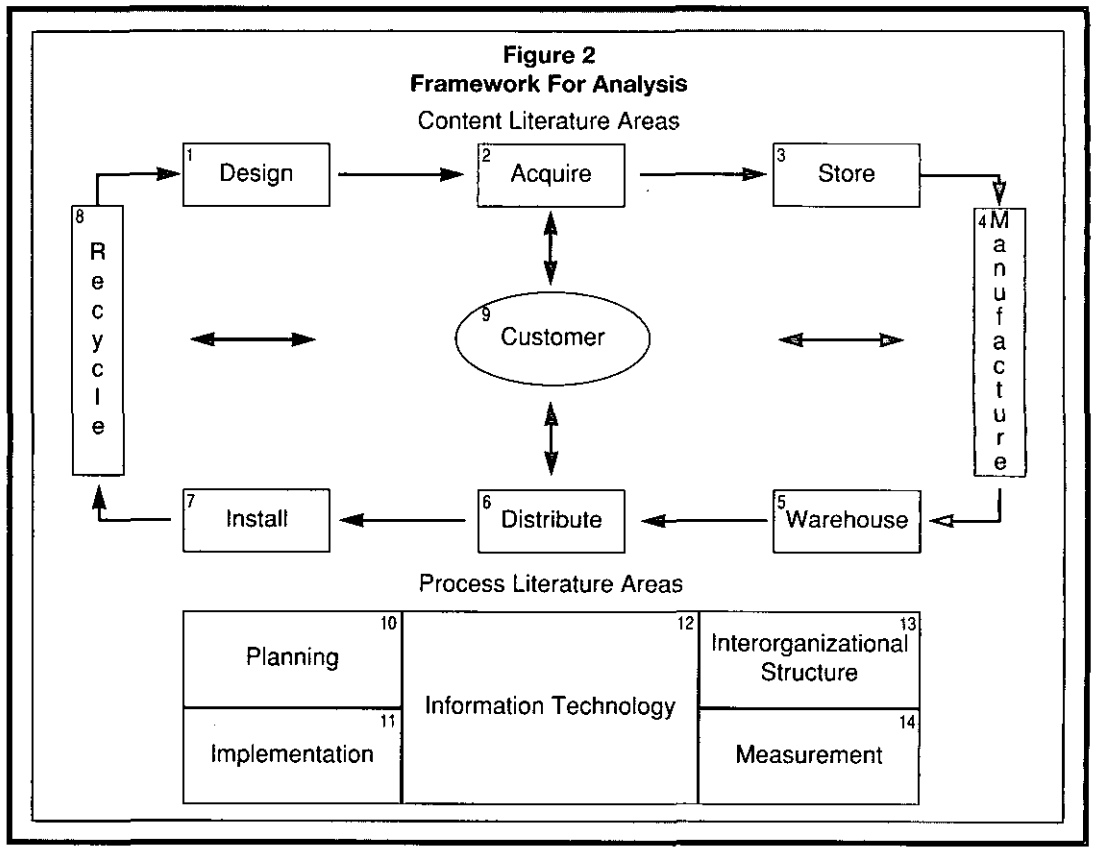
Analysis of the Process Literature

The five process areas identified from the literature are: planning, implementation, information technology, interorganizational structure and measurement.

Planning

Planning is a key component of SCM and consists of developing a SCM plan based on core philosophies adopted by a firm. Figure 3 provides an overview of the four core philosophies that drive SCM planning.

TQM. Total Quality Management (TQM) has been offered as a unifying theme for supply chain integration. Typical of this



