Linking SCOR planning practices to supply chain performance

An exploratory study

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Keywords *Supply chain management, Performance measurement*

Abstract *As supply chains continue to replace individual firms as the economic engine for creating value during the twenty-first century, understanding the relationship between supply-chain management practices and supply chain performance becomes increasingly important. The Supply-Chain Operations Reference (SCOR) model developed by the Supply Chain Council provides a framework for characterizing supply-chain management practices and processes that result in best-in-class performance. However, which of these practices have the most influence on supply chain performance? This exploratory study investigates the relationship between supply-chain management planning practices and supply chain performance based on the four decision areas provided in SCOR Model Version 4.0 (PLAN, SOURCE, MAKE, DELIVER) and nine key supply-chain management planning practices derived from supply-chain management experts and practitioners. The results show that planning processes are important in all SCOR supply chain planning decision areas. Collaboration was found to be most important in the Plan, Source and Make planning decision areas, while teaming was most important in supporting the Plan and Source planning decision areas. Process measures, process credibility, process integration, and information technology were found to be most critical in supporting the Deliver planning decision area. Using these results, the study discusses the implications of the findings and suggests several avenues for future research.*

Introduction

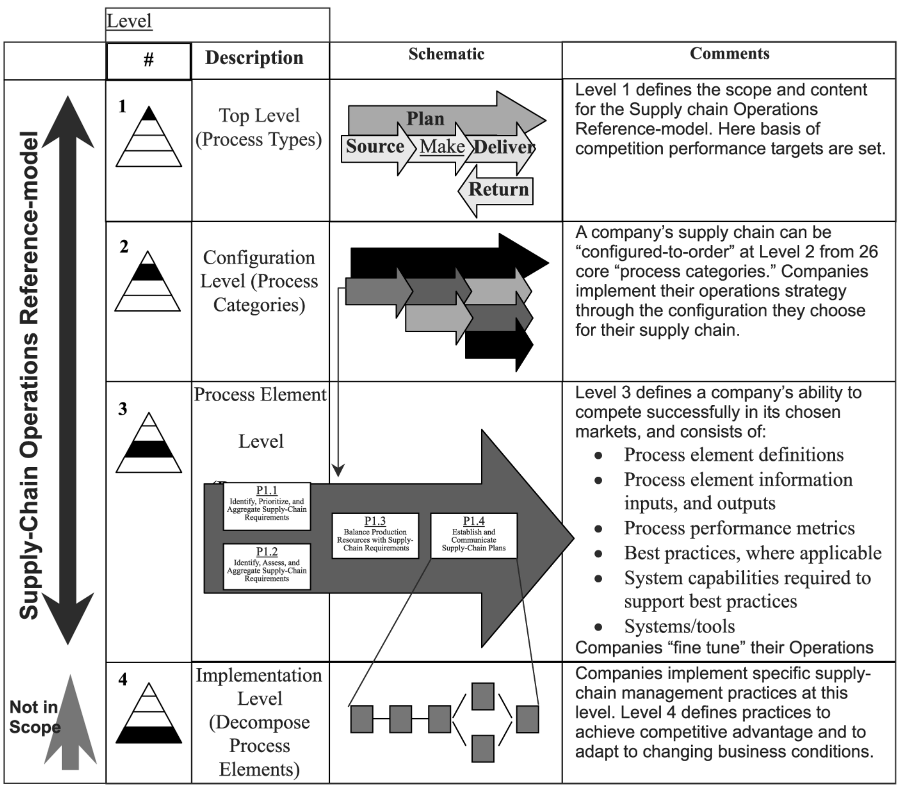
Increasingly, firms are adopting supply-chain management (SCM) to reduce costs, increase market share and sales, and build solid customer relations (Ferguson, 2000). SCM can be viewed as a philosophy based on the belief that each firm in the supply chain directly and indirectly affects the performance of all the other supply chain members, as well as ultimately, overall supply-chain performance (Cooper *et al.*, 1997). The effective use of this philosophy requires that functional and supply-chain partner activities are aligned with company strategy and harmonized with organizational structure, processes, culture, incentives and people (Abell, 1999). Additionally, the chain-wide deployment of SCM practices consistent with the above-mentioned philosophy is needed to provide maximum benefit to its members.

The Supply-Chain Operations Reference (SCOR) model was developed by the Supply-Chain Council (SCC) to assist firms in increasing the effectiveness of their supply chains, and to provide a process-based approach to SCM (Stewart, 1997). The SCOR model provides a common process oriented language for communicating among supply-chain partners in the following decision areas: PLAN, SOURCE, MAKE, and DELIVER. Recently, the details for the decision area of "RETURN" have been added to the SCOR Version 5.0 model. Since the SCOR model is the main framework used in the

International Journal of Operations & Production Management
Vol. 24 No. 12, 2004
pp. 1192-1218

