Supply Chain Management: Practices, Concerns, and Performance Issues

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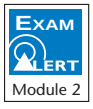
SUMMARY

The advent of information technology and intense global competition has enticed many world-class manufacturers and service providers into adopting an integrated strategic approach to supply chain management. Although many supply chain management efforts have failed to achieve the desired results, it has become a significant strategic tool for firms striving to achieve competitive success. Using a survey of senior supply and materials management professionals in the United States, this study investigates the contemporary practices and concerns of supply chain management. This study also relates the practices and concerns to firms' performance by means of bivariate correlation and multiple linear regression analysis. A general conclusion is that all of the significant supply chain management practices positively impact performance.



INTRODUCTION

During the 1990s, many manufacturers and service providers collaborated with their strategic suppliers to upgrade traditional supply and materials management functions and integrate them as part of corporate strategy. Correspondingly, many wholesalers and retailers also integrated their logistics functions with other functional areas to enhance competitive advantage. Eventually, these two traditional supporting functions of corporate strategy evolved and merged into a holistic and strategic approach to materials and logistics management, commonly known as supply chain management (SCM). The literature is replete with buzzwords such as supplier integration, partnerships, supply base management, supplier alliances, and supply chain synchronization to address aspects or stages of this new management philosophy (Tan 2001; Tan et al. 1998a; La Londe and Masters 1994).

Scott and Westbrook (1991) and New and Payne (1995) described SCM as the chain linking each element of the manufacturing and supply process from raw materials through to the end users, and treating all firms within the supply chain as a unified virtual business entity. Baatz (1995) further expanded SCM to include recycling. The philosophy of SCM focuses on how firms utilize their suppliers' processes, technology, and capability to enhance competitive advantage (Farley 1997), and the coordination of the manufacturing, logistics, materials, distribution, and transportation functions within an organization (Lee and Billington 1992). In an attempt to trace its development, Tan (2001) classified the SCM literature into two perspectives, that is, the purchasing perspective of the manufacturers and the logistics perspective of the merchants. While SCM includes all of the value-adding activities through the supply chain, a practical approach is to consider only strategic suppliers because it is too complex to achieve a full integration of all business entities within the supply chain (Tan et al. 1998a, 1998b). This narrower definition of SCM involves the integration of the various functional areas within an organization to enhance the flow of goods from immediate strategic

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suppliers through the manufacturing and distribution chain to the end users (Houlihan 1987, 1988).

This article describes a research effort driven by three objectives. The first objective was to derive a set of SCM practices and compare how practitioners ranked these practices to enhance competitive position. The second objective was to identify and compare the major concerns in implementing a successful SCM program. Finally, the third objective attempted to identify the practices and the concerns associated with successful supply chains.

The following section examines the evolution of SCM. Subsequent sections describe the research construct, provide demographic characteristics of the respondents, address non-response bias, and describe the survey methodology, followed by an analysis of the results and the managerial implications of the study. Future research directions are also discussed.

SUPPLY CHAIN MANAGEMENT LITERATURE

In the 1950s and 1960s, most manufacturers emphasized mass production to minimize unit production cost as the primary operations strategy, with little product or process flexibility. New product development was slow and relied exclusively on in-house technology and capacity. Excess inventory was used to cushion bottleneck operations to maintain a balanced line flow, thus resulting in huge investment in work-in-process (WIP) inventory. Sharing technology and expertise with customers or suppliers was considered too risky and therefore unacceptable, thus little emphasis was placed on cooperative and strategic buyer-supplier partnerships. In the 1970s, material requirements planning (MRP) was developed and managers realized the impact of huge WIP inventories on manufacturing cost, quality, product development, and delivery leadtime. Manufacturers resorted to new materials management concepts to improve performance.

The intense global competition of the 1980s forced world-class organizations to offer low-cost, high-quality, and reliable products with greater design flexibility. Manufacturers utilized Just-In-Time (JIT) and other management programs to improve manufacturing efficiency and cycle time. In the fast-paced JIT manufacturing environment with little inventory to cushion production problems, manufacturers began to realize the potential benefit and importance of strategic and cooperative buyer-supplier relationships. The concept of SCM emerged as manufacturers experimented with strategic partnerships with immediate suppliers. In addition to the procurement professionals, logistics experts carried the concept a step further to incorporate the physical distribution, transportation, and warehousing functions (Tan 2001).

The evolution of SCM continued into the 1990s as organizations further extended best practices in managing corporate resources to include strategic suppliers and the logistics function. Instead of duplicating non-value-adding activities such as receiving inspection, manufacturers trusted suppliers' quality control by purchasing from a handful of certified suppliers (Inman and Hubler 1992). Many manufacturers and retailers are embracing the concept of SCM to improve efficiency and effectiveness across the supply chain. Manufacturers are exploiting supplier strength and technology to support new product development efforts (Morgan and Monczka 1995), and retailers seamlessly integrate with their logistics providers to achieve direct store delivery without the need for receiving inspection (St. Onge 1996).

Research in SCM evolved along two separate paths that eventually merged into a common body of literature, with a primary focus on integration, customer satisfaction, and business results. The purchasing and supply perspective of SCM involves the previously disparate purchasing and supply management functions of the industrial buyers, whereas the transportation and logistics perspective evolves from the transportation and physical distribution functions of the retailers. A summary and discussion of the recent SCM literature can be found in Tan (2001).

Most of the recent SCM literature addresses the purchasing process, emphasizing that it is a basic strategic business process, instead of a supporting role to overall business strategy (Reck et al. 1992). Supply chain management is a philosophy that extends traditional internal activities by embracing an interenterprise scope, bringing trading partners together with the common goal of optimization and efficiency (Harwick 1997). SCM creates a virtual organization composed of several independent entities with the common goal of efficiently and effectively managing all of its entities and operations, including the integration of purchasing, manufacturing, distribution, and logistics management. The short-term objective of SCM is to increase productivity and reduce inventory and cycle time, while the long-term strategic goal is to increase customer satisfaction, market share, and profits for all members of the virtual organization. Strategic partners in a supply chain must realize that the purchasing function is the crucial link between the sources of supply and the organization itself, with support coming from overlapping activities to enhance manufacturability for both the customer and the supplier. For example, the involvement of purchasing in concurrent engineering is essential for selecting components to ensure that the requisite quality is designed into the product and to aid in collapsing design-to-production cycle time.