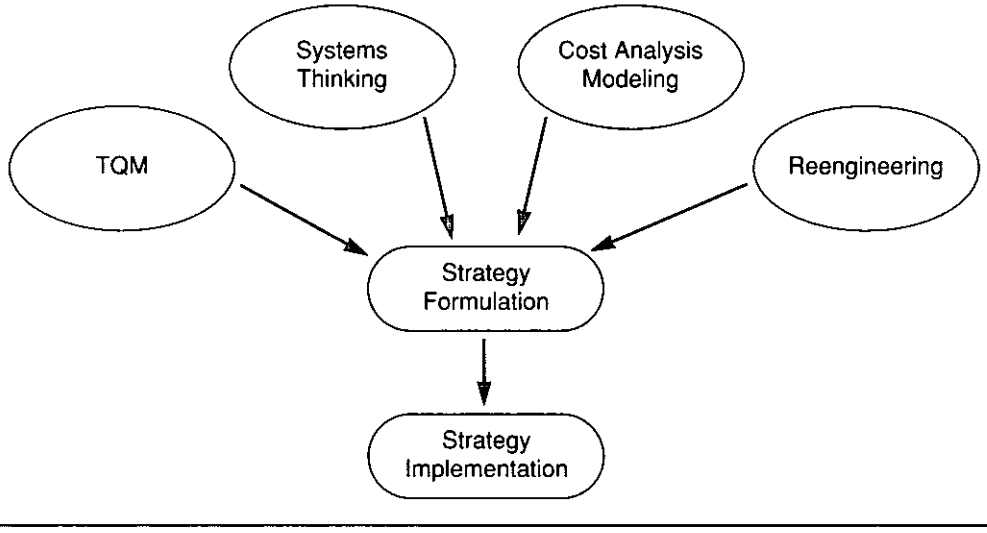
view is the importance of interorganizational relationships [77, 78]. Specifically, the concept of increasing collaboration between supplier and OEM (original equipment manufacturer) is a strong theme [79]. Suppliers gradually receive and share more information and schedules with OEMs and become co-maker of a product not just a supplier. While strong interorganizational relationships are important, Bessant et al., [80] also stress the importance of processes, procedures, tools, skills, and organizational structures that may help in moving to a more collaborative paradigm. Overall, the TQM philosophy has not gained sufficient attention in the SCM literature. In particular, the critical TQM themes of process improvement, variance control, and profound knowledge are yet to be tapped.

Systems Thinking. The underpinning philosophy mentioned most often in the SCM process literature is systems thinking [81,82,83,84]. Systems thinking involves movement away from functional department suboptimization of the supply chain to a holistic optimization of the entire supply chain. The focus in systems thinking is on how decisions made at a particular point in the chain affect the upstream and downstream points in the supply chain [85]. Bowersox et al. [86] introduce the concept of control with systems thinking by adding that the goal in SCM is not only a systems solution but also a control mechanism which monitors and corrects problems.

The types of systems described above are known as hard systems. Hard systems take an engineering approach to systems thinking where a problem is already outlined and the problem solver only needs to address "how" the problem will be solved [87]. A promising new area of inquiry in systems thinking is soft systems methodology (SSM). SSM requires the user to construct "what" the problem is as well as "how" it will be solved. SSM emphasizes analysis of human activity in its models. The user of SSM debates and learns by applying these models [88]. SSM allows managers to incorporate human elements and constant learning into supply chain planning and management.

Cost Analysis/Modeling. Cost analysis and modeling has also emerged as a philosophical underpinning to SCM [89,90,91]. Cavinato [92] developed a cost model which captures value across the

Figure 3
Core Philosophies of the Supply Chain Management Plan



supply chain. Cavinato's model is a way for departments in a firm to evaluate the impact of decisions on upstream and downstream functions.

Carter and Ferrin [93] analyzed the costs involved with transportation, purchasing, and suppliers and showed that cooperation among these parties can significantly reduce costs. Finally, Ellram [94] applied transaction cost theory to explain the different competitive forms of SCM.

Reengineering. Copacino [95], Eckler and Katz [96], and Nichols et al., [97] take significantly different perspectives to reengineering. Nichols et al. [98] stated the need for supply chain reengineering to move beyond internal reengineering efforts to include interorganizational issues, especially the use of information systems to reduce cycle time. Eckler and Katz [99] suggest that reengineering include interorganizational relations, especially between vendor and customer. The reengineering literature places a strong emphasis on addressing barriers to change management. The largest obstacle in reorganizing is to overcome firm barriers of efficiency and move toward integrated flexibility [100,101]. Eckler & Katz [102] suggest a three step reengineering process to overcome barriers including: audit, map, and implementation. Scott & Westbrook [103], described the usefulness of pipeline mapping which is an analytic technique to identify key process issues that could be reengineered.