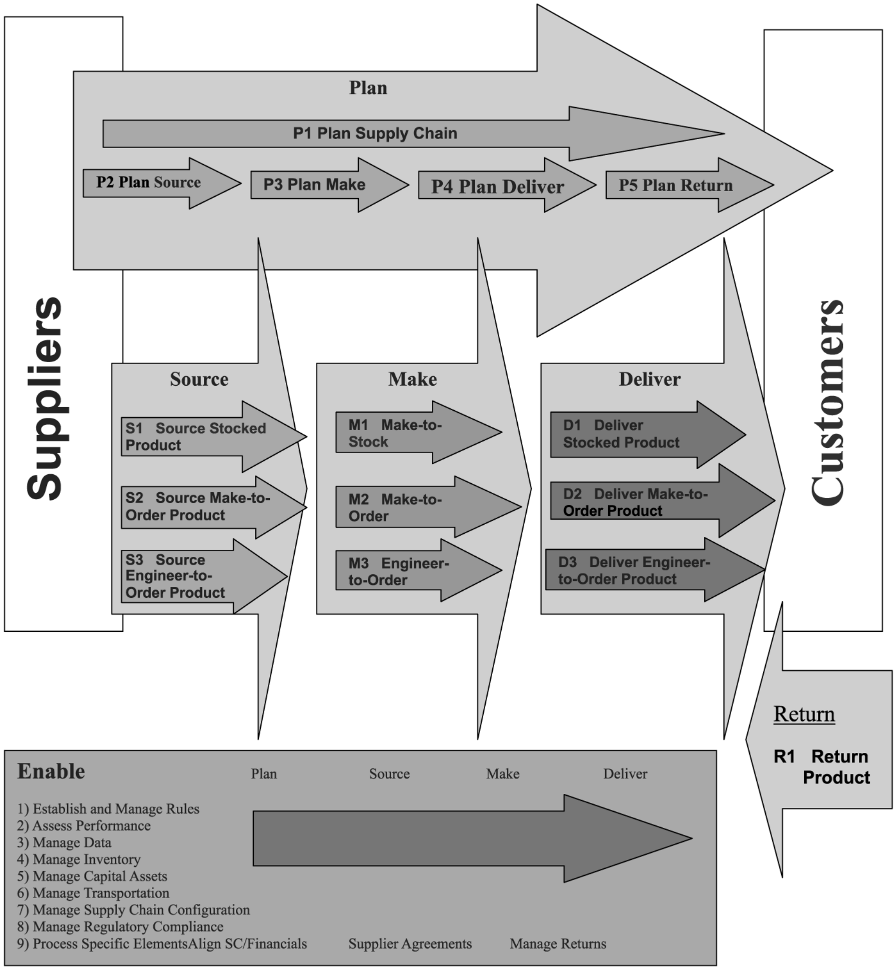
0144-3577
DOI 10.1108/01443570410569010

organization of this study, a short explanation is required. In each decision area there are three levels of process detail. A diagram depicting these levels is provided in Figure 1. Level 1 defines the scope and content of the core management processes for the above-mentioned decision areas. For example, the SCOR Plan process is defined as those processes that balance aggregate demand and supply for developing actions which best meet sourcing, production, and delivery requirements. Level 2 describes the characteristics associated with the following process types deployed within the core processes: planning, execution and enable. For example, supply chain partners require processes for planning the overall supply chain, as well as planning processes for supporting source, make, deliver, and return decisions. A diagram illustrating Level 2 for SCOR Model Version 4.0 is provided in Figure 2. Characteristics associated with effective planning processes include a balance between demand and supply and a consistent planning horizon. The SCOR model also contains Level 2 process categories defined by the relationship between a core management process and process type. Level 3 provides detailed process element information for each Level 2 process category. Inputs, outputs, description and the basic flow of process elements are captured at this level of the SCOR model.



Source: Adapted from *Supply Chain-Operations Reference Model Version 4.0, SCOR Version 4.0*, Supply-Chain Council (August 2000)

Figure 1.
Supply-Chain Operations Reference Model



Source: Adapted from *Supply Chain-Operations Reference Model Version 4.0, SCOR Version 4.0*, Supply-Chain Council (August 2000)

Figure 2.
Supply-Chain Operations Reference Model: Level 2

Although the SCOR model acknowledges the need for an implementation level (Level 4) for effective SCM, this level lies outside of its current scope. The rationale for its exclusion is that the SCOR model is designed as a tool to describe, measure and evaluate any supply-chain configuration. Thus, firms must implement specific supply-chain management practices based upon their unique set of competitive priorities and business conditions to achieve the desired level of performance. However, of the various supply-chain management practices available, which practices have the most influence on supply-chain performance? Furthermore, does the degree of influence vary by the decision areas outlined in the SCOR model? The purpose of this exploratory study is to investigate the relationship between supply-chain management planning practices and supply chain performance based on the four decision areas provided in SCOR Model Version 4.0 (PLAN, SOURCE, MAKE, DELIVER) and nine key supply-chain management planning practices derived from supply-chain management experts and practitioners.

The paper is organized as follows. First, the paper reviews the supply chain planning literature highlighting the need for empirical research linking supply chain planning practices to supply chain performance. Second, it provides a working definition of SCM and a description of the SCOR model used as a basis for the research. Third, a set of research questions is proposed linking supply-chain management planning practices to supply chain performance. Fourth, the paper describes the methods and analysis conducted to explore these questions. Finally, the results of the study along with future research opportunities are offered.

Review of the supply-chain management planning literature

Cooper and Ellram (1993) associate the following characteristics with effective SCM: Channel-wide inventory management; supply chain cost efficiency; long-term time horizons; joint planning, mutual information sharing, and monitoring; channel coordination; shared visions and compatible corporate cultures; supplier relationships; and the sharing of risks and rewards. The SCM research literature provides significant insight on the role of planning in facilitating the effective management of supply chains. For example, one area of SCM research focuses on planning the design and configuration of the supply chain to achieve competitive advantages (Vickery *et al.*, 1999; Childerhouse and Towill, 2000; Reutterer and Kotzab, 2000; Stock *et al.*, 2000; Korpela *et al.*, 2001a,b; Harland *et al.*, 2001) This area of research corresponds to P1 in Level 2 of the Supply-Chain Operations Reference Model. Another SCM research area revealed in the literature review is the necessity for supply chain information technology (IT) to foster information sharing (Chandrashekar and Schary, 1999; D'Amours *et al.*, 1999; Humphreys *et al.*, 2001; and Rutner *et al.*, 2001), supply chain competitiveness (Narasimhan and Kim, 2001) and the use of ERP systems (Manetti, 2001), advanced planning systems (Cauthen, 1999), and internet technologies (Cross, 2000; Brewton and Kingseed, 2001; and Deeter-Schmelz *et al.*, 2001). This literature suggests that the effective use of supply chain IT can have a dramatic impact on each of the four decision areas provided in SCOR Model Version 4.0 (Plan, Source, Make, Deliver).

The literature review also revealed the importance of partnership planning activities for collaborating among supply chain partners (Corbett *et al.*,1999; Narasimhan and Das, 1999; Raghunathan, 1999; Boddy *et al.*, 2000; Ellinger, 2000; Kaufman *et al.*, 2000; Waller *et al.*, 2000), integrating cross-functional processes (Lambert and Cooper, 2000), coordinating the supply chain (Kim, 2000), setting supply chain goals (Wong, 1999; Peck and Juttner, 2000), developing strategic alliances (McCutcheon and Stuart, 2000; Whipple and Frankel, 2000), establishing information-sharing parameters (Lamming *et al.*,2001), reviewing sourcing and outsourcing options (Ansari *et al.*, 1999; Heriot and Kulkarni, 2001) and defining supply chain power relationships among trading partners (Cox, 1999; Maloni and Benton, 2000; Cox, 2001a,b,c; Cox *et al.*, 2001; Watson, 2001). This literature also corresponds to each of the four decision areas provided in SCOR Model Version 4.0. Finally, the literature highlights the need for overall strategic supply chain planning to facilitate customer and supplier integration (Frohlich and Westbrook, 2001; Hauguel and Jackson, 2001), strategic supply chain design (Fine, 2000), an alignment between supply chain processes and strategic objectives (Hicks *et al.*, 2000; Tamas, 2000), effective order fulfillment and inventory management (Johnson and Anderson, 2000; Viswanathan and Piplani, 2001), and shareholder value via the achievement of competitive advantages (Christopher and Ryals, 1999; and Ramsay, 2001). A direct correspondence to P1 in Level 2 of the Supply-Chain Operations Reference Model is observed in this area of the literature.

There have been only a small number of studies attempting to empirically link specific SCM practices to supply chain performance. One significant study utilized the twenty-first century Logistics framework, a list of six critical areas of competence in achieving supply chain logistics integration, to investigate the relationship between logistics integration competence and performance (Stank *et al.*, 2001b). The six integration competencies in the framework are: customer integration; internal integration; supplier integration; technology and planning integration; measurement integration; and relationship integration. Their results showed that customer integration, internal integration and technology and planning performance are the dominant competencies related to performance. In this research, specific planning practices related to performance were difficult to identify, although some were implied within the measurement system used.

A review of this literature suggests the following conclusions. First, the importance and necessity of supply-chain management planning is well established in the literature and warrants continued research. Second, research published in this area corresponds to the four decision areas provided in SCOR Model Version 4.0. Third, because of this correspondence, the planning activities illustrated in Level 2 of the Supply-Chain Operations Reference Model can be used as a framework for directing future supply-chain management planning research. Finally, there is an absence of empirical research clearly linking specific supply chain planning practices to supply chain performance. Thus, this exploratory study is an empirical investigation of the relationship between supply-chain management planning practices and supply chain performance based on the four decision areas provided in SCOR Model Version 4.0 and nine key supply-chain management planning practices derived from supply-chain management experts and practitioners.

