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# Agile supply chain capabilities: Determinants of competitive objectives

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**Abstract**

Changing customer and technological requirements force manufacturers to develop agile supply chain capabilities in order to be competitive. Therefore, several companies are stressing flexibility and agility in order to respond, real time, to the unique needs of customers and markets. However, the resource competencies required are often difficult to mobilise and retain by single companies. It is therefore imperative for companies to co-operate and leverage complementary competencies. To this end, legally separate and spatially distributed companies are becoming integrated through Internet-based technologies. The paper reviews emerging patterns in supply chain integration. It also explores the relationship between the emerging patterns and attainment of competitive objectives. The results reported in the paper are based on the data collected from a survey using the standard questionnaire. The survey involved 600 companies in the UK, as part of a larger study of agile manufacturing. The study was driven by a conceptual model, which relates supply chain practices to competitive objectives. The study involves the use of factor analysis to reduce research variables to a few principal components. Subsequently, multiple regression was conducted to study the relationship amongst the selected variables. The results validate the proposed conceptual model and lend credence to current thinking that supply chain integration is a vital tool for competitive advantage.


*Keywords:* Agile manufacturing; Agile supply chains; Enterprise integration; Competitive objectives; Theoretical; Empirical; Resource competencies

## 1. Introduction

In a bid to cope with market instability, companies now look beyond cost and quality advantage. Speed, quality and flexibility are being emphasized as means of responding to the unique needs of customers and markets. However, the core resource competencies required to realise the extended range of objectives are often difficult to mobilise and retain by individual companies (Kasarda and Rondinelli, 1998; Gunasekaran, 1998; Gunasekaran and Yusuf, 2002). In the circumstance, companies are under pressure to co-operate and leverage core resource competencies amongst themselves whilst competing. Co-operation is particularly crucial for innovation and

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responsiveness during the early stage of production planning. Through the Internet, businesses and institutions now share common databases and collaborate ever than before (US Internet Council, 2000). In addition, companies submit joint bids for contracts and attribute responsibilities for design and manufacture of complex products, based on their relative competencies (Upton and McAfee, 1996). The drivers of supply chain integration include advances in information technology, complex customer requirements, intense global competition, and the desire to be the first to market with innovative products.

This paper discusses the drivers and emerging patterns of supply chain integration. A conceptual model of supply chain practices as determinants of manufacturing competitiveness and business performance was developed. Also, the relationship between the patterns of supply chain and attainment of competitive and business performance was explored. The exploration was based on the data collected from a survey using the standard questionnaire administered to 600 companies in the UK.

Statistical analyses of the impact of supply chain practices on competitive objectives were extended to include two internal resource competencies of process automation and employee empowerment. The results show that the internal resource competencies are characterised by negative interaction effects in their relationship with competitive and business objectives. This implies that those internal resource competencies are inadequate for enhanced manufacturing performance. Therefore, external competence building through supply chain integration as seamless flows of resource coalitions is essential for enhanced competitive performance.

Further, three patterns of supply chain practices were identified by statistical analysis. In line with statistical procedures, the patterns were interpreted as traditional, lean, and agile supply chains. The traditional pattern, which is renowned for protection, rather than the leverage of core competencies, as well as emphasis on terms and condition for attribution of costs and benefits, did not deliver significantly on competitive objectives. In contrast, the lean pattern, which was underpinned by upstream and downstream integration with suppliers and customers, had significant influence on competitive objectives. Also, the agile pattern was distinguished by a high degree of co-operation with competitors, data integration, and collaboration for manufacture rather than exclusively marketing. The supply chain practices described as agile enterprise had significant impact on the low cost objective although it was less popular amongst the companies studied.

The organisation of the paper follows as: Section 2 discusses the drivers of supply chain integration. The nature of an agile supply chain is presented in Section 3. Section 4 deals with a conceptual model for assessing the capability of an agile supply chain. Research methodology employed is discussed in Section 5. Section 6 includes results and discussions. Finally, Section 7 presents the summary and conclusions.

## 2. Drivers of supply chain integration

There are unprecedented pressures on companies to improve their operational efficiency for enhanced competitiveness and overall business performance. Such pressures include competition from foreign products, new product introduction by competitors, falling product life cycles, unanticipated customer shifts, and advances in manufacturing and information technology (Browne et al., 1995). Other pressures include the privatisation of public enterprises, economic downturns and agitation by shareholders for higher returns on investment. These pressures can eat deep into the size of available public and third party loanable funds. In addition, consumer sophistication and the emergence of intelligent products have led to more difficult design specifications and expectations on deliverable value added (Bhattacharya, 1996).

In the light of the pressures specified above, the most difficult challenge facing manufacturers today is how to integrate the upstream outsourcing functions and the downstream delivery functions with product design and manufacture (Helena, 1997). Integration would enable the value creation and transfer process, right from the supplier to the

end customer to operate as a seamless chain along which information, knowledge, equipment and physical assets flow as if water (Gunasekaran and Yusuf, 2002; Yusuf et al., 1999).

Seamless flow of physical and non-physical assets amongst companies would lead to pooling synergy and optimisation of tangible and intangible assets that are potentially available to the individual companies (Kasarda and Rondinelli, 1998; Upton and McAfee, 1996). Companies in a chain can apply the principles of job specialisation to plant operations. This means that design can take place in a remote site far away from some other plants where the components are machined, and assembled in different configurations in a fewer number of factories or at the point of sale (Feitzinger and Lee, 1997). The companies in the chain will have the benefit of focusing on a narrow aspect of operations where they have greatest competitive advantage (Quinn, 1992).

Advanced information technology (IT), which has turned the world into a global village through "speed of light" transfers of information, data and files, is a major driver of supply chain integration. Through the Internet, a single data file can be accessed simultaneously by spatially distributed entities. Although earlier IT applications were in support of secure and evidential transfers of trading reports, cash and other assets and obligations, the applications were eventually extended to logistics management (Russ and Camp, 1997).

As well, companies' growth through vertical integration and search for new markets in different countries has given rise to large administrative structures. Consequently, the need to process and transfer large volumes of data in the form of designs, plans, budgets and reports across several administrative and operation units becomes necessary. In addition, companies allying to become integrated global businesses needed mutual access to data on cost, personnel, stocks, sales and profit profiles. This is in addition to being able to monitor several alliance conditions such as compliance, contribution and attribution. The business scenario described necessitate advanced IT applications, with greater functionality than electronic data interchange (EDI). New IT capabilities in terms of reach, easier coding via inheritance, adding new data and generating automatic upgrades, and protecting components of data files from unwanted parties have therefore emerged (Mutsaers et al., 1998).