The transportation and logistics functions of the retailing industry focus on a different aspect of SCM, that is, one of location and logistics issues more often than transformation. Its origin can be traced to an effort for better managing the transportation and logistics functions (Fisher 1997; Lamb 1995; Whiteoak 1994; Turner 1993; MacDonald 1991). The transportation and logistics perspective incorporates logistics focus into the strategic decisions

of the business (Carter and Ferrin 1995; Houlihan 1988). It enables channel members to compete as a unified logistics entity instead of pushing inventory down the value chain. In this setup, the benefits of vertical integration can be obtained by coordinating the logistics functions of independent firms in the chain (La Londe and Masters 1994).

The goal of the transportation perspective of SCM is to replace inventory with information to provide visibility, so that merchandise can be replenished quickly and arrive where and when it is needed in smaller lot sizes, especially in a JIT system (Handfield 1994). It is a strategic tool and differs from classical transportation and logistics management in that the supply chain is a unified entity (Jones and Riley 1987), where inventories are used only as a last resort to buffer uncertainty in business patterns. A supply chain can reduce its overall inventory by efficiently redistributing stock within the supply chain (Davis 1993; Scott and Westbrook 1991). In the integrated logistics concept, short and reliable order cycles and the ability to fill entire orders are critical customer service elements (Ellram et al. 1989). The geographical spreads of channel members and cost structures become important determinants of the structure of logistical support (Fernie 1995; Taylor and Probert 1993).

When SCM research merged into a common body of knowledge that encompassed all of the value-adding activities, researchers realized the importance of incorporating SCM in the overall business planning process. However, Carter and Narasimhan (1994) noted that it was not widely practiced. Ellram and Pearson (1994) also discovered that despite the increased emphasis of integrating purchasing into overall corporate strategy, the primary function of purchasing remained a clerical role of negotiating prices/items. While many SCM strategic models have been proposed and studied (Frohlich et al. 1997; Watts et al. 1992; Freeman and Cavinato 1990; Reck and Long 1988) to link the crucial role of SCM in overall strategic corporate planning, they failed to suggest any action model that is useful to practitioners.

Despite the importance and theoretical development of SCM, there is little empirical research on how practitioners define and incorporate SCM practices into overall corporate strategy. While SCM efforts at some companies have resulted in improved competitiveness, similar results in other organizations have remained elusive. Little is known about the specific practices or concerns of a successful SCM implementation. This research investigates these issues by means of empirical data.

RESEARCH CONSTRUCTS

Supply Chain Management Practices

In the face of a competitive global market, organizations have downsized, focused on core competencies, and attempted to achieve competitive advantage by more effectively managing all internal and external value-adding activities. Many firms have reduced their supply base so they can more effectively manage relationships with strategic suppliers (Tully 1995). The literature indicates that buying firms are developing cooperative, mutually beneficial relationships with suppliers and viewing suppliers as virtual extensions of their firm (Mason 1996; Copacino 1996). Superior supplier capability can lead to exceptional quality or rapid integration of the latest technological breakthroughs into the buying firm's own products through early supplier involvement (Ragatz et al. 1997). Suppliers may also participate earlier in the product design process to render more cost-effective design choices, develop alternative conceptual solutions, select the best components and technologies, and help in design assessment (Monczka et al. 1994; Burt and Soukup 1985).

Emphasizing internal competencies requires greater reliance on external suppliers to support non-core requirements, particularly in design and engineering support (Prahalad and Hamel 1990). Firms thus find themselves expanding the need to effectively manage internal competencies to include members of the value chain. In an empirical survey, Tan et al. (1998b) identified 10 SCM practices, and showed that some of the practices affected firms' performance. However, while many SCM models have been proposed (Frohlich et al. 1997; Watts et al. 1992; Freeman and Cavinato 1990), there has been a lack of knowledge on actual industry practices for implementing effective SCM, and their relationship to firms' performance.

For the purpose of this study, 25 commonly cited SCM practices from the literature were identified (see Table III). These included practices related to supply and materials management issues, operations, information technology and sharing, and customer service. Since this was an exploratory study, no attempt was made to organize or group the 25 practices into any specific order or category.

Supply Chain Management Concerns

A key element of successful SCM involves the downstream integration of business customers as well as the management of upstream suppliers. However, integrating the entire value chain is a complex undertaking. Organizations encountering problems due to increased reliance on suppliers may reverse their downsizing emphasis and bring outsourced products and services back in-house, secure alternative sources of supply, or work with existing suppliers to increase their performance and capability (Watts and Hahn 1993). Alternatively, firms can use supplier evaluation to identify specific supplier deficiencies and to develop plans to address them (Krause 1997).

While it is beneficial to recognize the specific practices that result in successful SCM implementation, it is also helpful to understand the primary concerns hindering a successful supply chain. The primary goal of identifying these concerns was to provide practitioners with a list of issues that adversely impact firms' performance and

appropriate actions that could be taken. To operationalize this construct, nine commonly cited concerns that restrain successful SCM were identified (see Table IV) based on interviews and discussions with practitioners during plant visits and professional meetings. Once again, the SCM concerns were not organized in any order or categorized in the survey instrument. The concerns included cooperation and trust among supply chain members, information capability, competition, and geographical proximity.

Performance Measures

Economists disagree about the use of accounting data to measure firm performance because it ignores opportunity costs and the time value of money (Chen and Lee 1995). They have argued that business performance should be measured by financial data (e.g., internal rate of return). Financial data provides a measurement of a firm's performance via the market's valuation of the firm's securities. However, since future cash flows of the business entity cannot be observed, measures of business performance are typically based on accounting data (e.g., return on investment [ROI] or return on assets [ROA]). While Jahera and Lloyd (1992) observed that ROI was a valid performance measure for midsize firms, Tobin and Brainard (1968) challenged its validity as a performance measure. A firm's financial leverage can affect its ROI to such a degree that it renders comparisons between firms meaningless. ROI also ignores opportunity costs and the time value of investments. An alternate measure of performance, Tobin's q ratio, evaluates the ratio of the market value of a firm to the replacement cost of its assets (Tobin 1969). However, the prospect of obtaining accurate measures of each firm's market value and the replacement cost of its assets to calculate Tobin's q was deemed impractical for this research.

Given the lack of consensus regarding a valid cross-industry measure of corporate performance, performance in this study was operationalized by senior management's perceptions of a firm's performance in comparison to that of major competitors. This research adopted three of the nine performance measures used in Tan et al. (1998b). The measures are overall product quality, competitive position, and customer service levels.