Construct development

The literature review, along with discussions and interviews with supply chain experts and practitioners was used as the basis for developing the constructs for the study: supply chain planning practices and supply chain performance. Through this effort, nine key supply chain planning practices emerged: planning processes; process integration; process documentation; collaboration; teaming; process ownership; process measures; process credibility; and information technology (IT) support. Planning processes are required to determine the most efficient and effective way to use the organization's resources to achieve a specific set of objectives. Process integration refers to the tight coupling of two or more processes through shared systems, automated functions and event triggers (i.e. auto replenishment). Process documentation requires a clear, documented understanding and agreement of what is to be done within and between processes. It is usually achieved through process design and mapping sessions or review and validation sessions with the process teams. Maintenance and change control of this documentation is also a critical component. For collaboration and teaming to occur, individuals from the various functions involved in effective SCM must work as a tightly integrated group with shared authority to make decisions and take actions. A collaborative, team based SCM structure represents the span of involvement, influence and authority in an SCM organization, and enables multi-dimensional, cross-functional authority. Early research suggests that there are different types of collaboration based upon the intensity of the information exchanges, and the nature of the relationship. These types are transactional, cooperative (coordinative) and collaborative (McCormack, 2003). The formal creation of broad, cross-functional jobs with real overall supply chain process authority and ownership is a key component of process ownership. Process measures are used to identify and assign responsibility for supply chain process outcomes relating to such areas as efficiency, cost and quality, as well as to provide a link to the firm's reward system. Process credibility refers to the level of customer confidence in the output of the process and its use in making commitments. Finally, IT support refers to the process owners' and team members' perceived usefulness of the IT system in support of SCM processes.

The literature review, discussions and interviews also resulted in the emergence of seven key supply-chain management planning decision categories: operations strategy planning, demand management, production planning and scheduling, procurement, promise delivery, balancing change, and distribution management. Discussions then proceeded on how these decision categories relate to the Supply-Chain Operations Reference (SCOR) Model. This resulted in Figure 3, which maps the above-mentioned supply-chain management planning decision categories to the SCOR Model. This mapping suggests that operations strategy planning and promise delivery decisions tend to be aligned with a firm's internal SCOR decision areas, while decisions on balancing change tend to span internal and external SCOR decision areas across the entire supply chain. Additionally, procurement along with production planning and scheduling decisions tend to span across both internal and supplier SCOR decision

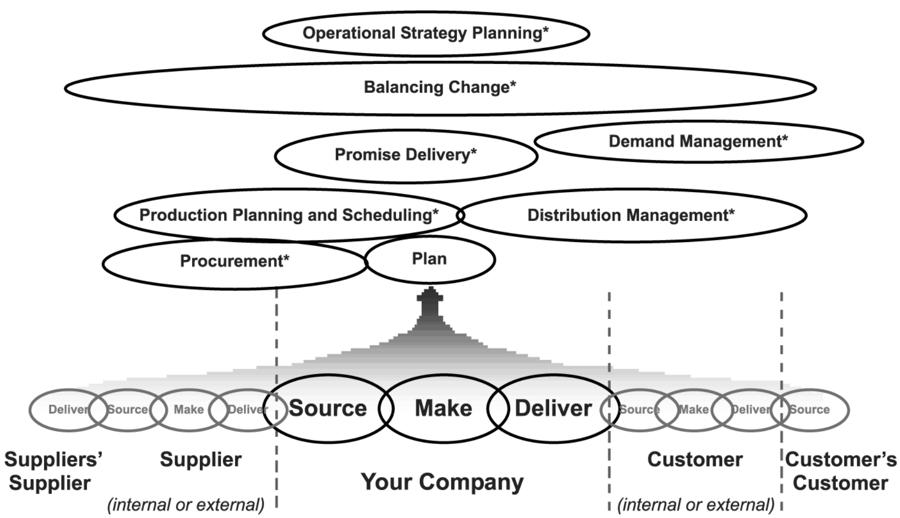


Figure 3.
Supply chain decision categories mapped to the SCOR model

areas, while demand and distribution management decisions span across both internal and customer decision areas.

The planning activities illustrated in Level 2 of the Supply-Chain Operations Reference Model were used to specify the domain of supply-chain management planning practices for the study (PLAN, SOURCE, MAKE, DELIVER). The experts and practitioners used in developing and validating the constructs were selected from the Chesapeake Decision Sciences (now AspenTech) user group list. This list spanned across multiple industries, and contained a high number of individuals with either a Masters or PhD degree in operations research. For this study, a practice is defined as a method, technique, procedure, or process.

The supply chain performance construct is a self-assessed performance rating for each of the SCOR decision areas. The construct is based on perceived performance, as determined by the survey respondents. It is represented as a single item for each decision area (see Appendix 1, Questions 32 (PLAN), 15 (SOURCE), 16 (MAKE), and 31 (DELIVER)). The specific item statement on supply chain performance for each of the SCOR decision areas is: "Overall, this decision process area performs very well." The participants were asked to either agree or disagree with the item statement using a five-point Likert scale (1 = strongly disagree; 5 = strongly agree).

Research questions

The following research questions were developed to operationalize the above-mentioned constructs:

RQ1. What are the most important supply-chain management planning practices in the PLAN decision area of SCOR Model Version 4.0 that relate to perceived supply chain performance?

RQ2. What are the most important supply-chain management planning practices in the SOURCE decision area of SCOR Model Version 4.0 that relate to perceived supply chain performance?

RQ3. What are the most important supply-chain management planning practices in the MAKE decision area of SCOR Model Version 4.0 that relate to perceived supply chain performance?

RQ4. What are the most important supply-chain management planning practices in the DELIVER decision area of SCOR Model Version 4.0 that relate to perceived supply chain performance?

Research methodology

The research approach for this study follows the process of investigation and measurement developed by Churchill (1979). A figure depicting the approach is provided in Figure 4. The approach includes specifying the domain of the construct, generating a sample of items which capture the domain as specified, purifying the measures through coefficient alpha or factor analysis, assessing reliability with new data, assessing the construct validity, and developing norms.

Survey instrument

The literature review, along with discussions and interviews with supply chain experts and practitioners was also used as the basis for developing survey questions

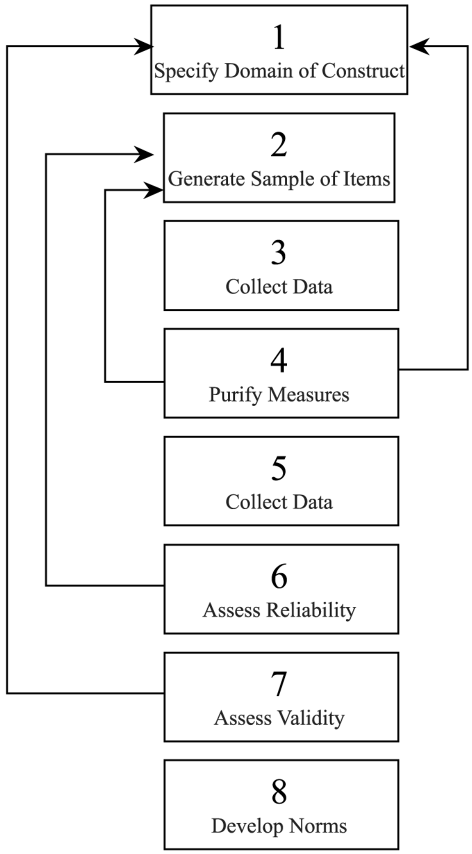


Figure 4.
Churchill research methodology

representing the nine key supply chain planning practices identified in the “Construct development” section. The discussions were structured around SCOR Model Version 4.0. A survey instrument was developed using a 5-item Likert scale measuring the frequency of the practices consisting of: 1 – never or does not exist; 2 – sometimes; 3 – frequently; 4 – mostly; and 5 – always or definitely exists. The survey asked respondents to provide their opinion concerning “what is done, how often, who does it and how it is done” in their supply chain. The initial survey was tested within a major electronic equipment manufacturer and with several supply chain experts. Based upon these tests, improvements in wording and format were made to the instrument, and several items were eliminated.