Finally, Copacino [104] described the concept of "supply chain visioning." The vision process is a vehicle for management to reengineer the supply chain through innovative thinking. Visioning promotes radical managerial thinking beyond functions and also achieves stronger alignment between operations and strategy [105].

Implementation

The literature on SCM implementation is sparse; however, many authors tout its importance [106,107,108]. Two articles that describe implementation in detail are the works of Jones and Riley [109], and Lee and Billington [110] who identified barriers to implementation as well as measurement and information system problems. Most problems involving information systems are due to outdated information system designs, which are constructed for a functional silo organizational structure [111]. Other barriers to SCM integration include: lack of top management support; implementation problems [112]; lack of financial resources; lack of technical expertise; and personnel to utilize information systems [113].

Several authors believe that the most important barrier to reengineering is people and not systems or technology [114, 115, 116]. Whether you are addressing technical or human issues, implementation needs to occur in steps [117, 118] or through the use

of a process reference model [119]. Stevens [120] and Hewitt [121] offer models of SCM implementation which have several key similarities. Both authors begin by describing a functional silo situation and move towards integration of areas by emphasizing process issues. Hewitt takes the processes to an "intercompany" level, whereas Stevens keeps the idea at the "intracompany" level. There is agreement that the final stage of SCM implementation is a process as opposed to a functional focus [122,123,124,125].

Information Technology

The information technology literature considers how information will pass through and be analyzed in the supply chain. Information technology can be divided into four segments: data storage, decision support tools, information transfer between areas or firms, and future applications.

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Data Storage. A key to SCM effectiveness is an underlying common database which stores information that can be used by any SCM member [126]. This common database ensures that managers use consistent information in their decision making. However, implementing centralized database systems is not easy. Local system compatibility, unintegrated organizational structure, and the loss of good local information are three key barriers to effective centralized database implementation [127]. Also, how does a firm share information among external information users in a supply chain? Firms will become more dependent on supply chain members which will require more powerful interorganizational information systems [128].

Decision Support Tools. Decision support tools are the different technologies and tools that allow supply chain managers to perform scenario analyses or aid in decision making. These tools form strategic simulation of portions of the supply chain to a relationship grid, which helps managers see the various types of supplier relationships. Simulation is a technology that is being used more often in SCM primarily for three reasons. First, simulation can be an implementation tool. Simulation can be used to optimize usage of information systems with systems dynamics modeling which enables the user to consider the impact of different SCM design strategies. This unique methodology developed by Naim and Towill [129] is a direct offshoot of the pioneering works of Jay Forrester [130]. Naim and Towill's work combines the use of qualitative and quantitative phases of analysis as a firm passes through SCM design stages. Second, simulation and other technologies such as decision support systems can show the effects of decisions on upstream and/or downstream areas [131, 132]. Hewlett Packard uses a decision support system to evaluate the impact of decisions on upstream and/or downstream areas along the supply chain [133]. A similar application of simulation is to see the impact of taking particular supply chain echelons outside a company [134]. Third, simulation software and games can train employees in SCM decision making. The London Business School has a SCM simulation game that aids managers in understanding supply chain complexities [135].

Scott and Westbrook [136] describe two non-simulation tools that are helpful in initial SCM development stages. A relationship grid helps managers evaluate the various types of supplier relationships and identify where change is needed. A pipeline map helps identify the entire supply chain pipeline, so that opportunities for improvement are exposed.

Information Transfer and the Future of Information Technology. The information technology system mentioned most often in the SCM literature is electronic data interchange (EDI). While several authors tout the use of EDI [137,138,139,140,141], authors such as Gorder et al. [142] and Turner [143] state that EDI must develop data definition standards, provide flexibility in data transformation, and become more user friendly if EDI is to be used effectively.

Beyond EDI several other information technologies are creating tighter more integrated supply chains. New software is now available from several companies which actually integrates suppliers, distributors, manufacturers and delivery fleets [144]. Supply chain managers are also finding that better communication is needed to help in solving day to day problems. Radio frequency based systems and cellular systems are becoming more common methods of information exchange [145].