Nevertheless, market turbulence arising from factors such as rapid introduction and customisation of products, difficult design specification, and customer shifts make continuous contact with customers and suppliers through supply chain integration most important (Russ and Camp, 1997; Davenport, 1998). In addition, various functions and spatially distributed project units of companies require more co-ordination and integration. Furthermore, as competition intensified, efforts to reduce cost through just-in-time purchasing, scheduling and distribution, led to more frequent monitoring of specified and delivered quality, schedules and other customer expectations as a routine process. For these reasons, some manufacturers have organised hierarchical networks of suppliers and "imposed" their own control structures and systems.

The advents of intelligent products, whose requirements are rather difficult for individual companies, create the greatest challenge for supply chain integration. The need arises to focus on narrow product modules with greatest competitive advantage whilst collaborating with other companies (Quinn, 1992). The processes of conception, design, manufacture and delivery are therefore becoming like a relay race amongst legally separate companies, who work with equal vigour and commitment to add the greatest value to end-customer continually (Badaracco, 1991; Lee and Lau, 1999; Soliman and Youssef, 2001). In this regard, sharing of design and manufacturing knowledge and competencies amongst companies is a vital tool of competition. Sharing enhances tracking of customer expectations whilst also reducing product and process development cycle times (Bhatt, 2000; Perry and Sohal, 2001).

## 3. The nature of an agile supply chain

Until recently, supply chains were understood mainly in terms of long-term upstream collaboration with suppliers. An equal amount of emphasis

is now paid to downstream collaboration with customers and lateral collaboration with competitors as a means of integrating the total value creation process. A supply chain, therefore, describes the series of linked activities amongst companies that contribute to the process of design, manufacture and delivery of products and services. The agility of a supply chain is a measure of how well the relationships involved in the processes mentioned above enhance four pivotal objectives of agile manufacturing (Hoek et al., 2001). These objectives are customer enrichment ahead of competitors, achieving mass customisation at the cost of mass production, mastering change and uncertainty through routinely adaptable structures, and leveraging the impact of people across enterprises through information technology.

The preceding list shows that enhanced responsiveness is a major capability of an agile supply chain. Enhanced responsiveness is important as an addition to the high level of efficiency in cost, quality and smooth operations flow, which have been associated with lean supply chains. These primary objective of a lean supply chain can be realised by using the most basic forms of data communication on inventories, capacities, and delivery plans and fluctuations, within the framework of just-in-time (JIT) principles (Womack et al., 1990). The aim of integration is to ensure commitment to cost and quality, as well as achieving minimum distortion to plans, schedules and regular delivery of small volumes of orders.

Supply chain agility can be discussed in terms of two dimensions of reach and range of activities covered by networking amongst companies (Browne et al., 1995; Kehoe and Boughton, 2001). Fig. 1 illustrates the two-dimensional framework. On the vertical axis, information reach extends from person to person through to global. On the horizontal axis, the range of activities widens from electronic messaging to Internet-based integration. Accordingly, the degree of freedom in supply chain integration widens from bill of material controls through purchasing efficiency to planning and control of supply chain operations.

An agile supply chain should extend to the highest levels on both dimensions of reach and range. At the highest levels of attainment of two dimensions, the conduct of internal operations will be transparent to suppliers and customers. Also, local teams of employees can think globally and take virtual initiatives with teams in other companies within the supply chain. To this extent, responsiveness to changing competitive requirement becomes easier to master as a matter of routine, and with little penalties in time, cost and quality.

In addition to the reach and range approach, agility and capability of a supply chain can be assessed in terms of the stage attained on three inter-dependent dimensions of supply chain maturity (Venkatraman and Henderson, 1998). The three dimensions are shown in Fig. 2 (column 1) as customer interaction, asset configuration and

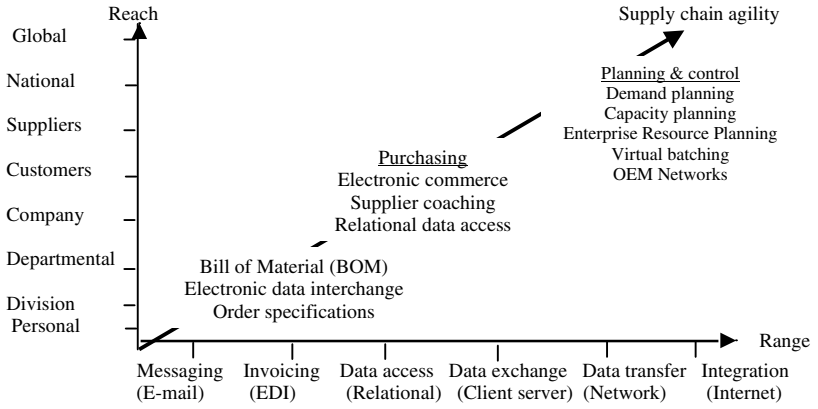


Fig. 1. Reach and range analysis of supply chains (Browne et al., 1995; Kehoe and Boughton, 2001).

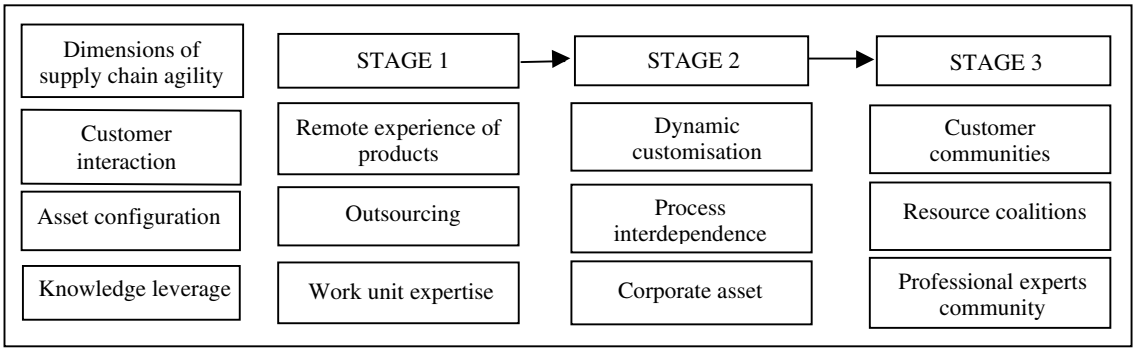


Fig. 2. Three dimensions and stages of supply chain maturity (Venkatraman and Henderson, 1998).

knowledge leverage. The challenge of an agile supply chain will be to improve and ensure balance across the three dimensions. Fig. 2 also shows three stages that can be used to evaluate progress on each of the three dimensions of supply chain maturity.