The Supply Chain Council board of directors also reviewed the survey instrument. Based upon this review, the survey was slightly reorganized to better match the SCOR model. The survey questions grouped by SCOR decision area are provided in Appendix A. The questions focus on decision making in the seven key supply-chain management planning decision categories (operations strategy planning, demand management, production planning and scheduling, procurement, promise delivery, balancing change, and distribution management) for each of the four SCOR decision areas. We were unable to build a consensus for questions relating process credibility to the SOURCE decision area of SCOR Model. Therefore the survey instrument does not contain any items corresponding to this area.

Sample

The study participants were selected from the membership list of the Supply Chain Council. The "user" or practitioner portion of the list was used as the final selection since this represented members whose firms supplied a product, rather than a service, and were thought to be generally representative of supply chain practitioners rather than consultants. This list consisted of 523 individuals and 90 firms. A sample profile is provided in Table I. The sample represents 11 distinct industry types. Approximately 29 percent of the respondents were classified as "Other" in relation to industry type. A profile of the respondents by position and by function is provided in Tables II and III respectively. Table II reveals that 38 percent of the respondents classified themselves as being either senior leaders or executives, while 20 percent considered themselves to be senior managers. Thirty-four percent of the respondents were classified as managers, while the remaining 8 percent were classified as individual contributors. Table III reveals that approximately 18 percent of the respondents work in the purchasing function, while approximately 16 percent work in planning and scheduling. Approximately 43 percent of the respondents work in functions other than the nine categorized in the survey instrument (sales, information systems, planning and scheduling, marketing, manufacturing, engineering, finance, distribution, and purchasing). Upon investigation, this category represented the new

Industry description	Number of responses	Response percentages
Electronics	6	10.9
Transportation	2	3.6
Industrial products	2	3.6
Food & Beverage/CPG	8	14.5
Aerospace & Defense	2	3.6
Chemicals	4	7.3
Apparel	1	1.8
Utilities	10	18.2
Pharmaceuticals/Medical	3	5.5
Mills	0	0.0
Semiconductors	1	1.8
Other	16	29.1
Total	55	100%

Table I.
Sample profile

Respondent position	Number of responses	Response percentages
Senior leadership/executive	19	38.0
Senior manager	10	20.0
Manager	17	34.0
Individual contributor	4	8.0
Total	50	100%

Table II.
Respondent profile by position

Respondent function	Number of responses	Response percentages
Sales	1	2.0
Information systems	3	5.9
Planning and scheduling	8	15.7
Marketing	0	0.0
Manufacturing	4	7.8
Engineering	0	0.0
Finance	0	0.0
Distribution	4	7.8
Purchasing	9	17.7
Other	22	43.1
Total	51	100%

Table III.
Respondent profile by function

supply chain oriented jobs such as "Global Supply Chain Manager" or "Supply Chain Team Member". The remaining respondents work in manufacturing (approximately 8 percent), distribution (approximately 8 percent), information systems (approximately 6 percent), and sales (approximately 2 percent).

Data collection

The survey instrument was distributed by mail with a cover letter explaining its purpose and sponsorship by the Supply Chain Council. The recipients were asked to complete the survey within two weeks and either fax or mail the completed form to a designated address. Recipients were also encouraged to distribute the survey to other practitioners within their firm. Of the 523 surveys distributed, 28 were returned due inaccurate addresses. Fifty-five usable surveys were returned for a response rate of 10.5 percent. Upon investigation, this low response rate was due to the length of the survey and its timing. It was distributed during August, a traditional vacation time in most of the USA and Europe. When questioned by phone, many people stated that they were on vacation during the survey period or did not have time to complete the survey since they were preparing for vacation. An analysis of non-response bias was made to determine its impact on the data. The sample was divided into quartiles based upon the time of submission and means were examined. No significant differences were identified. The sample was also examined for any role, position or functional bias. As can be seen from Tables I, II and III, the sample appears to represent a cross-section of roles, positions and functions and is not heavily weighted toward a few segments. From this examination it was concluded that no bias was present. The number of returned surveys (55) also met the minimum number needed for factor analysis (Hair *et al.*, 1992, p. 239).

Analysis

Factor analysis is used to examine the underlying patterns or relationships for a large number of variables and to determine whether or not the information can be condensed or summarized in a smaller set of factors or components (Hair *et al.*, 1992). The purpose of factor analysis in this study was to find a way to condense the variables used to describe the constructs into a smaller set of new composite dimensions or factors with a minimum loss of information. This smaller set of factors was then used in regression analysis to test the hypothesized relationships. The sample size was over 50, which is the minimum criterion for the use of factor analysis, and the item significance level for this size of sample was set at a loading of 0.4 using published guidelines (Hair *et al.*, 1992, p. 239).

An exploratory component factor analysis using maximum-likelihood extraction and oblique (varimax) rotation was performed on the data to examine the dimensions underlying the construct. This analysis was used to examine whether the number of dimensions conceptualized could be verified empirically. The initial analysis used a five-factor strategy for each of the SCOR areas of Plan, Source, Make and Deliver. Adjustments were made to the measurement model as suggested by this analysis until a final factor matrix emerged for each area.

Coefficient alpha measures the internal consistency of a set of items and were partly used to assess the quality of the instrument. A low coefficient alpha indicates that the sample of items performs poorly in capturing the construct and a large alpha indicates that the test correlates well with true scores. A minimum acceptable criterion of 0.7 was used for this analysis (Churchill, 1979).