SURVEY METHODOLOGY

A survey instrument in the form of a questionnaire was designed based on the constructs previously described. Respondents were asked to indicate, using a five-point Likert scale, the importance of the 25 practices (1 = low, 5 = high) in their firm's SCM efforts. For questions regarding SCM concerns, respondents were asked to indicate, on a similar five-point Likert scale, the likelihood that the nine issues prevented their firm from achieving the full potential of SCM. To elicit information on performance, respondents were asked to indicate, using a similar five-point Likert scale, their company's performance relative to that of major industry competitors in terms of overall product quality, overall competitive position, and overall customer service levels. Some other questions including demographics information were also presented in the questionnaire.

The survey instrument was pretested by 30 supply and materials managers for content validity. Where necessary, questions were reworded to improve validity and clarity. The pretest questionnaires were not used for subsequent analyses. The revised survey instrument was sent to 1,500 supply and materials managers identified from the Institute for Supply Management™ (ISM) (formerly the National Association of Purchasing Management) membership list. Firms represented by these individuals were from Standard Industrial Classification (SIC) 20 to 39. The respondents represented manufacturers of food and kindred products, tobacco products, textile mill products, apparel and other textile products, lumber and wood products, furniture and fixtures, printing and publishing, chemicals and allied products, petroleum and coal products, rubber and plastics products, leather and leather products, fabricated metal products, industrial machinery and equipment, electronic and other electric equipment, transportation equipment, and miscellaneous manufacturing industries. Two mailings and a follow-up reminder yielded 101 usable returned surveys.

A second phase of the survey targeting 3,000 supply and materials managers identified from the American Production and Inventory Control Society (APICS) was conducted. The first APICS survey was mailed on October 1, 1999, and the follow-up postcards were mailed two weeks later. The final reminder with a complete, identical questionnaire was mailed on November 1, 1999. The last usable survey was received in the first quarter of 2000. Two mailings and a follow-up reminder yielded a total of 310 usable surveys. The combined ISM and APICS surveys resulted in a response rate of 9.1 percent (411 responses). Subsequently, t-tests were conducted to compare the sales, number of employees, and responses to the relevant survey questions between the ISM and APICS data. The analysis did not reveal any statistical difference between the two populations. Therefore, results of the two surveys were combined.

Non-Response Bias

To investigate the possibility of non-response bias in the data, responses of early and late waves of returned surveys of the ISM and APICS data were tested separately. The last wave of surveys received was considered to be representative of non-respondents (Armstrong and Overton 1977; Lambert and Harrington 1990). Specifically, 30 of the survey items used for the analysis were randomly selected. Each sample was split into two groups on the basis of early and late survey return times, and t-tests were performed on the responses of the two groups. The t-tests yielded no statistically significant differences between the early and late response groups, suggesting that non-response bias was not a problem in this study.

Common Method Bias

This research collected data from a single respondent from each target firm, without collecting and cross-validating responses from a second informant from the same firm. Some researchers argue that relying on a single informant to answer complex social judgments about organizational characteristics increases random measurement error. Thus, strong assessments of convergent or discriminant validity cannot be made. However, the cost associated with using multiple informants from each organization is prohibitive. Therefore, this research used data from a single respondent while attempting to minimize the extent of common method variance by targeting the surveys to senior managers. It was assumed that the senior managers were more objective and knowledgeable with respect to their firms' operations.

RESPONDENTS' PROFILE

Table I shows the respondents' profile of the combined ISM and APICS data. Final product manufacturers (44 percent) made up the largest portion of the respondents, and potentially had a significant impact on the survey results since they were likely to focus on the purchasing and supply activities of SCM. The responding companies varied in size, employing between 10 and 300,000 employees (including part-time and temporary employees). Annual gross sales of the companies ranged from $5,000 to $59 billion, with a median of $125 million.

Slightly more than half (50.4 percent) of the respondents were ISO 9000 series certified, which was higher compared to the 24 percent reported by Tan et al. (1998a) (which used a mailing list from the American Society of Quality). A very small portion (4.7 percent) of the respondents was ISO 14000 certified. More than half of the respondent firms (67.3 percent) practiced some form of SCM, and approximately 60 percent maintained some form of supplier certification program. While the literature indicated that certifying suppliers' processes was preferred (Inman and Hubler 1992), a large portion of the respondent firms certified both products and processes.

More than 58 percent of the respondents had a supplier partnership or strategic alliance program. Indeed, 77.6 percent of the respondents with supplier partnership programs reported an increase in such programs over the last three years. The respondents also indicated that the two most important achievements of the partnership program were an increase in cooperation and communication among suppliers and buyers, and a lower total cost. More than half (52.5 percent) of the respondents reported an increase in outsourcing activity for primary materials and components, and 36.5 percent saw an increase in outsourcing activity for maintenance, repairs, and operating (MRO) supplies over the last three years. Data from this study suggest that firms are concentrating their business volume with a smaller supplier base. Over the last three years, 39.7 percent have reduced the supplier base for materials and components, and at the same time 29 percent have reduced the number of suppliers for MRO.

The respondents were also asked to identify the supply chain partners they considered part of their firm's SCM efforts. More than one-third of the respondents considered the transportation function as an activity of SCM. The supply and logistics respondents, as should be expected, focused more on suppliers than customers as part of their SCM efforts. For example, 48.4 percent included their first-tier suppliers in their SCM efforts, whereas only 33.6 percent included first-tier customers (Figure 1). Even so, 52 percent focused on customers through three tiers. This could be explained by the increased interest of manufacturers in integrating suppliers' technology and capability, especially in new product development.

STATISTICAL ANALYSIS

Reliability Analysis

The reliability of the scales for performance measures and SCM practices and concerns was evaluated using Cronbach's α (Cronbach 1951). For each scale, a value of $\alpha > 0.75$ was obtained (Table II), suggesting that the scales were reliable (Nunnally 1988). The standardized item α is the α value that would be obtained if all of the items were standardized to have a variance of 1. Since there was little difference between the two αs, the items on the scales have fairly comparable variances. The analysis also suggested keeping all of the questions in the three measurement scales. The SCM practice scale, which consisted of 25 questions, was the most reliable among the three measurement scales.