Interorganizational Structure

A critical issue in SCM structure is the use of cooperative relationships and partnerships. The role of partnerships in a supply chain is addressed by several authors [146,147,148]. Carter & Ferrin [149] postulate that compromises by the buyer, seller, and carrier can serve to improve profitability for all parties. The authors develop a generalized model and test it to substantiate this point. Not all authors believe that partnerships are beneficial to SCM. Research performed by A.T. Kearney as reported in an article by Anscombe [150] questions whether the use of partnerships is useful in SCM. The results of this study suggest that firms misinterpret the partnership idea and strive to create partnerships in all of their relationships which may not be desirable or reasonable. An empirical study performed by Lambert, Emmalhainz and Gardner [151] supports this conclusion and goes one step further by providing managers with a model that can be used to determine when partnerships are appropriate.

As firms globalize, the issue of global partnerships [152], business networks [153], and business ecosystems [154] evolve as areas of future opportunity that few authors have explored. Firms such as Wal-Mart and Disney are successfully creating and managing ecosystems where competitors, customers, and suppliers coevolve to form new industries. These ecosystems are heavily dependent on effective SCM.

SCM puts tremendous pressure on the ability of firms to structure strong relationships with suppliers, customers, and sometimes, competitors. Poorly structured supply chains in the west are creating opportunities for suppliers who can latch onto core systems and take a more prominent position in their supply chains. As power in western supply chains becomes distributed across suppliers, the ability to effectively administer power becomes crucial.

Measurement

Improper use of measurement tools or lack of measurements can be a barrier to implementing SCM [155,156]. Table 2 summarizes measures which have appeared in various articles. The most important issue in SCM measurement involves integrated versus non-integrated measures. Authors who call for more integrated performance measurement systems [157,158] note that the trend in SCM is towards integrated measures. Integrated measures involve measurement of an entire process or series of processes across functional areas. For example, Xerox [159,160] measures the time (in days) it takes to go from cash paid to cash deposited in their accounts (cash-to-cash). The cash-to-cash measurement includes many functions such as accounting, production (how fast the copier is manufactured), logistics (how fast the copier is delivered), and sales. Whereas, a traditional measure such as number of invoices past 30 days due does not incorporate the functional areas of manufacturing and distribution. The integrated measures help to avoid optimization at one point in the supply chain without considering the problems that may occur at other points. Integrated measures offer more control over the supply chain since key managers have measures reflecting actions across a number of functional areas.

Table 2 addresses three areas important to SCM measurement. First is the scope of the measurement system such as cost, time, or productivity/asset utilization. Second is a definition of the measurement or its name. Third is the behavior of the measures, which can be in a linear, ratio, or curvilinear form. Note that all of the cost measures in Table 2 are integrated measures. The most interesting is the use of curves by Hewlett Packard [161]. Curves are a useful tool because they help to show the balance that must occur between two areas such as cost and service. Hewlett Packard uses curves as measures for two reasons: curves incorporate the tradeoffs in decision making and can show average performance over the long haul or on a targeted average. Hewlett Packard uses curves to more accurately identify long-term trends and verify if annual goals are met.

While the list of measures in Table 2 covers various areas of the supply chain, several key omissions stand out. First, there are few measures which incorporate processes across firms. Only the measurements provided by Camp and Hewitt involving response time, cash-to-cash, and operating expense, analyze processes across suppliers, manufacturers, and distributors. Second, there are no measures addressing

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...a key area ignored in the SCM literature is new product development.

the effective combination of integrated and nonintegrated measures. By giving a supply chain member measurement information on their own performance (nonintegrated) as well as performance of the whole chain (integrated), two goals are achieved. First, the primary producer of the chain (such as Xerox) can see how the chain is performing overall, and if performance is poor, they can use the measurements on the individual supply chain members to see where problems are occurring. Second, by providing supply chain members with integrated measures, they will have more incentive to work with other members to increase performance on these measures. Without integrated measurement information, supply chain members have little incentive to work with other members. The only concern is to perform well on their own measures even if that performance is at the expense of other supply chain members. As firms move toward more integrated measures interesting issues arise. How will integrated measures be managed by the supply chain? Will there be one firm in charge of managing integrated measures? Who will control the integrated measures?

The literature suggests a wide net of functional responsibility for supply chain integration. Despite this wide coverage, the logistics flavor to SCM appears to be increasingly visible. Newer process areas or modes of achieving integration continue to appear in the literature. The process literature is distinctly lacking in empirical proof for the success of the methods offered for achieving supply chain integration. The awareness of SCM as a viable concept is gaining serious attention among practitioners and academics.