Plan analysis

Factor analysis on variables relating to the PLAN decision area (see Table IV) resulted in loadings for the following factors: demand management process; supply chain collaborative planning; and operations strategy planning team. The demand management process factor had nine items representing critical elements of a demand management process. These are items such as process documentation,

Factor	Coefficient alpha	Scale items	Factor loadings
Demand planning process	0.94	P18 – Documented forecasting process	0.86
		P19 – Use historical data in forecast	0.84
		P20 – Use mathematical methods	0.87
		P21 – Process occurs on scheduled basis	0.91
		P22 – Forecast for each product	0.76
		P24 – Owner for DM process	0.71
		P27 – Forecast is credible	0.82
		P28 – Used to make plans/commitments	0.84
		P29 – Forecast accuracy measured	0.74
SC collaborative planning	0.87	P6 – Defined customer priorities	0.70
		P7 – Defined product priorities	0.69
		P13 – Team examines customer profitability	0.56
		P14 – Team examines product profitability	0.70
		P15 – Participates in customer/supplier relationships	0.76
		P17 - Analyze product demand variability	0.62
		P25 – DM uses customer information	0.51
		P9 – Supply Chain performance measures	0.60
Operations strategy planning team	0.90	P1 – Operations strategy planning team established	0.77
		P2 – Team has formal meetings	0.95
		P3 – Major functions represented on team	0.82
		P4 – Team process documented	0.80
		P5 – Owner for process	0.61

Table IV.
Factor analysis – PLAN decision area

ownership, credibility and key practices (mathematical models, use of historical data, etc). The supply chain collaborative planning factor had eight items representing the following specific collaborative planning process elements: supply chain planning team participation in customer and supplier relationships; understanding and use of customer demand information; and the understanding and use of customer priorities balance with company priorities. The operations strategy planning team factor had five items representing teaming elements such as: the designation of a planning team with cross functional members; conducting formal meetings; a documented process for the team; and an owner for the supply chain planning process. Coefficient alphas were generated on all factors yielding a value of 0.94 for demand management process, 0.87 for supply chain collaborative planning, and 0.90 for operations strategy planning team. These were all deemed acceptable using the criteria of 0.7.

Source analysis

An analysis of variables relating to the SOURCE decision area (see Table V) resulted in loadings for the following factors: source planning process, procurement planning process team, supplier transactional collaboration, supplier operational collaboration, and supplier strategic collaboration. Source planning process had four items representing elements of the planning process such as: process documentation; understanding of supplier inter-relationships; a process owner; and information support. Procurement planning process team had three items representing teaming elements such as: the designation of a procurement planning team with cross functional members; conducting formal meetings; and an owner for the procurement planning process. Supplier collaboration had three factors that represent the various types of collaboration: transactional, operational and strategic. Supplier transactional collaboration had two items representing the sharing of planning and scheduling information with suppliers and the measurement and feedback of supplier

Factor	Coefficient alpha	Scale items	Factor loadings
Source planning process	0.86	S1 – Procurement process documented	0.60
		S2 – IT supports process	0.82
		S3 – Supplier inter-relationships understood/documented	0.67
		S4 – Process owner identified	0.64
Procurement planning process team	0.89	S12 – Procurement process team designated	0.91
		S13 – Team meets on regular basis	0.89
		S14 – Other functions work closely with team	0.58
Supplier transactional collaboration	0.78	S8 – Share plan / schedule with suppliers	0.58
		S11 – Measure and feedback supplier performance	0.72
Supplier operational collaboration	–	S10 – Collaborate with suppliers to develop source plan	0.75
Supplier strategic collaboration	–	S5 – Have strategic suppliers for all products/services	0.70

Table V.
Factor analysis – SOURCE decision area

performance. Supplier operational collaboration had one item representing collaborative planning with suppliers. Supplier strategic collaboration had one item representing the designation of strategic suppliers for all products and services. Coefficient alphas for the factors were 0.86 for source planning process, 0.89 for procurement planning process team, and 0.78 for supplier transactional collaboration. Supplier operational collaboration and supplier strategic collaboration were both single item measures making coefficient alphas non-applicable. The values were all deemed acceptable using the criteria of 0.7.

Make analysis

Factor analysis on variables relating to the MAKE decision area (see Table VI) resulted in loadings for the following factors: make planning process, make scheduling process and make collaborative planning. Make planning process had six items representing process ownership, process integration, formal planning cycles, cross-functional representation, process credibility and measurement. Make scheduling process had three items representing process integration, constraint based methods and information system support. Make collaboration had three items representing the inclusion of supplier lead times, the inclusion of customer planning and scheduling information, and change control. Coefficient alphas for the factors were 0.84 for make planning process, 0.77 for make scheduling process was 0.77 and 0.70 for make collaborative planning. These were all deemed acceptable using the criteria of 0.7.

Deliver analysis

An analysis of variables relating to the DELIVER decision area (see Table VII) resulted in loadings for the following factors: deliver planning process, deliver process credibility, IT support and ownership, deliver process measures and deliver process integration. Deliver planning process had seven items representing process documentation, process ownership, measurements, cross-functional participation and specific order management practices. Deliver process credibility had three items representing customer satisfaction with delivery performance, process credibility

Factor	Coefficient alpha	Scale items	Factor loadings
Make planning process	0.84	M2 – Integrated/coordinated across divisions	0.65
		M3 – Process owner designated	0.76
		M4 – Weekly planning cycles	0.66
		M10 – Measure adherence to plan	0.45
		M11– Adequately address needs of business	0.54
		M12 – Sales/Mfg./Distribution collaborate in process	0.56
Make Scheduling Process	0.77	M7 – Using constraint-based planning methods	0.51
		M8 – Shop Floor scheduling integrated	0.96
		M9 - IT supports process	0.67
Make Collaborative Planning	0.70	M6 – Supplier lead times updated monthly	0.42
		M13 –Integrate customer's plan/schedule	0.51
		M14 – Formal change process	0.95

Table VI.
Factor analysis – MAKE decision area

Factor	Coefficient alpha	Scale items	Factor loadings
Deliver planning process	0.81	D1 – Order commit process documented	0.79
		D2 – Promise delivery process owner	0.75
		D3 – Track on time customer orders	0.69
		D7 – Measure customer requests v. actual	0.53
		D10 – Promise orders beyond inventory levels	0.53
		D11 – Capability to respond to unplanned orders	0.66
		D13 – Sales/mfg./distr./planning collaborate	0.45
Deliver process credibility	0.85	D4 – Customers satisfied with deliver performance	0.90
		D5 – Meet short term demands with inventory	0.67
		D9 – Delivery commit credible to customers	0.76
IT support and ownership	0.76	D14 – IT support of order commit process	0.54
		D18 – IT support distribution management	0.90
		D20 – Distribution management owner	0.70
Deliver process measures	0.77	D19 – Network inter-relationships understood	0.65
		D29 – Distribution management process measures	0.68
		D30 – Measures used to recognize/reward	0.73
Deliver process integration	0.71	D27 – Inventory measures and controls	0.71
		D28 – Use auto replenishment in distribution	0.69

Table VII. Factor analysis – DELIVER decision area

concerning delivery commitments, and specific finished goods safety stock practices. IT support and ownership had three items representing IT support for the order commitment, distribution management processes, and distribution management process ownership. Deliver process measures had three factors representing understanding and documentation of DELIVER network interrelationships (variability and metrics), distribution management process measures, and using these measures to recognize and reward participants. Deliver process integration had two items representing distribution network inventory measures and controls, and the use of automatic replenishment in the network. Coefficient alphas for the factors were 0.81 for deliver planning process, 0.85 for deliver process credibility, 0.76 for IT support and ownership, 0.77 for deliver process measures, and 0.71 for deliver process integration. These were all deemed acceptable using the criteria of 0.7.

7. Results

Descriptive statistics for the supply chain performance variable and SCOR variables derived from factor analysis is provided in Appendix 2. Single variable linear regression analysis was used to test the hypothesized relationships between the identified factors in each SCOR area and the self-assessed performance rating of each area. The independent variables are a summation of the scale items within each factor extracted via factor analysis (see Tables IV-VII). The dependent variable in each case is a self-assessed performance rating for each of the SCOR decision areas. It is represented as a single item for each decision area, and reflects the survey respondent's view of their performance in a particular SCOR decision area (see Appendix A, Questions 32 (PLAN), 15 (SOURCE), 16 (MAKE), and 31 (DELIVER)). The results of the regression analysis are illustrated in Table VIII. Since each regression model contains only one independent variable, these models are equivalent to bivariate correlations.