Bivariate Correlation of SCM Practices and Concerns vis-à-vis Performance

Mean responses for the 25 SCM practices ranged from 2.18 to 4.41, with a median of 3.67 (Table III). Although a practice with a higher mean value could not be interpreted as statistically more important than the others, the four highest-ranked practices were determining customers' future needs, reducing response time, and suppliers' and respondents' on-time deliveries. These four practices seemed to be time-based related. Surprisingly, geographical proximity (locating closer to your customers and requiring suppliers to locate closer to your firm) was not rated at the top of the list. One would expect geographical proximity between suppliers and buyers to be critical for implementing a successful supply chain, especially in a JIT environment where there is little excess inventory to cushion delivery or scheduling problems. The data suggest perhaps that firms can use logistics processes to solve the location/distance question.

The use of formal (3.65) and informal (3.60) sharing was ranked below the median, suggesting that while the literature emphasized information sharing through electronic

Table I

RESPONDENTS' PROFILE

Sample Size	Mailed	Received	%
ISM	1,500	101	6.73
APICS	3,000	310	10.33
Total	4,500	411	9.13

Respondents' Business Function	%
Raw Material Manufacturer	3.7
Component Manufacturer	14.1
Final Product Manufacturer	44.0
Wholesaler and Retailer	14.0
Others*[1]	24.2
	100.0

Number of Employees*[2]	#	Annual Gross Sales	$
Median	500	Median	$125 m
Minimum	10	Minimum	$5,000
Maximum	300,000	Maximum	$59 b

Others – Percent of Respondents …	%
With ISO 9000 series certification*[3]	50.4
With ISO 14000 certification	4.7
With a supplier certification program*[4]	59.9
With a supplier partnership or strategic alliance program	58.3
Reported an increase in strategic alliance programs over the last three years	77.6
Reported an increase in outsourcing activity for MRO over the last three years	36.5
Reported an increase in outsourcing activity for primary materials/components over the last three years	52.5
Reported a decrease in the supplier base for MRO over the last three years	29.0
Reported a decrease in the supplier base for primary materials/components over the last three years	39.7

*[1]Includes contract manufacturer, utility company, auto repair workshop, government, and turnkey.
*[2]Includes part-time and temporary employees.
*[3]18.6% of the respondents are ISO 9000 certified, 51.8% are ISO 9001 certified, 34.2% are ISO 9002 certified, 2.5% are ISO 9003 certified, and 1.5% are ISO 9004 certified. The total percent exceeded 100% because some respondents obtained multiple certifications.
*[4]19.5% of the respondents with supplier certification programs certify suppliers' products, and 8.1% certify suppliers' processes. 72.4% certify both products and processes.

Figure 1

ACTIVITIES OF SUPPLY CHAIN MANAGEMENT

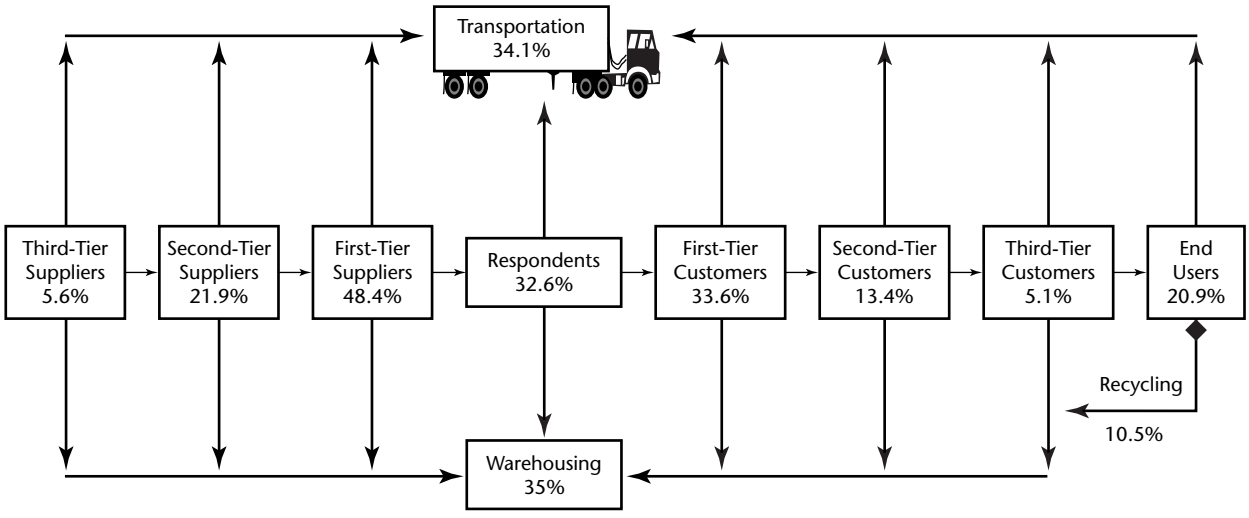

Table II

RELIABILITY ANALYSIS

Scale Items	# of Questions	Cronbach's α	Standardized Item α
Performance Measures	3	0.751	0.753
Supply Chain Management Practices	25	0.895	0.898
Supply Chain Management Concerns	9	0.759	0.763

data interchange (EDI) to be an essential component of SCM, it was not found to be as critical as other practices. Creating a compatible information system (3.61) was also ranked below the median. While a compatible information system greatly simplifies transmission of documents exchanged through EDI between partners in a supply chain, many firms believe that strategic advantage can be achieved only with proprietary EDI capability (Bowersox and Closs 1996). Creating a compatible information system to accommodate the needs of all users along the supply chain is a very complex undertaking. The complexity results because different users require transactions with different characteristics, and a compatible system must accommodate them all. Further, compatible systems do not provide competitive advantage since they can be readily duplicated by competitors. The dilemma of incompatible systems can easily be resolved by the use of a value-added network that, in addition to managing transactions and translating communication standards, can also be used to reduce the number of communication linkages.

Another interesting observation is the conflict of data between Table III and Figure 1. In Table III, the importance of extending the supply chain beyond immediate suppliers and customers (2.83) was ranked nearly at the bottom, based on the mean values; while in Figure 1, fully 46 percent show that they are involved with second- and third-tier suppliers and customers. While theoretically, SCM includes all value-adding activities from the extraction of raw materials to the end of the useful life of a product, it is considered too complex to achieve a full integration of all business entities within the value chain. Some data (e.g., Tan et al. 1998a) suggest that businesses just focus on immediate suppliers and customers, and thus ignore the theoretical total cost reduction opportunities of SCM.