Directions of Future Research

SCM is increasingly important to managers. Yet, it is evident that the literature is fragmented. Some suggestions for future research are presented in this section.

Incorporate Design and New Product Development in Supply Chain Research

Most of the SCM articles deal with the purchasing - manufacturing interface and/or the manufacturing - warehouse/distribution interface. It is the opinion of the authors that a key area ignored in the SCM literature is new product development. There are few areas left where firms can pursue sustainable competitive advantage. New product development is one of these areas [162]. Can research on new product development ignore SCM issues and still provide a holistic view of the complexities that underlie the new product development process? We do not believe this is possible or desirable. Similarly, design issues have a significant impact on supply chain structure, relationships, and performance [163,164].

Timing is clearly a concern when it comes to design issues. In highly competitive industries such as the computer industry, it is no longer sufficient to simply have the best new product. Payback periods in the computer industry are so short that delays due to material problems can devastate product profitability. Similarly, flexibility attained in manufacturing through the practices of "design for procurability" [165] and "design for logistics" have emerged. Use of the expertise of the supply base or ingenious packaging can reduce pressures on the internal manufacturing and design functions. Another innovation in design that has helped supply chain integration is the concept of modularization which enables customized products to be made with relative ease and lower lead times. Finally, the emerging concern for the environment has led some firms to design products that can be recycled after the user ceases to use the product. Despite these advances, a broader conceptualization of integration through practices such as "design for supply chain" and "reverse flow logistics" need to be explored.

Integrate Across Disciplines

In some cases, firms are putting customers in direct contact with design teams, first tier suppliers, and manufacturing. The framework used in this paper to classify research reveals the complexity of the concepts, considerations, and linkages involved. Logistics, manufacturing, and purchasing dominate the literature to date. The SCM literature suggests integration across disciplines but how many SCM articles are truly integrated (collaboration of functional areas) efforts? If integration is a key driver of the SCM concept, then research and theory must reflect an integrated effort.

Table 2
Measurements

Measurement Area	Measurement	Type of Measure
Service	% fill rate against customer specified conditions (Camp 1995)	Linear
Cost	Logistics cost (Camp 1995)	Linear
Productivity Asset/Utilization	Inventory (value of raw materials excluding labor and overhead) (Raia 1992)	Linear
Productivity Asset/Utilization	Recycle utilization (Camp 1995)	Linear
Productivity Asset/Utilization	Throughput - number of items sold (Raia 1992)	Linear
Time	Response time (Camp 1995)	Linear
Time	Cash-to-cash (Hewitt 1992)	Linear
Time	Operating expense amount of money to convert inventory into throughput (Raia 1992)	Linear
Productivity Asset Utilization and Service	Corporate goal is ROA with 100% customer satisfaction (Camp 1995)	Linear
Service and Time	Order aging curve with days late on X axis and cumulative orders shopped on Y axis (Davis 1993)	Curve
Service and Time	Line item fill rate - with % demand met on Y axis and time on X axis (Davis 1993)	Curve

Perhaps, the lack of functional integration has constrained the development of strong SCM theory and empirical-based literature.

Expand the Role of the Customer and Customer Information

The role of the customer is an area that many articles mention, but few articles discuss in detail. The role of the customer in progressive firms has gone beyond being a source of product-related information to a more active participant in cross-functional design and procurement teams. Interface of the customer with areas such as manufacturing, not only helps manufacturing but also helps other areas such as distribution [166]. Customer information is becoming accessible to more supply chain members. Suppliers, distributors, and manufacturers are now privy to customer sales information on a dynamic real-time basis. More research is needed to investigate how the different members of the supply chain receive and use customer information. As the customer and customer information becomes increasingly diffused through the supply chain, research needs to examine the best practices for such diffusion.

A rich area that is unexplored in SCM is the use of measurements to better integrate the customer into the supply chain. We have described some of the new ways firms are integrating customers into the supply chain and using customer information. Current measurements at firms such as Xerox are measuring interfunctional and intercompany processes, but few companies incorporate customer satisfaction into their measures as Xerox does. Creation of measures across internal and external processes that incorporate customer satisfaction is an area for future research.