On customer interaction, the first stage of remote experience of products includes efforts to reach out to customers through sales catalogues, television demonstrations and, most recently, web-based advertisements, demonstrations and shopping. By remotely reaching out to spatially distributed customers through virtual means, a company can identify clusters of unique preferences for dynamic customisation (Stage 2). Eventually, dynamic customisation can be targeted at communities of customers (Stage 3), who have strong commitment to customer-specified product upgrades rather than variety as an end in itself. When a company attains the stage of customer communities, leading edge technology products can be introduction more rapidly due to the advantage of customer-input into their evolution as well as the benefit of market concentration.

As for customer interaction, the asset configuration dimension matures from emphasis on commercial outsourcing of materials and components, to business process inter-dependence. This means delegating critical business processes to members of a chain rather than outsourcing. Eventually, spatially distributed and inter-dependent business processes mature into resource coalitions. At this stage, companies will contribute and share knowledge and competence within global networks of resources, and focus on limited areas of the value creation processes where comparative advantage is higher. On the third dimension of knowledge leverage, supply chain agility requires advance from emphasis on individual job competencies and structures, to teaming and free flow of tacit knowledge across work units. Ultimately, the principles of free flow of knowledge across work units should extend to entire value chains as joint stakeholders in the process of conceiving, creating and delivering value. At this stage, a company aims to leverage competencies not only internally amongst its own employees and teams, but also within a globally linked but spatially distributed professional community of experts.

Across the three stages of maturity towards virtual organising, the target locus of action would extend from task units to organisation units and to inter-organisational units. Across the three stages as well, performance objectives would mature from operating efficiency through economic value added, to enhanced survival prospects (Venkatraman and Henderson, 1998).

The preceding discussion shows that an agile supply chain should strive to meet the three requirements specified in column 4 of Fig. 2. The requirements are ownership of customer communities or niche markets, membership of manufacturing resource coalitions, and possession of a workforce that operates within a community of professional experts. Inter-organisational leverages should drive competitive strategies, plans and

innovation. Most importantly, the supply chain should enhance growth and long-term survival.

Closely related to the three elements of virtual organising as a means of assessing the agile capabilities of a supply chain, four dimensions of agile supply chain practices have been identified (Hoek et al., 2001). They are:

- Customer sensitivity through continuous enrichment as against focusing on waste elimination.
- Virtual integration, with emphasis on instantaneous response in addition to stable production flows.
- Process integration through self-managing teams as against work standardisation and conformance.
- Network integration through "fluid" clusters of associates who venture into temporal opportunities.

Fig. 3 models the four elements. Customer sensitivity means that collaborative initiatives should be driven by quick response to customer requirements. In this respect, manufacturing processes require integration and specialisation based on relative areas of excellence in core competencies. Network integration requires that companies in the chain have a common identity, which can range from commitment to agile practices, compatibility of structure, information architecture and tradable competencies. The third element is process integration and inter-dependence so that core modules of products can be delegated within networks of agile competitors. Lastly, virtual integration envisages access to information, knowledge and competencies of companies through the Internet.

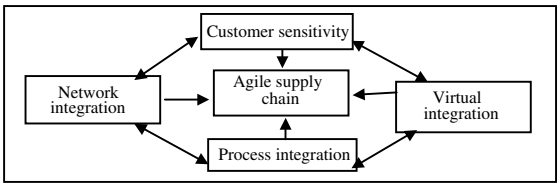


Fig. 3. Elements of an agile supply chain (courtesy: Hoek et al., 2001).

## 4. A conceptual model for assessing an agile supply chain

In Fig. 4 is a conceptual model for assessing the capability of an agile supply chain. The model consists of four dimensions: (i) value chain practice, (ii) competitive objectives, (iii) impact of change drivers and (iv) business performance. The arrows indicate the direction of impact. The essential differences are the ease of formation and dissolution, relative status and commitment of members, the degree of data integration through the Internet, and goals, which can range from advancement of manufacturing knowledge, outsourcing or marketing. These differences are proposed to determine the attainment of competitive and business objectives as well as the impact of change drivers on operations.

It is expected that patterns of supply chain integration will differ across companies. Conceptually, supply chain practices should range from conditional alliances, to master–servant long-term relationships with suppliers and customer, and to the Internet-based collaboration. Across these range of supply chain practices, access to data and knowledge, as well as the ease of responding real time to changing market conditions differ. Such differences are expected to impact differently on competitive and performance outcomes.

Three supply chain patterns are dominant in the literature (Gunneson, 1997). The first is the traditional alliance, which is the dominant practice among companies seeking global spread, as a strategy of penetrating new markets. It is renowned for difficult conditions on contribution, responsibilities and sharing. Data exchange is limited to sales reports and final accounts, which

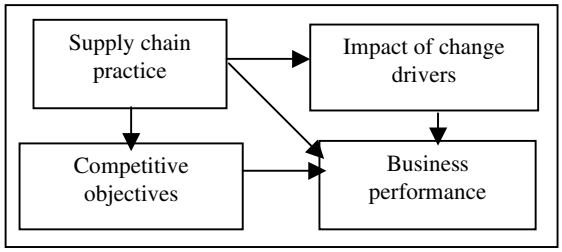


Fig. 4. A conceptual model for assessing an agile supply chain.

are essential for assessing compliance with terms and conditions as well as for tracking resources, profits and losses. Such alliances focus on outsourcing rather than sharing of knowledge and competencies. In the new competitive game plan, the traditional pattern of alliance practice has become increasingly irrelevant.

A concept referred to as the lean supply chain is the second dominant form of alliance practice. It is renowned for long-term collaboration with preferred suppliers and customers. The goal is to secure cost and quality advantage as well as ensure smooth flow of operations, within the framework of just-in-time deliveries of small volumes of output. In support of the goal, collaborative initiatives include electronic linkages, part ownership, coaching and long-term contractual obligations with suppliers and distributors. Data generation and exchange are largely electronic. These forms of data exchange would just have been adequate for monitoring stock, sales, demand and capacity levels. There seems to be no concerted effort to leverage manufacturing competencies amongst companies as equals. As such, the lean model of integration also has limited impact on competitiveness in a turbulent market.