The last three columns of Table III show the results of a bivariate correlation analysis of the SCM practices vis-à-vis performance. Determining customers' future needs, reducing response time, suppliers' on-time delivery, improving the integration of activities, creating a greater level of trust among supply chain members, communicating future strategic needs, the use of formal information sharing, aiding suppliers to increase their JIT capability, and five other practices are statistically and positively related to overall product quality. The managerial implication of this simple analysis is that firms should concentrate on these practices to improve product quality.

Creating a greater level of trust among supply chain members, on-time deliveries, aiding suppliers to increase their JIT capability, and 10 other practices were effective tools for improving overall customer service. To improve overall competitive position, the survey results suggested that firms should focus on determining customers' future needs, reducing response time, on-time deliveries, aiding suppliers to increase their JIT capability, participating in the sourcing decisions of suppliers, and other practices that showed a significant relationship.

A general conclusion was that all of the significant SCM practices positively impact performance. Although significant correlation between two variables does not imply causation, firms should focus on the significant practices to improve quality, customer service, and overall competitive position. A higher significant correlation coefficient could be translated into larger impact on the firm's performance. For example, improving the integration of activities across the supply chain (0.202) has a larger impact than determining customers' future needs (0.105) on improving product quality. Another managerial implication was that firms should also focus on those practices that significantly impact all three performances simultaneously. For example, suppliers' on-time deliveries affect product quality, customer service, and competitive position, whereas respondents' on-time deliveries affect only two of the three measures (Table III).

Mean responses to questions on SCM concerns ranged from 2.41 to 3.45, with a median of 2.98 (Table IV). While the lack of sophisticated information systems received the highest mean score, several other concerns also received high scores. Based on the mean values, the lack of ability in managing supply chain inventory (3.33) was ranked a higher concern than the lack of cooperation among supply chain members (3.07) and trust (3.07). The lack of concern regarding customers' and suppliers' geographical distance was consistent with the finding reported in Table III (locating closer to customers and suppliers). While competition from other supply chains was ranked a very low concern in this study, other studies suggest that it will increase and intensify as SCM develops and evolves into the next century (Morgan and Monczka 1996).

The last three columns of Table IV show the results of bivariate correlation analysis of the nine SCM concerns

Table III

CORRELATION OF SUPPLY CHAIN MANAGEMENT PRACTICES VS. PERFORMANCE

Supply Chain Management Practices	Mean	Performance Measures		
		Product Quality	Customer Service	Competitive Position
(a) Determining customers' future needs	4.41	0.105†	0.135*	0.168*
(u) Reducing response time across the supply chain	4.31	0.121*	0.150*	0.148*
(s) On-time delivery directly to your firm's points of use	4.28	0.123*	0.171*	0.128*
(r) On-time delivery directly to customers' points of use	4.24	0.118	0.138*	0.134*
(k) Improving the integration of activities across your SC	4.10	0.202*	0.156*	0.207*
(l) Searching for new ways to integrate SCM activities	3.99	0.061	0.115†	0.131*
(p) Creating a greater level of trust among SC members	3.97	0.148*	0.224*	0.097
(n) Communicating your firm's future strategic needs	3.90	0.176*	0.242*	0.129*
(m) Establishing more frequent contact with SC members	3.83	0.038	0.079	0.048
(y) Contacting the end users to get feedback	3.81	0.108†	0.158*	0.108†
(b) Increasing your firm's JIT capability	3.70	0.115†	0.049	0.082
(o) Communicating customers' future strategic needs	3.68	0.082	0.099	0.101
(j) Use of formal information sharing agreements	3.65	0.154*	0.141*	0.183*
(x) Creating a compatible information system	3.61	0.111†	0.122*	0.145*
(i) Use of informal information sharing	3.60	0.049	0.036	0.095
(c) Aiding suppliers to increase their JIT capability	3.47	0.175*	0.162*	0.108†
(v) Involving SC in your product/service/marketing plans	3.41	0.108†	0.168*	0.169*
(q) Identifying additional SC	3.31	0.080	0.111†	0.129*
(t) Creating SCM teams to include different companies	2.95	0.095	0.100	0.082
(e) Participating in the marketing efforts of customers	2.88	0.035	0.080	0.098
(d) Participating in the sourcing decisions of suppliers	2.85	0.183*	0.055	0.135*
(w) Extending SC beyond immediate suppliers/customers	2.83	0.057	0.093	0.122*
(f) Locating closer to your customers	2.40	-0.026	0.027	0.051
(g) Requiring suppliers to locate closer to your firm	2.18	0.043	0.030	-0.012
(h) Use of a third-party SCM specialist	2.18	-0.052	-0.088	-0.085

*Significant at $\alpha = 5\%$.
†Significant at $\alpha = 10\%$.

Table IV

CORRELATION OF SUPPLY CHAIN MANAGEMENT CONCERNS VS. PERFORMANCE

Supply Chain Management Concerns	Mean	Performance Measures		
		Product Quality	Customer Service	Competitive Position
(i) Lack of sophisticated information system	3.45	-0.216*	-0.204*	-0.102†
(g) Lack of ability in managing SC inventories	3.33	-0.227*	-0.272*	-0.180*
(c) Lack of cooperation among supply chain members	3.07	-0.114†	-0.200*	-0.064
(b) Lack of trust among supply chain members	2.99	-0.133*	-0.191*	-0.065
(d) Your firm's lack of leverage within your supply chain	2.98	-0.184*	-0.217*	-0.262*
(h) Lack of interest among your suppliers or customers	2.92	-0.086	-0.214*	-0.119†
(e) Your suppliers' geographical distance	2.66	-0.139*	-0.056	-0.038
(a) Competition from other supply chains	2.51	-0.025	0.035	-0.036
(f) Your customers' geographical distance	2.41	-0.089	-0.019	-0.108†

*Significant at $\alpha = 5\%$.
†Significant at $\alpha = 10\%$.

vis-à-vis performance. As expected, all of the significant coefficients were inversely related to the performance measures. The lack of sophisticated information systems (-0.216) adversely affected product quality, indicating that firms should invest in information systems to enhance product quality. The lack of leverage within the supply chain (-0.184) and four other concerns also adversely affected product quality. The lack of sophisticated information systems, ability in managing supply chain inventory, trust and cooperation among supply chain members, leverage within the value chain, and interest of supply chain members adversely affected customer service. Similarly, five supply chain concerns adversely affect competitive position. The managerial implication is that while there may not be much a firm can do in the short term to improve its leverage within the supply chain, it should invest in information technology to support EDI and to truly integrate in a successful supply chain. A second implication is that buying practices should be consolidated to build leverage when and where possible.