A rich area that is unexplored in SCM is the use of measurements to better integrate the customer into the supply chain.

Address the Differences in Supply Chains in Manufacturing Versus Service Companies

Logistics in retailing is primarily a pull system (highly customer driven). This is likely due to the heavy influence of the logistics literature on the SCM concept. Manufacturing supply chains on the other

hand are driven somewhat by the customer, but the supply side also plays a significant role. No research has addressed the differences in supply chains across industries and the effects of these differences.

Balance Conceptual/Theoretical Research and Empirical Research

The majority of articles on SCM have been case studies or conceptual. As the concept of SCM matures, a need to validate and build on the SCM concept exists. A first step will be to transfer concepts into theory. The only attempt to provide a theoretical underpinning has been through the use of transaction costs analysis [167]. We believe SCM is at a stage where there needs to be more theory building which can be empirically tested. Without theory development and testing, more ideas will emerge and compete with existing ideas and the concept of SCM will eventually become diluted and unimportant.

We believe SCM is at a stage where there needs to be more theory building which can be empirically tested.

Conclusion

This paper provides an overview of research on SCM from several different disciplines. A conceptual framework is offered to categorize the literature and to suggest areas for future research. An in-depth critique of the research on SCM is presented. Suggestions are advanced for future research.

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Appendix

Author	Linkages	Key Ideas
Anscombe (1994)	13	Results of 1994 survey suggest that concept of partnership is unhelpful because it implies a common ideal solution to all relationships. How power is used for benefit of the entire supply chain is key to developing successful relationships.
Anscombe (1994)	12, 13	Two trends will shape the future of supply chain management: 1) companies need to focus more of their improvement efforts outside traditional boundaries of the company; and, 2) increasing differentiation of services between customers which are served by different supply chains.
Armistead and Mapes (1992)	2, 4, 6, 12, 14	Top managers at several companies hope to attain supply chain integration through: 1) use of end to end performance measures; 2) greater integration of material schedules; 3) organizational structure changes for end to end responsibility; 4) improvements in customer service, inventory turnover and cost.
Arnitzer, Brown, Harrison and Trafton (1995)	12, 13	Use of global supply chain model at DEC to minimize cost or weighted cumulative production and distribution time or both subject to meeting estimated demand and restrictions on local content, offset trade, joint capacity for multiple production echelons, and time periods. The model is a large mixed integer program.
Bessant, Levy, Sang and Lamming (1994)	1, 2, 12, 13	The role of TQM as a key component of supply chain relationships is explored. Results indicate that management of seven specific components is crucial to effective interfirm supply chain relations.
Bowersox, Carter and Monczka (1995)	2, 4, 5, 6, 10, 11, 13	Discussion of the creation of the materials logistics management (MLM) program at Michigan State. The program focuses on understanding the interfaces between physical distribution, manufacturing, and purchasing.
Busch (1988)	2, 3, 4, 5, 6, 7, 11, 13	The argument is made that materials management is finally beginning to assert itself. Integrated materials management at Stihl Corporation is described in detail including synchronization, information, purchasing optimization, interface, synergy, and flexibility.
Camp (1995)	1-9, 10, 11, 13, 14	How Xerox used a supply chain to meet end user requirements that satisfy the customer using a minimum of working capital devoted to inventory assets and logistics expense. Details of the strategy measures and benchmarking are discussed.
Carter and Ferrin (1995)	2, 3, 5, 6, 10, 12	Analysis of relationship between traffic management and purchasing. The authors contend that effective buyer-seller negotiations must include transportation concerns. A trilateral optimized SCM model is used to show cooperation with full information disclosure can significantly reduce supply chain costs.
Cavinato (1992)	1-7, 9, 14	Develops a total cost /value model starting with raw material acquisition going to