Quite unlike the traditional and lean supply chains, the agile supply chain is underpinned by global exchange of manufacturing competencies. The agile chain has a stronger impact on competitiveness because it enables mobilisation of global resources to track evolving changes in technology and material development as well as market and customer expectations. Inter-dependent factories can focus and rapidly replicate narrow aspects of the value creation process where competitive advantage is greatest (Quinn, 1992). Focusing and co-operation within the virtual enterprise has the potential to enhance capability for low cost, quality, speed, flexibility and product innovation. These in turn will lead to higher revenues, profits, market-share, customer loyalty and better survival prospects.

Based on the conceptual model in Fig. 4, the relative impacts of three models of supply chains on competitive and business performance measures were identified, based on data from a survey by questionnaire. Attainment of seven dimensions of supply chain practices by companies was studied. Table 1 lists the seven dimensions.

## 5. Research methodology

In order to explore current attainment of the seven dimensions of supply chain practices and their impacts on competitive performance, a survey by questionnaire was administered to 600 manufacturing companies. One hundred and nine responses (representing a response rate of 18.17%) were considered useful for the study. The companies were asked to indicate the extent to which the dimensions apply to their operations. The

Table 1
Profile of respondents' scores on supply chain practices

| Dimensions of supply chain practices | Agree strongly (5), % | Agree (4), % | Neutral (3), % | Disagree (2), % | Strongly (1), % |
|---|---|---|---|---|---|
| Co-operation with competitors | 14.0 | 14.0 | 35.5 | 13.1 | 23.4 |
| Long-term collaboration with customers and suppliers | 46.7 | 36.4 | 9.3 | 5.6 | 1.9 |
| Leverage of core resources with other companies operating as a network | 9.3 | 10.3 | 28.0 | 22.4 | 29.0 |
| Difficult operating conditions compel co-operation with other companies | 1.9 | 20.6 | 36.4 | 21.5 | 16.8 |
| Alliances amongst complementary equals are more effective | 11.2 | 29.0 | 43.0 | 10.3 | 2.8 |
| Computer-based data integration with other companies | 4.7 | 10.3 | 27.1 | 17.8 | 38.3 |
| We value alliances for co-manufacture more than for market penetration | 2.8 | 15.9 | 43.0 | 16.8 | 16.6 |

responses were ordinal on a 5-point Likert scale, which ranged from strongly agree (5) right to strongly disagree (1).

Data were also collected in the same format on two internal competencies of process automation and employee empowerment. This is in order to compare the performance impacts of emerging patterns of supply chains as external capabilities, alongside the performance impacts of process automation and employee empowerment as internal capabilities. The companies were also asked to indicate their attainment of seven manufacturing objectives, which have to be equally improved upon by agile manufacturers. The objectives are low cost, quality, dependability, speed, volume flexibility, product customisation, and leadership in new technology products. As well, the companies were requested to indicate the direction of change in seven measures of business performance over the last three years. The measures are sales turnover, net profit, market share, percentage of sales from new products, customer loyalty based on the ratio of repeat orders to total sales turnover, and overall performance against competitors. All the competitive and performance objectives studied have been widely used in related prior studies (Vonderembse and Tracey, 1999; Flynn et al., 1995).

The data was analysed using SPSS Release 10.0 for Windows. Reliability tests were conducted for all variables studied. For example, business performance had an $F$-statistic of 3.66 at $p = 0.008$ and an $\alpha$ coefficient of 0.72. Also, an $F$-value of 198.01 at $p = 0.00$ and an $\alpha$ coefficient of 0.681 were computed for measures of automation. As for the measures of employee empowerment, a $\chi^2$ of 81.73 at $p = 0.00$ and an $\alpha$ coefficient of 0.746 were computed. Significant $F$-values indicate that each of the variables employed to measure a concept is unique. Also, a minimum $\alpha$ value of 0.60 for such variables means that the variables converge and are good measures of the concept studied. In addition, the data satisfied the requirements of normal distribution and equal variance across sample sub-groups, which means that parametric tests such as factor and regression analyses are in order (Vonderembse and Tracey, 1999; Henry, 1998).

Factor analysis was used to reduce the research variables to only a few factors. The two most useful results are total variance explained and a component matrix. The former computes explained variances whilst the latter computes the weights of the variables in a few number of easily interpretable factor components. The relationships amongst the factor components were tested with path analysis. The method provides insights into the pattern of relationships amongst a set of variables. Path coefficients were computed with regression analysis, based on standardised scores of the factor components. The most important results of regression analysis are a squared regression coefficient ($R^2$), which shows the total change in a dependent variable attributable to all independent variables. In addition, an $F$-statistic reveals the ratio of explained to unexplained variation. Furthermore, a table of standardised regression coefficients reveals the strength of each independent variable on the dependent variable. Higher $R^2$ and $F$-values at $p < 0.05$, in addition to only a few variables having significant coefficients at $p < 0.05$ mean that a model was correctly specified (Flynn et al., 1995).

Companies in the study were selected randomly from a database called Financial Analysis Made Easy (FAME), which publishes contact and summary financial information of major UK companies. Attention was paid to spread of the companies across a wide range of industries and size based on sales turnover. About 55%, 20% and 25% of the respondents were small, medium and large-scale companies. The percentage distribution on seven product groups ranged from 23.9% in industrial, hospital and agricultural equipment, to 9.2% in food, chemicals and pharmaceuticals. Furthermore, 37.6% of the companies compete in markets consisting of several companies of relatively equal size, whilst 57.7% trade in markets dominated by a few large companies.

## 6. Results and discussion

The responses to questions on supply chain practices are summarised in Table 1. The table shows that a higher proportion of the respondents

(40.2%) agreed that insistence on complementary equality was alliances whilst 51.4% disagreed with exchange of core resource capabilities with other companies. The two results provide indication that traditional conditionality in alliance formations remains popular. Furthermore, 83.1% agreed those long-term relationships with suppliers and customers are desirable. However, only 22.5% of companies agreed that difficult operating conditions now compel supply chain integration. In addition, only 15% of companies claimed some computerised data integration with other companies. Similarly, 28% agree on alliances amongst competitors while 19% preferred co-manufacturing to commercial marketing and purchasing alliances. These positions are contrary to the suggestions in the literature. The results show that agile chains, which stress competitors' alliances, exchange of capabilities and computer-based integration are far from realisation.