Factor Analysis

For each of the three item scales, exploratory factor analysis was used to identify the not directly observable factors based on the variables (i.e., performance measures, SCM practices and concerns). The goal was to identify a smaller set of factors to represent the relationships among the variables parsimoniously (i.e., to explain the observed correlation with fewer factors). In this research, principal components analysis with eigenvalues greater than one was used to extract factors, and varimax rotation was used to facilitate interpretation of the factor matrix. The Bartlett Test of Sphericity (to test the null hypothesis that the correlation matrix is an identity matrix) and the Kaiser-Meyer-Olkin measure of sampling adequacy (small value of KMO indicates factor analysis is inappropriate) were used to validate the use of factor analysis.

The 25 SCM practices were reduced to six underlying factors (Table V). "P_1: Supply Chain Integration" comprises the five strategic practices that address supply chain integration. This factor alone accounts for 30.5 percent of the variance in the data. "P_2: Supply Chain Characteristics" involves the operating characteristics of the supply chain. "P_3: Information Sharing" includes the four practices relating to the use of information technology and sharing in SCM. "P_4: Strategic Location" consists of the three practices of which two are directly related to the geographical proximity of the suppliers and buyers. "P_5: Customer Service Management" consists of three practices, and "P_6: JIT Capability" relates directly to the buyer and supplier JIT capability. These six factors accounted for a total of 59.2 percent of the total variance in the data. Thus, a model with six factors was considered adequate to represent the data (Nunnally 1988).

The nine SCM concerns were reduced to three underlying factors (Table VI). The first factor, "C_1: Supply Chain Coherence," accounted for 35.4 percent of the variance in the data. It is comprised of three SCM concerns that address the coherent issues of the supply chain. "C_2: Information Capability" consists of four items and accounted for 15.9 percent of the variance in the data. The last supply chain factor, "C_3: Geographical Proximity," relates to the geographic location of the supplier and the buyer. It accounted for 11.4 percent of the variance in the data. The three factors accounted for 62.7 percent of the total variance in the data, indicating that a model with three factors was sufficient to represent the data.

Regression Analysis

For each of the three performance measures, multiple linear regression was carried out using the nine factors as independent variables described above. The Durbin-Watson statistic and normal probability plots were used to verify that residuals were independent and normally distributed. All independent variables were entered simultaneously in the regression analyses. All three regression models were statistically significant at $\alpha = 0.05$ (Table VII).

Two of the nine factors were statistically significant in the first regression model, overall product quality. The only factor relating to SCM practices that positively impacted overall product quality was JIT capability (P_6). JIT is an integrated set of activities with a primary focus on processes, designed to achieve high-volume production using minimal levels of inventory. Since JIT uses a "pull" inventory flow system, it requires high levels of quality at each stage of the process and strong supplier relations. There is no excess inventory to cushion any production or delivery problems. This is consistent with the evidence that suggests maintaining integrity of processes through efficient manufacturing practices is the key to improving quality (Greene 1993). Increasing the JIT capabilities of both the buyer and the supplier in the supply chain allows for more efficient processes to be implemented to further reduce waste. Non-value-adding activities such as inspection of incoming materials can be eliminated, and more frequent and reliable deliveries in smaller lot sizes can be utilized in a JIT purchasing environment to ensure consistently high quality levels for purchased materials.

Factor C_2 (-0.158), which refers explicitly to the concerns for information capability, adversely affected the overall product quality. A lack of sophisticated information and ability in managing supply chain inventories hinders the implementation of JIT capability, and thus affects overall product quality. SCM provides visibility and reduces demand uncertainty with the aid of sophisticated information systems, such as EDI, by replacing inventory with reliable information. Thus, overall product quality deteriorates in the absence of information systems.

Three factors relating to SCM practices — supply chain integration (P_1), information sharing (P_3), and JIT capability (P_6) — had a positive impact on overall competitive

Table V

FACTOR ANALYSIS — SUPPLY CHAIN MANAGEMENT PRACTICES

Factor	% of Variance	Scale Items	Factor Loading
P_1: Supply Chain Integration	30.46%	(l) Searching for new ways to integrate SCM activities	0.839
		(k) Improving the integration of activities across your SC	0.799
		(u) Reducing response time across the supply chain	0.724
		(m) Establishing more frequent contact with SC members	0.582
		(v) Involving SC in your product/service/marketing plans	0.456
P_2: Supply Chain Characteristics	7.95%	(n) Communicating your firm's future strategic needs	0.763
		(p) Creating a greater level of trust among SC members	0.691
		(q) Identifying additional SC	0.592
		(o) Communicating customers' future strategic needs	0.568
		(x) Creating a compatible information system	0.519
		(w) Extending SC beyond immediate suppliers/customers	0.466
		(t) Creating SCM teams to include different companies	0.387
P_3: Information Sharing	6.00%	(i) Use of informal information sharing	0.674
		(j) Use of formal information sharing agreements	0.655
		(e) Participating in the marketing efforts of customers	0.584
		(a) Determining customers' future needs	0.517
P_4: Strategic Location	5.41%	(f) Locating closer to your customers	0.753
		(g) Requiring suppliers to locate closer to your firm	0.705
		(h) Use of a third-party SCM specialist	0.639
P_5: Customer Service Management	5.17%	(r) On-time delivery directly to customers' points of use	0.799
		(s) On-time delivery directly to your firm's points of use	0.728
		(y) Contacting the end users to get feedback	0.439
P_6: JIT Capability	4.19%	(b) Increasing your firm's JIT capability	0.813
		(c) Aiding suppliers to increase their JIT capability	0.789
		(d) Participating in the sourcing decisions of suppliers	0.456

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.856.
Bartlett Test of Sphericity = 2475.33, Significance = 0.000.

Table VI

FACTOR ANALYSIS — SUPPLY CHAIN MANAGEMENT CONCERNS

Factor	% of Variance	Scale Items	Factor Loading
C_1: Supply Chain Coherence	35.37%	(b) Lack of trust among supply chain members	0.7934
		(c) Lack of cooperation among supply chain members	0.7790
		(a) Competition from other supply chains	0.6726
C_2: Information Capability	15.93%	(i) Lack of sophisticated information system	0.7927
		(g) Lack of ability in managing SC inventories	0.6615
		(h) Lack of interest among your suppliers or customers	0.6515
		(d) Your firm's lack of leverage within your supply chain	0.4315
C_3: Geographical Proximity	11.39%	(f) Your customers' geographical distance	0.8740
		(e) Your suppliers' geographical distance	0.8637

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.730.
Bartlett Test of Sphericity = 622.340, Significance = 0.000.