7.1 Regression results

In the PLAN decision area, Table VIII shows that the demand planning process variable has the strongest relationship to supply chain performance, followed by supply chain collaborative planning and operations strategy planning team. Based on the beta values, demand-planning process is the most important PLAN variable relative to supply chain performance, followed by supply chain collaborative planning and operations strategy planning team. Additionally, the supplier transactional collaboration variable has the strongest relationship to supply chain performance, followed by source planning process, procurement planning process team, supplier operational collaboration, and supplier strategic collaboration in the SOURCE decision area. An examination of the beta values show that supplier transactional collaboration is the most important SOURCE variable relative to supply chain performance, followed by source planning process, procurement planning process team, supplier operational collaboration and supplier strategic collaboration.

In the MAKE decision area, Table VIII reveals that the make planning process variable has the strongest relationship to supply chain performance, followed by make scheduling process and make collaborative planning. Based on the beta values, make planning process is the most important MAKE variable relative to supply chain performance, followed by make planning process and make scheduling process. Finally, the deliver process measures variable has the strongest relationship to supply

	Beta values	Significance level	Adjusted R^2
PLAN factors			
Demand planning process	0.72	0.00	0.50
SC collaborative planning	0.46	0.00	0.20
Operations strategy planning team	0.43	0.00	0.17
SOURCE factors			
Source planning process	0.66	0.00	0.43
Procurement planning process team	0.65	0.00	0.41
Supplier transactional collaboration	0.74	0.00	0.54
Supplier operational collaboration	0.57	0.00	0.31
Supplier strategic collaboration	0.47	0.00	0.20
MAKE factors			
Make planning process	0.71	0.00	0.50
Make scheduling process	0.49	0.00	0.23
Make collaborative planning	0.55	0.00	0.29
DELIVER factors			
Deliver planning process	0.30	0.03	0.07
Deliver process credibility	0.33	0.02	0.09
IT support and ownership	0.55	0.00	0.29
Deliver process measures	0.69	0.00	0.48
Deliver process integration	0.49	0.00	0.22

Notes: dependent variable = supply chain performance; independent variable = SCOR decision area factor

Table VIII.
Single variable regression analysis

chain performance, followed by IT support and ownership, deliver process integration, deliver process credibility, and deliver planning process in the DELIVER decision area. An examination of the beta values show that deliver process measures is the most important DELIVER variable relative to supply chain performance, followed by IT support and ownership, deliver process integration, deliver process credibility and deliver planning process.

Conclusions

Based upon the aforementioned results, conclusions regarding the impact of SCOR planning practices on supply chain performance for each SCOR planning decision area are provided below. Additionally, generalized conclusions with respect to the impact of the nine identified key supply chain practices are offered and summarized in Table IX.

PLAN conclusions

For the PLAN decision area, demand planning, which includes forecast development activities, has a significant impact on supply chain performance. This also includes the measurement of forecast accuracy along with the establishment of a process owner for the demand process. Collaborative planning process activities were also found to have a significant impact on supply chain performance within this decision area. These activities include: defining product and customer priorities; establishing customer and supplier relationships; analyzing customer and demand variability information; reviewing product and customer profitability information; and establishing supply chain performance metrics. The creation of an operations strategy team was found to have an impact on supply chain performance. The team should be comprised of representatives from the major supply chain functions (i.e. sales, marketing, manufacturing, logistics, etc.), hold regular meetings, and have a documented operations strategy process. In addition, an owner for the supply chain planning process is required to ensure its effectiveness.

SOURCE conclusions

Supplier transactional collaboration activities have a significant impact on supply chain performance within the SOURCE decision area. These activities include the sharing of planning and scheduling information with suppliers. The source planning process, which includes the documentation of procurement processes, the establishment of information technology that supports theses processes, and the management of supplier inter-relationships, also has a significant impact on supply chain performance in this

PRACTICE	PLAN	SOURCE	MAKE	DELIVER
Planning processes	X	X	X	X
Collaboration	X	X	X	Indirect
Teaming	X	X	–	–
Process measures	Indirect	Indirect	Indirect	X
Process credibility	–	–	–	X
Process integration	–	–	–	X
IT support	–	–	–	X
Process documentation	Indirect	Indirect	Indirect	Indirect
Process ownership	Indirect	Indirect	Indirect	Indirect

Table IX. General conclusions for the nine key supply chain practices decision area. Supplier inter-relationships included in the source planning process include the management of product and delivery variability, along with metrics for monitoring such variability. Additionally, the designation of a source planning process owner is required to ensure its effectiveness. The establishment of a procurement process planning team was found to have an impact on supply chain performance within the SOURCE decision area. This team should meet on a regular basis, and work closely with other functional areas such as manufacturing and sales. Supplier operational collaboration also has a significant impact on supply chain performance in this decision area. This involves the development of a joint operational plan that is supportive of strategic sourcing activities and outlines how routine transactional activities are to be conducted by the participants. Supplier strategic collaboration activities also impact supply chain performance in the Source decision area. These activities include electronic ordering and supplier-managed inventory. In addition, the presence of on-site employees of key suppliers facilitates strategic supplier collaboration activities that enhance overall supply chain performance.

MAKE conclusions

MAKE planning process activities have a significant impact on supply chain performance within the Make decision area. These activities include: collaboration tasks among the sales, manufacturing, and distribution organizations during the planning and scheduling process; a joint assessment of the needs of the business among the sales, manufacturing, and distribution organizations; and the establishment of performance metrics which facilitate the monitoring of "adherence to schedule" requirements. To ensure its effectiveness, the process must be integrated and coordinated across functional and organizational boundaries. In addition, weekly planning cycles are required to facilitate necessary changes to the plan based on relevant data and information. Finally, the establishment of a make planning process owner is required to ensure the effectiveness of the process. Make collaborative planning also has a significant impact on supply chain performance in this decision area. This involves: the integration of customer planning and scheduling information into the manufacturing planning process; the development of a formal, document, and collaborative approval process for schedule changes, and the periodic updating of supplier lead times based on collaborative information. The make scheduling process also has a significant impact on supply chain performance within the MAKE decision area. Key elements of this process includes: the integration of shop floor scheduling with the overall scheduling process; the use of constraint-based planning methodologies (e.g., the use of advanced planning and scheduling software based on the Theory of Constraints); and the use of information technology to support the make scheduling process (i.e., MRP and ERP systems).

DELIVER conclusions

For the DELIVER decision area, delivery process measures have a significant impact on supply chain performance. These metrics should document supply chain inter-relationships in a manner that is understandable by the supply chain trading partners, and be used to reward and recognize the process participants. The degree to which the information system supports the distribution management process was also found to impact supply chain performance within this decision area. The system's specific support of the order commitment process was found to be critical to effective distribution management. A designated distribution management process owner is required to ensure the effective use of information technology in support of the process.