The results in Table 1 reveal that long-term commercial relationships with customers and suppliers is most popular whilst data integration and open leverage of core resources were yet to be popular in industry.

The seven dimensions of supply chain practice were tested for relationship with manufacturing and business objectives. Table 2 presents the results. The significance levels of correlation coefficients are shown in parentheses. The table shows that customer/supplier collaboration, and computer-based data integration had the widest and strongest relationship with competitive objectives. On the other hand, Table 2 indicates that leverage of core resources has negative correlation with the agile objective of new technology leadership. As well, difficult operating conditions as a driver of co-operation has a negative correlation with sales turnover. The reasons accounting for the negative relationships are not far fetched. Companies might be playing safe and hoarding their best competencies, processes and data from network members. This can be more so when in a turbulent situation, what happens next would remain largely unknown. Indeed, the bane of the Internet as well as inter-company networking today remains the quality, transparency and honesty contained in available information. This also determines derivable benefits.

Several examples abound on the negative relationship between leverage of core resources and technology leadership on one hand, as well as between difficult operating conditions as a driver of integration and sales turnover growth. It is known world wide that several years of alliance relationship between Honda and Rover led to the sale of the latter to the former. As well, Volkswagen has just bought up Skoda Auto after several years of co-operation. Where competitive situation and structures of allying companies are incompatible, trust will be low. This can result in lower competitive and performance outcomes. Nevertheless, subsequent results indicate that failed efforts at integration can be attributed to traditional alliances, which pursue objectives and utilise structures different from those of agile supply chains.

Finally, computer-based data integration, which occupies the centre-stage in the requirements of agile supply chain, correlated significantly with sales turnover and market share growth. It therefore has the strongest relationship with bottom line measures of business success, followed by collaboration with customers and suppliers.

As explained earlier, path analysis is more useful in revealing the direction and strength of

Table 2
Significant correlation between supply chain practices and manufacturing objectives

| | Customer/supplier alliances | Protection of core competence | Difficult conditions compel alliances | Data integration |
|---|---|---|---|---|
| Product customisation | 0.198 (0.41) | | 0.22 (0.03) | |
| New technology leadership | 0.20 (0.04) | −0.25 (0.01) | | |
| Dependability | 0.234 (0.02) | | | |
| Sales turnover growth | 0.215 (0.03) | | −0.23 (0.02) | 0.254 (0.01) |
| Market share growth | | | | 0.219 (0.026) |

relationship among a complex set of variables. Proper comprehension demands a compact analysis, which is achievable by employing factor analysis to reduce research variables into a few principal components. Table 3 presents the principal components of factor analysis, as emerging patterns of supply chains. Three distinct patterns were significant in terms of eigenvalues not less than one. The three patterns, which are described as agile, lean and traditional, account for 61.03% of variance in the distribution of respondents' scores.

In the traditional model, three variables were loaded highly at over 0.60 out of a total coefficient of 1.00 for a perfect fit. Leverage of core resources was negative at 0.658. Difficult competitive condition as a driver of co-operation was positive at 0.668. This can be interpreted as an alliance formed in haste, and lacking in structures for networking as a competitive strategy. As well, the high loading of complementary equality at 0.731 can imply lack of trust, which means that attention would have been placed more on rules than the output of the process. This is the traditional type of supply chains. Traditional supply chains are renowned for mutual suspicion of partners, complex negotiations on structure, protection of core areas of strength, compliance and sharing of costs and benefits.

In the model described as lean, alliance with customers and suppliers was loaded solely at 0.907. All other dimensions of alliance practice were compressed by the statistical procedure as insignificant. This is the lean pattern of alliance practice, which is largely defined by long-term relationship with customers downstream and suppliers upstream. In a manufacturing environment characterised by just-in-time practices, lean alliances are essential in ensuring consistent flow in the fragile balance of daily, repeated deliveries of small orders as pulled by customers. The original equipment manufacturers occupy the centre stage and dictate the tune through part ownership and coaching. They employ the lean network as a means of aggressive selling and distribution as well as for cost and quality gains. The relationship is more for commercial outsourcing and distribution than for product and process development.

In relation to the two preceding patterns of alliance practice, the agile model was significantly populated by integrated data exchange at 0.727, alliances for design and manufacture rather than marketing at 0.665, alliances with competitors at 0.638 and leverage of core resources at 0.461. This is the most advanced pattern of current practice in supply chain integration. The variables that define the pattern are closest to the requirements of agile value chains as specified in the literature. However, the results in Table 1 reveal that the variables that constitute agile pattern the lowest percent of perceived relevance or desirability to current operations of the companies studied. Yet, several exploratory tests including the results in Table 2 show that computer-based data integration, which defines the agile pattern, has the strongest positive relationship with sales turnover and market share growth. Nevertheless, as market turbulence intensifies, manufacturers will tend to place more

Table 3
Factor models of supply chains

| Dimensions of supply chain practices | Emerging patterns of supply chains | | |
|---|---|---|---|
| | Agile | Lean | Traditional |
| Co-operative alliances with competitors | 0.638 | | |
| Long-term collaboration with customers and suppliers | | 0.907 | |
| Leverage of core resources with other companies | 0.461 | | −0.658 |
| Difficult conditions as a driver of co-operation | | | 0.668 |
| Alliances amongst complementary equals | 0.357 | | 0.731 |
| Computer-based data integration with other companies | 0.727 | | |
| Alliances for design and manufacture rather than marketing | 0.665 | | 0.316 |
| Eigenvalues | 1.691 | 1.087 | 1.494 |
| Percentage of variance explained | 24.15 | 15.53 | 21.35 |

emphasis on variables loaded in the agile alliance model.

The method of factor analysis was also employed to reduce other variables in the study to their principal components. The standardised coefficients of each variable that were loaded in the factor components were used for multiple regression analysis. The significant regression results indicate the strengths of impact of the different patterns of alliance practice as well as the internal resource capabilities of process automation and employee empowerment on competitive objectives and business performance measures. The significant path coefficients are reported in Fig. 5.