Table VII

REGRESSION ANALYSIS

Regression Model*	R^2	Durbin-Watson Test
Overall Product Quality = $4.311 + 0.093\ P_6 - 0.158\ C_2$	0.121	1.945
Overall Competitive Position = $4.039 + 0.103\ P_1 + 0.157\ P_3 + 0.098\ P_6 - 0.162\ C_2$	0.139	1.780
Overall Customer Service Levels = $4.132 + 0.156\ P_2 - 0.101\ C_1 - 0.215\ C_2$	0.170	1.975

*All of the regression models (enter method) and parameters were statistically significant at $\alpha = 5\%$.

position. It was not surprising that advanced JIT capability enhanced the overall competitive position of an organization by first improving its overall product quality. The growing intensity in competition in the global marketplace has forced many world-class manufacturers to reexamine their competitive priorities to enhance competitive position. Quality, reliability, on-time delivery, and speedy new product introduction were cited as the top competitive priorities among these manufacturers (Kim 1996). Thus, advanced JIT capability ultimately leads to enhanced overall competitive position. Information sharing is crucial to efficient operations everywhere along the supply chain and to every functional area. Interestingly, the impact of information sharing (0.157) slightly outweighed the impact of JIT capability (0.098).

While information sharing enhances a firm's performance, the lack of information capability (-0.162 C_3) adversely affected the overall competitive position. Once again, this is consistent with the overall product quality model. Advanced information technology is needed to support an efficient SCM network for proper information exchange and provide useful data required for integrated performance of procurement operations, logistics, and manufacturing supports.

The last regression model indicates that the supply chain characteristics factor affected overall customer service levels. In addition, the lack of information capability and supply chain coherence adversely affected the ability to provide customer service. Interestingly, the model suggests that the "concern" factors related to geographical proximity had no impact on overall product quality, competitive position, or the ability to provide customer service. However, information capability adversely affected all three performance measures. The managerial implication is that managers must invest to improve information capability. Fortunately, the advent of electronic interchange, bar coding, and radio frequency scanning technologies has greatly aided the evolution of information capability in the last century.

CONCLUSIONS

A truly integrated supply chain requires a massive commitment by all members of the chain. The buying organization may have to overhaul the purchasing process and integrate a supplier's engineering teams and product designers directly into its own decisionmaking process. Since the cost of changing a partner in the supply chain can be large, the purchasing firm can become captive to its suppliers. Poor supplier performance is not the only risk; the purchaser needs to worry about the possibility of a supplier passing trade secrets to competitors or, with its newfound abilities, venturing out on its own. While there are many other pitfalls of effective SCM, such as conflicting objectives and missions among supply chain members, inadequate definition of customer service, and separation of supply chain design from operational decisions (Lee and Billington 1992), this survey indicated that more than two-thirds of the respondents practiced some form of SCM. It clearly shows that SCM is a viable business strategy.

Integrating the purchasing and logistics process with other key corporate processes creates a closely linked set of manufacturing and distribution processes. It allows firms to deliver products and services to both internal and external customers in a more timely and effective manner. To further exploit the competitive advantage associated with integrated processes, leading organizations adopt a strategic approach to managing the supply chain, such as forming strategic alliances with suppliers and distributors instead of vertical integrating. Interestingly, although SCM developed along two separate paths, it eventually merged into a unified body of literature with a common goal of waste elimination and increased efficiency throughout the value chain.

REFERENCES

Armstrong, J.S. and T.S. Overton. "Estimating Non-Response Bias in Mail Surveys," *Journal of Marketing Research*, (14:3), 1977, pp. 396-402.

Baatz, E.B. "CIO 100 — Best Practices: The Chain Gang," *CIO*, (8:19), 1995, pp. 46-52.

Bowersox, D.J. and D.J. Closs. *Logistical Management: The Integrated Supply Chain Process*, McGraw-Hill, New York, NY, 1996.

Burt, D.N. and W.R. Soukup. "Purchasing's Role in New Product Development," *Harvard Business Review*, September-October 1985, pp. 90-97.

Carter, J.R. and B.G. Ferrin. "The Impact of Transportation Costs on Supply Chain Management," *Journal of Business Logistics*, (16:1), 1995, pp. 189-212.

Carter, J.R. and R. Narasimhan. "The Role of Purchasing and Materials Management in Total Quality Management and Customer Satisfaction," *International Journal of Purchasing & Materials Management*, (30:3), Summer 1994, pp. 3-13.

Chen, K.C.W. and C.W.J. Lee. "Accounting Measures of Business Performance and Tobin's q Theory," *Journal of Accounting, Auditing & Finance*, (10:3), 1995, pp. 587-609.

Copacino, W.C. "Seven Supply-Chain Principles," *Traffic Management*, (35:1), 1996, p. 60.

Cronbach, L.J. "Coefficient Alpha and the Internal Structure of Tests," *Psychometrika*, (16), 1951, pp. 297-334.

Davis, T. "Effective Supply Chain Management," *Sloan Management Review*, 1993, pp. 35-46.

Ellram, L.M. and J.N. Pearson. "The Role of the Purchasing Function: Toward Team Participation," *International Journal of Purchasing and Materials Management*, (29:3), Summer 1993, pp. 3-9.

Ellram, L.M., B.J. La Londe, and M.M. Weber. "Retail Logistics," *International Journal of Distribution and Materials Management*, (19:12), 1989, pp. 29-39.

Farley, G.A. "Discovering Supply Chain Management: A Roundtable Discussion," *APICS — The Performance Advantage*, (7:1), 1997, pp. 38-39.

Fernie, J. "International Comparisons of Supply Chain Management in Grocery Retailing," *The Service Industries Journal*, (15:4), 1995, pp. 134-147.

Fisher, M.L. "What is the Right Supply Chain for Your Product?" *Harvard Business Review*, March-April 1997, pp. 105-116.

Freeman, V.T. and J.L. Cavinato. "Fitting Purchasing to the Strategic Firm: Frameworks, Processes, and Values," *Journal of Purchasing and Materials Management*, (26:1), Winter 1990.

Frohlich, M., J.R. Dixon, and P. Arnold. "A Taxonomy of Supply Chain Strategies," *Proceedings of the 28th Annual Meeting of the Decision Sciences Institute*, 1997.