		the customer. The model captures costs to the firm, costs to supply and distribution members and costs to the customer.
Christopher (1993)	3-7, 9, 10-14	Logistics strategy and the way the supply chain is managed are a vital source of competitive advantage. Logistics must be seen as part of a firms overall marketing strategy.
Cooke (1992)	4, 6, 9	Several firms are now using an approach to coordinate material flow from warehouse to the retail shelf called channel integration. In channel integration the buyer shares sales information with manufacturers so that both buyer and supplier can carry less inventory.
Copacino (1994)	13, 14	Introduces "supply chain visioning" which involves a series of working sessions where managers focus on the value requirements of each segment of a firm's business. The result is a focus on a unique distinctive competence of the firm or vision and managers discuss how operations can meet the vision.
Davies and Brito (1996)	14	Analysis of cost structure in grocer supply chains. Difference in supply chains are due primarily to internal cost differences among supply chain members rather than differences in logistics costs.
Davis (1994)	11, 12	Data analysis tools are now available that take data in virtually any format and present it in virtually any format, and on almost any platform. A number of companies that offer manufacturing software are discussed.
Davis (1993)	2, 3, 4, 5, 6, 9, 11, 13, 14	The supply chain methodology at Hewlett Packard is presented. The methodology hinges on HP's ability to grapple with uncertainty throughout their supply chain network. HP carefully accounts for upstream and downstream effects of uncertainty introduced at particular nodes along the supply chain. A decision support system is used.
Dawe and Rogers (1993)	6, 12	Most emphasis in the literature has been on data processing without considering data collection, storage and improvements in data communications. Research indicates a gap in logistics technology usage in barcoding in EDI. The results of a survey show that less than 60% of the firms use EDI and less than 60% use Barcoding. Five key barriers exist to the use of these technologies.
Eckler and Katz (1992)	2, 4, 9, 10, 12, 13	The emphasis is on identifying the key integrated processes and applying supply chain reengineering principles to the supply chain.
Ellram (1991)	12, 13	Industrial organization and transaction cost theory is applied to the supply chain concept so that future research can possibly benefit using the channels perspective to gain insight into the concepts of credible commitment and opportunism.
Ellram and Cooper (1990)	2, 3, 4, 5, 6, 9, 11, 12, 13	The focus is on the risks of using partnerships and/or third party providers in the supply chain. Strategic, economic, and managerial issues are discussed.
Evans, Naim and Towill (1993)	2, 4, 6,11	The thrust of SCM is to create better information. Cost savings can be achieved through: 1) supply chain simulation so that information system implementation is optimized; and, 2) feed actual customer demand forward to all players in the chain.
Giunipero and Brand (1996)	2, 10	An empirical study of purchasing managers found that SCM is primarily thought of as developing relations with suppliers to improve commitment, coordination, and reduce costs for the buyer.
Gorder, Ridenhower and York (1992)	2, 4, 11, 12	If EDI is left in its current form EDI will get relegated to the back room and eventually become obsolete. For EDI to prosper it must have: standard data definitions, automated transformations of data, and flexible dynamically defined data access.
Hakansson and Snehota (1995)	12	The role, development and performance of companies is explained by their ability to develop relationships. Efficiency of internal processes can be significantly impacted by successful external relationships.
Hall (1991)	6, 9	Distribution has gone from a functionally oriented department to supply chain integrator through the ability to provide a number of value added options within cost profiles to meet customer's needs.
Hammel and Kopczak (1991)	2, 4, 6, 11	Discussion of Hewlett Packard's display terminal operation where two m ajor changes were made between 1985-1991. 1). Engine product line was redesigned for improved manufacturability and flexibility, 2) Improved product availability by introducing a new Distribution Requirements Planning process to create a system