Three boxes, which were labelled as teaming, training and intelligent automation in Fig. 5 depict three of the four components to which process automation and employee empowerment were factored. The four factor, which was described as flexible automation has no significant relationship with any other variable in the regression model. Such variables or factors are often excluded from path analysis results. In addition, two boxes were labelled as lean supply chain and agile supply chain, respectively. The third pattern of supply chain, which was explained earlier as the traditional supply chain, did not relate to any other factor model. It was therefore excluded. The next four boxes in Fig. 5 were labelled as cost leadership, quality leadership, time-based technology leadership, and flexibility leadership. They represent the core competitiveness dimensions to which seven manufacturing objectives were reduced by factor analysis. Finally, two boxes were labelled, respectively, as impact of change driver and business performance. The former is an aggregate measure of the direction of impact of change drivers such as globalisation, new product introduction, product customisation and IT on the operations of a company. The other box, which is business performance, is also an aggregate measure of growth in performance measures such as sales turnover, net profit and market share. The arrows indicate the directions of impact whilst the coefficients measure the strength of impact.

The results in Fig. 5 show that internal resource competencies have limited impacts on the competitive leadership models. Teaming imparts positively on flexibility leadership and business performance whilst it has a negative indirect influence on the impact of market turbulence. The only impact of training as a resource capability is negative on flexibility leadership. Nevertheless, intelligent automation impacts directly on quality leadership, market turbulence, and indirectly on business performance. The limited impacts of the internal resource competencies of intelligent automation, training and teaming can be attributed to negative interaction effects amongst them. Teaming and intelligent automation have negative interaction effects on quality leadership. Also, training and teaming have non-compensating effects on flexibility leadership. There is the challenge therefore, of how to harmonise current teaming and training practices with the requirements of intelligent automation. This challenge

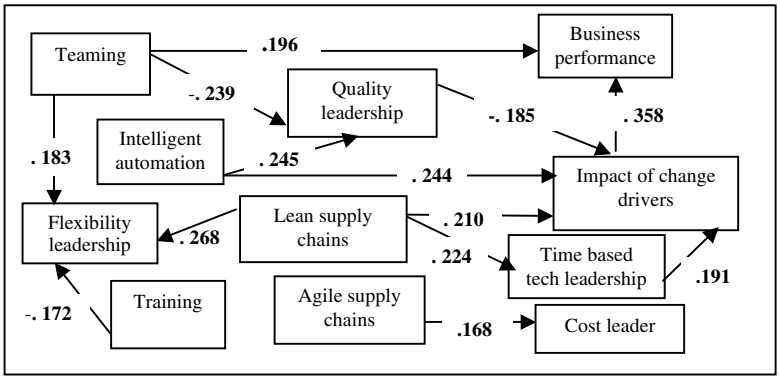


Fig. 5. Path empirical results.

provides further justification for supply chain integration as an additional source of resource competencies.

Fig. 5 shows that the lean supply chain impacts on flexibility leadership, time-based technology leadership, and impact of change drivers. Not only this, the impacts extend indirectly to overall business performance. Much more importantly, the lean supply chain has positive interaction with teaming in relation to flexibility leadership. It also interacted positively with intelligent automation in relation to the impact of change drivers. Furthermore, the agile supply chain impacts on cost leadership, although the impact did not translate to business performance. As more companies embrace and further emphasise the variables loaded that define agile supply chain in Table 3, its range and spread of impact on competitive capabilities will increase. The current low level of adoption of agile supply chain and the limited range of impact as shown in Fig. 5, tally with the findings of Gordon and Sohal (2001). Their results showed that variables, which defined the agile supply chain, had lower adoption and impact on competitiveness, in relation to each of alliances with customers and alliances with suppliers.

In the light of relationships revealed in Fig. 5, it is tenable that the two models of alliance practice as well as intelligent automation remain the most critical resource competencies for companies. There were no negative interaction effects amongst them. This implies that internal and external competence building are both desirable for enhanced competitive performance. Similarly, the lean and agile supply chains had no negative interaction effects. This implies that the two can be integrated. The lean chain only needs to embrace virtual networking, embrace competitor alliances, and harp more on joint design and manufacture rather than commercial outsourcing and distribution.

## 7. Summary and conclusions

This paper discussed the nature of an agile supply chains and explores some of its attributes and capabilities. The attributes include Internet-based collaboration, a significant amount of sales turnover and profit from virtual business, open leverage of capabilities within networks of companies and manufacturing, rather than outsourcing and marketing alliances. Subsequently, the level of adoption of seven core dimensions of alliance practice often mentioned in the literature was studied through a survey by questionnaire. This was done alongside the two core internal resource competencies of process automation and employee empowerment. Companies' attainments of several measures of manufacturing performance were also investigated. In order to enable a focused analysis, the variables were reduced into a few principal components through factor analysis. Thereafter, multiple regression was applied to compute path coefficients. This was in order to reveal the strength of impact amongst the principal components of research variables.

The results show that only a few companies have adopted agile supply chain practices. In contrast, most companies have embraced long-term collaboration with supplier as well as customer, which was conceptualised in this study as lean supply chain practices. The traditional model of alliance practice has limited influence in the study. The lean and agile models of supply chains had no negative interaction effects on competitive and performance measures. We suggest that they can be integrated in order to generate greater synergy in their impacts. Integration would require the lean model to improve on Internet-based data integration, embrace several competitors in lean networks, and emphasise collaborative design and manufacture. Whilst the dominant thinking in the literature is that lean initiatives focus on cost and quality, the lean supply chain impacts flexibility and time-based technology leadership objectives rather than cost and quality. In contrast however, the agile supply chain influenced cost rather than flexibility and time-based technology leadership.

Further evidence in support of the development of collaborative supply chains irrespective of their form, emanates from the negative interaction effects amongst internal resource competencies of intelligent automation, teaming and training. The negative interaction or compensation effects limited their impacts on competitive objectives,

change drivers, and business performance. The attrition between teaming and intelligent automation, as well as between teaming and training compel development of external competencies in the drive for enhanced competitive performance.

The high agreement on supplier/customer collaboration is an indication that the lean pattern of supply chain is predominant amongst UK manufacturers. Nevertheless, the lean supply chain has a higher level of impact on competitive objectives in contrast to the agile supply chain, should not be seen as the evidence that the former is superior to the latter. It will take some time before current investment and research efforts in agile supply chains lead to more appreciable results on competitive outcomes.