Greene, R. *Global Quality: A Synthesis of the World's Best Management Models*, ASQC Press, Milwaukee, WI, 1993.

Handfield, R.B. "U.S. Global Sourcing: Patterns of Development," *International Journal of Operations and Production Management*, (14:6), 1994, pp. 40-51.

Harwick, T. "Optimal Decision-Making for the Supply Chain," *APICS — The Performance Advantage*, (7:1), 1997, pp. 42-44.

Houlihan, J.B. "International Supply Chain Management," *International Journal of Physical Distribution and Materials Management*, (17:2), 1987, pp. 51-66.

Houlihan, J.B. "International Supply Chains: A New Approach," *Management Decision: Quarterly Review of Management Technology*, (26:3), 1988, pp. 13-19.

Inman, R.A. and J.H. Hubler. "Certify the Process, Not Just the Product," *Production and Inventory Management Journal*, (33:4), 1992, pp. 11-14.

Jahera, J.S. and W.P. Lloyd. "Additional Evidence on the Validity of ROI as a Measure of Business Performance," *The Mid-Atlantic Journal of Business*, 1992, pp. 105-112.

Jones, T.C. and D.W. Riley. "Using Inventory for Competitive Advantage through Supply Chain Management," *International Journal of Physical Distribution and Materials Management*, (17:2), 1987, pp. 94-104.

Kim, J.S. *Search for a New Manufacturing Paradigm, Research Report Series*, Boston University School of Management, Boston, MA, 1996.

Krause, D.R. "Supplier Development: Current Practices and Outcomes," *International Journal of Purchasing and Materials Management*, (33:2), Spring 1997, pp. 12-19.

La Londe, B.J. and J.M. Masters. "Emerging Logistics Strategies: Blue Print for the Next Century," *International Journal of Physical Distribution and Logistics Management*, (24:7), 1994, pp. 35-47.

Lamb, J.J. "An Evolutionary Idea," *World Trade*, (8:7), 1995, pp. 40-46.

Lambert, D.M. and T.C. Harrington. "Measuring Non-Response Bias in Mail Surveys," *Journal of Business Logistics*, (11:2), 1990, pp. 5-25.

Lee, H.L. and C. Billington. "Managing Supply Chain Inventory: Pitfalls and Opportunities," *Sloan Management Review*, (33:3), 1992, pp. 65-73.

MacDonald, M.E. "Integrate or Perish!" *Traffic Management*, (30:10), 1991, pp. 31-36.

Mason, T. "Getting Your Suppliers on the Team," *Logistics Focus*, (4:1), 1996, pp. 10-12.

Monczka, R.M., R.J. Trent, and T.J. Callahan. "Supply Base Strategies to Maximize Supplier Performance," *International Journal of Physical Distribution and Logistics*, (24:1), 1994, pp. 42-54.

Morgan, J. and R.M. Monczka. "Alliances for New Products," *Purchasing*, (118:1), 1995, pp. 103-109.

Morgan, J. and R.M. Monczka. "Supplier Integration: A New Level of Supply Chain Management," *Purchasing*, (120:1), 1996, pp. 110-113.

New, S.J. and P. Payne. "Research Frameworks in Logistics: Three Models, Seven Dinners and a Survey," *International Journal of Physical Distribution and Logistics Management*, (25:10), 1995, pp. 60-77.

Nunnally, J.C. *Psychometric Theory*, McGraw-Hill, Englewood Cliffs, NJ, 1988.

Prahalad, C.K. and G. Hamel. "The Core Competence of the Corporation," *Harvard Business Review*, (68:3), 1990, pp. 79-91.

Ragatz, G., R. Handfield, and T. Scannell. "Success Factors for Integrating Suppliers into New Product Development," *Journal of Product Innovation Management*, (14), 1997, pp. 190-202.

Reck, R.F. and B.G. Long. "Purchasing: A Competitive Weapon," *Journal of Purchasing and Materials Management*, (24:3), Fall 1988.

Reck, R.F., R. Landeros, and D.M. Lyth. "Integrated Supply Management: The Basis for Professional Development," *International Journal of Purchasing and Materials Management*, (28:3), Summer 1992, pp. 12-18.

Scott, C. and R. Westbrook. "New Strategic Tools for Supply Chain Management," *International Journal of Physical Distribution & Logistics*, (21:1), 1991, pp. 23-33.

St. Onge, A. "New Concepts in Supply Chain Management," *Modern Materials Handling*, (51:3), 1996, p. 33.

Tan, K.C. "A Framework of Supply Chain Management Literature," *European Journal of Purchasing and Supply Management*, (7:1), 2001, pp. 39-48.

Tan, K.C., R.B. Handfield, and D.R. Krause. "Enhancing Firm's Performance through Quality and Supply Base Management: An Empirical Study," *International Journal of Production Research*, (36:10), 1998a, pp. 2813-2837.

Tan, K.C., V.J. Kannan, and R.B. Handfield. "Supply Chain Management: Supplier Performance and Firm Performance," *International Journal of Purchasing and Materials Management*, (34:3), Summer 1998b, pp. 2-9.

Taylor, D.H. and S. Probert. "European Logistics Systems Employed by U.K. Manufacturing Companies," *International Journal of Physical Distribution and Logistics Management*, (23:2), 1993, pp. 37-47.

Tobin, J. "A General Equilibrium Approach to Monetary Theory," *Journal of Money, Credit and Banking*, (1), 1969, pp. 15-29.

Tobin, J. and W. Brainard. "Pitfalls in Financial Model Building," *American Economic Review*, (58), 1968, pp. 99-122.

Tully, S. "Purchasing's New Muscle," *Fortune*, (20), 1995, p. 76.

Turner, J.R. "Integrated Supply Chain Management: What's Wrong with This Picture?" *Industrial Engineering*, (25:12), 1993, pp. 52-55.

Watts, C.A. and C.K. Hahn. "Supplier Development Programs: An Empirical Analysis," *International Journal of Purchasing and Materials Management*, (29:2), Spring 1993, pp. 11-17.

Watts, C.A., K.Y. Kim, and C.K. Hahn. "Linking Purchasing to Corporate Competitive Strategy," *International Journal of Purchasing and Materials Management*, (28:4), Fall 1992, pp. 2-8.

Whiteoak, P. "The Realities of Quick Response in the Grocery Sector: A Supplier Viewpoint," *International Journal of Physical Distribution and Logistics*, (24:10), 1994, pp. 33-39.