Delivery process integration along with delivery process credibility were found to have a significant impact on supply chain performance within the DELIVER decision area. Key integration features include the establishment of inventory control mechanisms and metrics for each node in the distribution network, along with the use of automatic replenishment throughout the network. Indicators of delivery process credibility include the degree to which customers are satisfied with current on-time delivery performance, the ability to meet short-term customer demands, and the customer's confidence level in projected delivery commitments. Delivery planning process activities were also found to have a significant impact on supply chain performance within this decision area. These activities include: establishing order commitments based on a collaboration process among the sales, manufacturing, and distribution organizations; tracking the percentage of completed customer orders delivered on time; and measuring variations between customer requests versus actual delivery. In addition, the deliver planning process should monitor delivery over-commitments and delivery flexibility. A designated planning process owner is required to ensure its effectiveness.

Generalized conclusions for the nine key supply chain practices

Table IX provides a summary of general conclusions regarding relationships between the nine identified key supply chain planning practices based on a review of the literature and discussions with supply chain experts and practitioners, and the SCOR Model areas included in the study (PLAN, SOURCE, MAKE, DELIVER). A review of the table reveals that the planning process variables in all four SCOR Model areas have the strongest relationship to supply chain performance. Collaboration variables were found to have a direct impact on SC performance in the PLAN, SOURCE, and MAKE areas of the SCOR Model. Additionally, collaboration was found to have an indirect impact on supply chain performance in the DELIVER decision area. The collaboration results of the study are consistent with the findings of a study conducted by Stank *et al.* (2001a), which found that collaboration improves supply chain service performance.

The table also reveals that teaming variables were found to have a direct impact on supply chain performance in the PLAN and SOURCE areas. In addition, a process metrics variable was found to have a direct impact on supply chain performance in the DELIVER area of the SCOR Model. However, process metrics was found to only have an indirect impact on supply chain performance in the PLAN, SOURCE, and MAKE areas. A process credibility, process integration, and information technology support variable was found to have a direct impact on supply chain performance in the DELIVER area. The process integration results of the study are consistent with a study conducted by Stank *et al.* (2001b) that reveals a relationship between supply chain integration and performance. Process documentation was found to have only an indirect impact on supply chain performance in the four SCOR Model areas included in the study. Finally, process ownership was found to have an indirect impact on supply chain performance in all four SCOR Model areas.

Implications

This study, although preliminary and exploratory in nature, provides a beginning framework for the comparison and discussion of supply chain planning practices that relate to supply chain performance. The supply chain planning practices related to process integration, collaboration, teaming, process measurement, process documentation and process ownership have been shown to be important to supply chain performance, currently lack broad implementation by supply chain partners. This suggests that integrated supply chain management may be more difficult to operationalize in practice than the popular supply chain press or consultants would have one to believe.

This study also suggests is that some of the best practices proposed as mechanisms for improving overall supply chain management performance may not have the degree of impact often presented in the literature. The study shows that some best practices help to improve supply chain performance only in specific decision areas. Further research on this topic might indicate that some practices are industry or "configuration" specific and do not provide the same results for every supply chain.

The final implication of this study is that information technology solutions are only part of the answer to improved supply chain performance. The study suggests that integration is an organization and people issue, and that IT should serve as an enabler to organization and process change. Thus, firms who have purchased an information technology solution and expect it to drive improvements in supply chain management may be disappointed with the final results, due the limitations of IT's impact on supply chain performance revealed in the study.

Limitations

This study provides an exploratory view of the relationship between supply chain management planning practices and supply chain performance using a limited data set. Thus, a major limitation of the study is that it is not possible to make cross industry comparisons or to draw generalizable conclusions about this relationship for all supply chain populations based on the presented results. The purpose of this study is to provide some preliminary insights regarding supply chain management practices and their impact on performance, and to offer a research framework using the SCOR model to facilitate future studies. Finally, this study has resulted in the development of a valid assessment instrument that is capable of gathering relevant information regarding the supply chain planning decision areas. Thus, future researchers can further assess the validity of the implications offered in the study.

Future research

A future research opportunity lies in using the assessment instrument used in this study to gather and develop cross industry best practice information to determine if industry type plays a significant role in the applicability of specific SCM planning practices. Another research opportunity resulting from this exploratory study is to examine why there appears to be a gap between the recognition of a SCM planning practice as important to supply chain performance, and the implementation of the practice. Finally, the role of supply chain structure on the degree to which these practices influence performance also warrants future research.

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Appendix 1. Survey questions with individual correlations

Decision Area: PLAN
Includes P1: Plan Supply Chain

Individual correlations to supply chain performance

1. Do you have an operations strategy planning team designated?……………………. 0.4407
2. Does this team have formal meetings?…………………………………………… 0.3255
3. Are the major Supply Chain functions (Sales, Marketing, Manufacturing, Logistics, etc) represented on this team?……………….……………………………….. 0.4363
4. Do you have a documented (written description, flow charts, etc) operations strategy planning process?……………….……………………………….. 0.2134
5. Is there an owner for the supply chain planning process?………………………... 0.3536
6. Has the business defined customer priorities?…………………………………… 0.3807
7. Has the business defined product priorities?…………………………..……… 0.2512
8. When you meet, do you make adjustments in the strategy and document them?…... 0.4855
9. Does the team have supply chain performance measures established?……………… 0.3840
10. Does the team look at the impact of their strategies on supply chain performance measures? ………………………………………………………………... 0.3453
11. Does the team use adequate analysis tools to examine the impact before a decision is made?…………………………………………………………………... 0.3971
12. Is the team involved in the selection of supply chain management team members?.. 0.1127
13. Does this team look at customer profitability?…………………………………... 0.2805
14. Does this team look at product profitability?……………………………………… 0.1186
15. Does this team participate in customer and supplier relationships?……………….. 0.3357
16. Do your information systems currently support the Demand Management process?.. 0.4336
17. Do you analyze the variability of demand for your products? ………………………... 0.6448
18. Do you have a documented demand forecasting process?.. ………………………… 0.6780
19. Does this process use historical data in developing the forecast? …………………... 0.6820
20. Do you use mathematical methods (statistics) for demand forecasting? …………... 0.5742
21. Does this process occur on a regular (scheduled) basis? ...……………………….. 0.6667
22. Is a forecast developed for each product?…………………………..……… 0.5657
23. Is a forecast developed for each customer?…………………………..……… 0.4135
24. Is there an owner for the demand management process?………………………….. 0.5974
25. Does your demand management process make use of customer information? ……… 0.3977
26. Is the forecast updated weekly? ………………………………………………… 0.2499
27. Is the forecast credible or believable? …………………………………………… 0.7151
28. Is the forecast used to develop plans and make commitments? ……………………. 0.6400
29. Is forecast accuracy measured? ……………………………………………….. 0.5300
30. Are your demand management and production planning processes integrated? …. 0.7253
31. Do sales, manufacturing and distribution organizations collaborate in developing the forecast? ………………………………………………………………… 0.6735
32. Overall, this decision process area performs very well……………………………… 1.0000

Figure A1.