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# Supply chains and value webs

*By Eamonn Kelly and Kelly Marchese*

## Overview

OVER the last few decades, supply chain professionals have helped transform the business environment. They have contributed to accelerated globalization by directly connecting actors in emergent and developed economies. They have enabled many major corporations to become nimbler and leaner by focusing on what they themselves do best, while carefully constructing external arrangements for the rest. Supply chain professionals have helped reduce costs, improve efficiency, and substantially enhance operational performance. And they have altered the basis of competition—as one scholar has suggested, increasingly today, "Companies don't compete—supply chains do."[1]

**Ecosystems are dynamic and co-evolving communities of diverse actors who create new value through increasingly productive and sophisticated models of both collaboration and competition.**

**Read more about our view of business ecosystems in the Introduction.**

***Supply chains are increasingly becoming value webs that span and connect whole ecosystems of suppliers and collaborators; properly activated, they can play a critical role in reshaping business strategy and delivering superior results.***

By mastering the management of assets that exist outside the traditional boundaries of the firm, the supply chain profession has also helped forge the dynamic, collaborative, industry-transcending world of ecosystems described throughout this report. As the era of the vertically integrated corporation has waned, new and more fluid alternatives have proliferated. But to date these arrangements have typically replaced ownership with "control."[2] In ecosystems, *influence* will need to be achieved across increasingly complex networks—through relationships, collaboration, and co-creation. Many traditional supply chains are becoming increasingly agile, adaptive, and resilient, and are supporting faster and more flexible responses to the changing needs of customers. Today's supply chains contain growing varieties of players interacting in interdependent and often indirect ways.[3]

In fact, many "supply chains" appear to be evolving into "value webs," which span and connect whole ecosystems of suppliers and collaborators. Properly activated, these value webs can be more effective on multiple dimensions—reducing costs, improving service levels, mitigating risks of disruption, and delivering feedback-fueled learning and innovation. This is likely to accelerate as new technologies generate more data, provide greater transparency, and enable enhanced connectivity with even tiny suppliers and partners. The shift can create new challenges for the supply chain profession—but also extraordinary opportunities to play an even more central strategic role in shaping the future of enterprise.

## What's behind this trend?

A set of powerful developments have worked together to help transform the business environment, changing how supply chains are configured, further heightening their strategic significance for many firms, and creating new leadership imperatives for the years ahead.

First, advancing information and communications technologies drastically reduced the transaction costs of dealing with outside entities, so that in short order, many assets that had made sense to own and activities traditionally performed in-house were now often better sourced from external suppliers. The general loosening of corporate dependence on ownership of key assets contributed to the activation of many new external resources and capabilities—and an explosion of new actors ready and able to contribute.

This technological enablement of inter-firm coordination has coincided with a long-term political movement: trade liberalization by many nations around the world. Together, the two forces enabled the offshoring, global outsourcing, and foreign market entries that helped create the new global economy. The leading firms of mature economies moved rapidly to globalize their operations, many of them with an eye to a future when all the growth of the world's population—the next billion people—would be in emerging economies.[4] Meanwhile, many businesses in less mature economies gained the opportunity to grow and join the global economic mainstream.

Leading firms everywhere soon realized there was a "sweet spot" to be found by effectively marrying globalization to "localization." Nestlé, for example, declares that "food is a local matter," and operates its networks according to a basic principle: "Centralize what you must, but decentralize what you can."[5] The Coca-Cola Company works to strike a similar balance. One commentator describes its strategy as "mingling global and local… utilizing local suppliers and local bottlers, employing local people, and addressing local culture and taste."[6] For many operations managers, such goals call for complex, multifaceted enhancements of activities taking place at multiple locational levels.

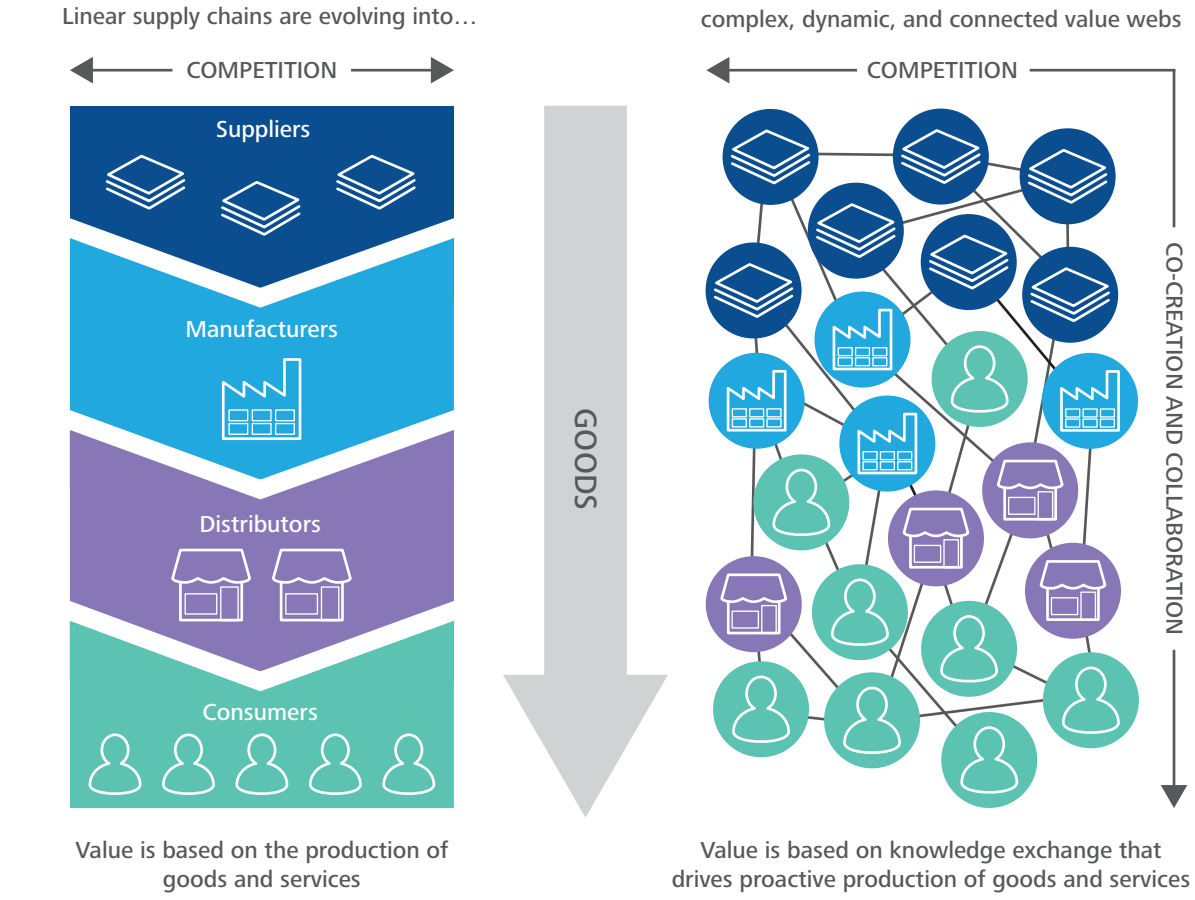
Today, new waves of technology are accelerating these already established shifts. Continuous innovation and global dissemination of new technologies and tools are directly enabling new connectivity, collaboration, and co-creation across multiple businesses. The rise of the Internet of Things—which connects increasingly smart products—is greatly enhancing the creation of and access to data, and producing ever-increasing transparency. Substantial technological changes unfolding today in manufacturing, including 3D printing and new robotics, are set to transform many production processes and may significantly disrupt today's distribution models.