		in which the distribution center pulled product from the factory
Harrington (1995)	1, 2, 4, 6, 11, 12, 13	A study at A .T. Kearney is discussed where only 33% of North American firms have begun to integrate their supply chains with suppliers. For firms to achieve breakthrough results process reengineering and team based organization with an emphasis on self management must occur.
Harrison (1990)	2, 4, 11, 13	The impact of quality in the supply chain especially the role of OEMs is discussed. The role of quality differs as you move along the supply chain. EDI plays a key role in developing quality.
Hewitt (1992)	1-8 ,11, 13, 14	Several myths concerning integrated supply chain management are analyzed. Key points include: integration is the focus not cost cutting, the human motivational aspects of change will be more difficult to manage than the technical change aspects, and the ultimate goal is to make the complex more simple.
Hewitt (1994)	2, 3, 4, 6, 7, 8, 12, 13	Application of the business process reengineering and business process management are shown which if applied appropriately lead to breakthrough levels of inter and intra operational efficiency and effectiveness. Includes experiences of several pioneering practitioners.
Houlihan (1987)	2, 4, 6, 9, 11, 13	The concept of supply chain management is introduced multinational firms are particularly vulnerable to logistics problems. Strategies to grapple with these unreliabilities are discussed.
Johansson (1994)	2, 4, 8, 13	Total quality environmental management and supply chain management are merged by the authors. Products can increase their value by incorporating a life cycle perspective.
Jones and Riley (1985)	2, 4, 6, 9, 10	The article covers four areas including: inventory myths versus realities; how to gain competitive advantage through SCM; case studies of supply chain techniques; and, barriers to a supply chain approach.
Lalonde and Pohlen (1996)	14	Direct product profitability, total cost of ownership, and activity based costing provide useful information but do not address the entire supply chain. Supply chain costing measures the costs of activities spanning the entire channel.
Lambert, Emmelhainz and Gardner (1996)	10, 11, 13	A model is presented which can be used to determine if a partnership is appropriate and if so, what type of partnership.
Lee and Billington (1992)	1, 2, 9, 10, 13	Description of what manufacturing support managers at Hewlett Packard see as needs for model support in managing material flows in supply chains Is done. The authors develop a model for supply chains not totally under centralized control.
Lee and Billington (1993)	1, 6, 10, 11, 12, 14	Pitfalls to managing the supply chain inventory. Pitfalls 1-4 look at information definition and supply chain management, 5-9 relate to operational problems and 10-14 are strategic and design related.
Loforte (1993)	12, 13	An actual program called "Trailblazer" implemented by a global company to address SCM issues outside the country and logistics function is discussed. The trailblazer team developed its own mission statement and goals and objectives. Significant results were achieved and the results and methodology were published within the firm.
Matthyssens and Van den Bulte (1994)	2, 12	The most important change in the buyer-supplier landscape is increased cooperation, outsourcing, and globalization. Relationship marketing is a possible solution to these challenges.
Muller (1993)	5, 6, 11	Becton Dickson's use of global supply chain as a customer service strategy which delivers services tailored to specific customer needs.
Naim and Towill (1994)	11, 12	A framework using systems dynamics modeling with analysis and simulation aids is used to consider the impact of different supply chain design strategies prior to implementation.
Nichols, Jr. and Wetherbe (1994)	2, 4, 10, 11	Reengineering organizational processes across the supply chain may be more beneficial than internal reengineering. Interorganizational information systems is the key to improve cycle time performance across the supply chain. An organization study analyzes performance across a supply chain in the computer electronics industry.
Raia (1992)	2, 4, 14	Emphasis is on creating a seamless material flow. Examples from Pratt Whitney, Spectrum Management, Freightliner, and Rockwell describe how measures and the use of bottleneck/constraint identification and information schedule sharing can be used as effective tools to reduce supply chain costs.

Scott and Westbrook (1991)	14, 10, 12	Several tools to overcome the barriers to SCM are presented including: a pipeline map and a relationship grid.
Stenross and Sweet (1991)	2, 4, 6, 7, 8, 9, 10, 11, 13, 14	Implementing SCM in Xerox's document processing business with emphasis on logistics costs, asset levels, and customer satisfaction's impact on ROA/profits multinational cross functional teams vision and route map, executive support and benchmarking.
Stevens (1992)	14	Supply chain strategy is analyzed as a competitive weapon. Managing the supply chain requires a balance between the goals of high customer-service and low inventory-investment/low unit-cost goals which is usually seen as a tradeoff. A four step process of supply chain integration is presented.
Towill , Naim and Wikner (1992)	12, 14	Uses simulation models to analyze proposed supply chains. Results of various scenarios are simulated where intermediate supply chain echelons are taken over or changed in some other way.
Turner (1993)	12, 13	Author talks to several logistics professionals to discuss what SCM is. Specific discussion is on information systems, implementation and how SCM must go beyond EDI and barcoding.
Wikner, Towill and Naim (1992)	12	Uses simulation through a three level production distribution system to gain a system dynamic understanding of supply chain decision making.

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