Decision Area: SOURCE
Includes P2: Plan Source

Individual correlations to supply chain performance

1. Is your Procurement process documented (written description, flow charts)? …….	0.6393
2. Does your information system support this process? ………………………………	0.4202
3. Are the supplier inter-relationships (variability, metrics) understood and documented? ………………………………………………………………………..	0.7616
4. Is a "process owner" identified? ……………………………………………………	0.5079
5. Do you have strategic suppliers for all products and services? ………………………	0.4747
6. Do suppliers manage "your" inventory of supplies? …………………………………	0.4399
7. Do you have electronic ordering capabilities with your suppliers? ………………….	0.3569
8. Do you share planning and scheduling information with suppliers? ………………..	0.5839
9. Do key suppliers have employees on your site (s)? …………………………………	0.4677
10. Do you "collaborate" with your suppliers to develop a plan? ………………………	0.4528
11. Do you measure and feedback supplier performance? ……………………………..	0.7877
12. Is there a procurement process team designated? …………………………………...	0.5331
13. Does this team meet on a regular basis? …………………………………………….	0.5142
14. Do other functions (manufacturing, sales, etc) work closely with the procurement process team members? …………………………………………………………….	0.6227
15. Overall, this decision process area performs very well. …………………………….	1.0000

Figure A2.

Decision Area: MAKE
Includes P3: Plan Make

Individual correlations to supply chain performance

1. Do you have a documented (written description, flow charts, etc) production planning and scheduling process? ……………………………………………………	0.5396
2. Are your planning processes integrated and coordinated across divisions? ……….	0.4817
3. Do you have someone who "owns" the process? ………………………………….	0.6043
4. Do you have weekly planning cycles? …………………………………………….	0.6541
5. Are supplier lead times a major consideration in the planning process? ………..…	0.3865
6. Are supplier lead times updated monthly?………………………………………....	0.5176
7. Are you using constraint-based planning methodologies? ………………………....	0.4176
8. Is shop floor scheduling integrated with the overall scheduling process? ………..	0.5182
9. Do your information systems currently support the process? …………………….	0.4871
10. Do you measure "adherence to plan"?…………………………….………………	0.4190
11. Does your current process adequately address the needs of the business?………	0.7419
12. Do the sales, manufacturing and distribution organizations collaborate in the planning and scheduling process? …………………………………………………	0.6255
13. Is your customer's planning and scheduling information included in yours? …….	0.2551
14. Are changes approved through a formal, documented approval process? ………..	0.4611
15. Are plans developed at the "item" level of detail?…………………………………	0.2226
16. Overall, this decision process performs very well………………………………….	1.0000

Figure A3.

Decision Area: DELIVER
Includes P4: Plan Deliver

Individual correlations to supply chain performance

1.	Is your order commitment process documented (written description, flow charts)?…	0.3158
2.	Do you have a Promise Delivery (order commitment) "process owner"? ..…………	0.4042
3.	Do you track the percentage of completed customer orders delivered on time? …..	0.0764
4.	Are the customer's satisfied with the current on time delivery performance? ……	0.3938
5.	Do you meet short-term customer demands from finished goods inventory?…….	0.2284
6.	Do you "build to order"?………………………………………………………….	0.0214
7.	Do you measure customer "requests" versus actual delivery? …………………..	0.1976
8.	Given a potential customer order, can you commit to a firm quantity and delivery date (based on actual conditions) on request?…………………………..	0.4178
9.	Are the projected delivery commitments given to customers credible (from the customer's view)? ………………………………………………………………...	0.4298
10.	Do you promise orders beyond what can be satisfied by current inventory levels?	0.0715
11.	Do you maintain the capability to respond to unplanned, drop-in orders? ………	0.3128
12.	Do you automatically replenish a customer's inventory? ……..………………….	0.1883
13.	Do the sales, manufacturing, distribution and planning organizations collaborate in the order commitment process? ………………………………………………..	0.4240
14.	Do your information systems currently support the order commitment process?..	0.6816
15.	Do you measures "out of stock" situations? ………………………………………	0.3586
16.	Is your order commitment process integrated with your other supply chain decision processes? ……………………………………………………………..	0.5221
17.	Is your Distribution Management process documented (written description, flow charts)?……………………………………………………………………………	0.3817
18.	Does your information system support Distribution Management? ……………	0.7251
19.	Are the network inter-relationships (variability, metrics) understood and documented? ………………………………………………………………………..	0.5883
20.	Is a Distribution Management process owner identified? …………………………	0.2805
21.	Are impacts of changes examined in enough detail before the changes are made?..	0.3939
22.	Are changes made in response to the loudest "screams"? …………………………	- 0.1786
23.	Are deliveries expedited (manually "bypassing" the normal process)? ……………	-0.0370
24.	Do you use a mathematical "tool" to assist in distribution planning? ………………	0.5272
25.	Can rapid re-planning be done to respond to changes? …………………………..	0.3993
26.	Is the Distribution Management process integrated with the other supply chain decision processes (production planning and scheduling, demand management, etc)?	0.6889
27.	Does each node in the distribution network have inventory measures and controls?	0.5820
28.	Do you use automatic replenishment in the distribution network? …………………	0.2657
29.	Are Distribution Management process measures in place? …………………………	0.6596
30.	Are they used to recognize and reward the process participants? ………………….	0.4362
31.	Overall, this decision process area performs very well…………..………………….	1.0000

Figure A4.

Appendix 2. Descriptive statistics for factor scale items

PLAN factors	Mean	Std dev.
P18	2.96	1.40
P19	3.46	1.34
P20	3.17	1.44
P21	3.57	1.43
P22	3.52	1.38
P24	3.28	1.55
P27	2.65	1.19
P28	3.40	1.22
P29	2.94	1.47
P6	3.13	1.16
P7	3.07	1.21
P13	2.00	1.07
P14	2.68	1.24
P15	2.72	1.24
P17	2.87	1.25
P25	2.81	1.19
P9	3.07	1.37
P1	3.39	1.38
P2	3.15	1.36
P3	3.09	1.48
P4	2.52	1.41
P5	3.35	1.49

Table AI. PLAN

SOURCE factors	Mean	Std dev.
S1	3.51	1.21
S2	3.33	1.17
S3	3.00	1.18
S4	3.70	1.22
S12	3.35	1.39
S13	3.15	1.33
S14	2.98	1.20
S8	2.85	1.17
S11	3.21	1.15
S10	2.60	1.08
S5	3.54	0.99

Table AII. SOURCE

DELIVER factors	Mean	Std dev.
D1	3.46	1.40
D2	3.22	1.40
D3	3.87	1.37
D7	3.20	1.50
D10	3.00	1.27
D11	3.32	1.28
D13	2.70	1.22
D4	3.62	0.88
D5	3.35	1.20
D9	3.47	1.08
D14	3.18	1.11
D18	2.87	1.13
D20	3.24	1.27
D19	2.51	1.01
D29	2.80	1.12
D30	2.22	1.11
D27	2.43	1.22
D28	2.68	1.36

Table AIII.
DELIVER

MAKE factors	Mean	Std dev.
M2	2.61	1.16
M3	3.41	1.18
M4	3.20	1.38
M10	2.86	1.26
M11	2.77	1.11
M12	2.80	1.17
M7	2.55	1.28
M8	2.85	1.34
M9	2.96	1.02
M6	2.24	1.14
M13	2.12	1.01
M14	2.42	1.24

Table AIV.
MAKE

Supply chain performance factors	Mean	Std dev.
P32	2.67	1.12
S15	3.07	1.10
M16	2.81	0.89
D31	2.83	1.02

Table AV.