The speed and scale of these changes are creating new opportunities for many supply chain professionals—and also putting increased pressure on them to adapt. Their role is expanding far beyond enhancing performance by getting essentially the same things done, but differently and elsewhere. Their focus is extending beyond continuous improvement of existing operations. Instead, these professionals are being positioned as increasingly strategic leaders discovering fundamentally different ways of creating new value, driving continuous innovation and learning, and sustaining enterprise growth.

## The trend

Having helped transform the operating and performance models of most major enterprises over the last few decades, many supply chains are now playing an even more central strategic role. They are helping lead their businesses into the dynamic, hyper-connected, and collaborative world of ecosystems. In doing so, many are now creating and leading more complex systems perhaps better characterized as *value webs*. The word "chain" has a powerful metaphoric logic that captures well

**Figure 1: Supply chains evolve into value webs**




Source: Deloitte analysis.

Graphic: Deloitte University Press | DUPress.com

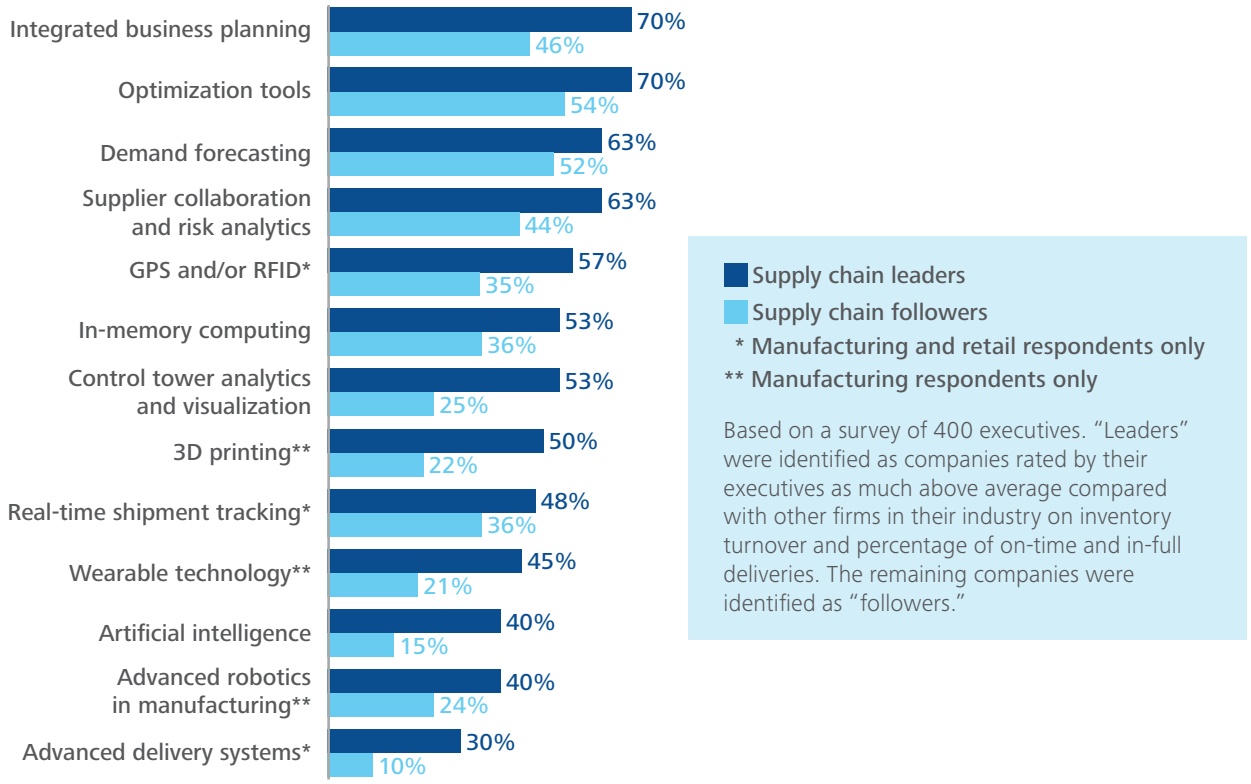
a series of discrete links by which goods are bought, have value added to them, and are sold to the next value-adder—up until an end buyer consumes them. This remains of critical importance. However, increasingly, value is being created not only within firms, but in the rich interactions between them. Linear sequences of procurement are increasingly supplemented by more iterative and innovation-oriented collaborations.

To be sure, in a world of value webs, the essential goals of traditional supply chain management do not go away. But they are often augmented by new imperatives—like learning, agility, and renewal. Collaboration is an addition to, not a replacement of, traditionally more closed, contractual arrangements. Clear commitments to meet rigorously monitored standards and service-level agreements will remain critical. But to claim the benefits of an increasingly fluid and interdependent value web, leaders should surround their contracts with trust; build on transactions and one-time deals to cultivate long-term relationships and mutual learning; combine the power of control with the potential of co-creation; make sure that defined, fixed standards do not create barriers to valuable innovation and co-evolution; and not only leverage leading practices, but also aim to create "next practices."

Some leading companies have explicitly adopted hybrid approaches to embrace such dualities. In one frequently quoted example, Chinese motorcycle manufacturer Dachangjiang deliberately pursued both value web and supply chain arrangements by breaking its design into multiple modules, awarding several suppliers responsibility and substantial latitude for each, and actively encouraging collaboration between them to promote

**Figure 2. Supply chain leaders vs. followers: Use of technical capabilities and new technologies**

Question:
For each of the supply chain capabilities below, please indicate whether it is currently in use at your company.




Source: 2015 Deloitte Supply Chain Leadership Survey.

Graphic: Deloitte University Press | DUPress.com

innovation, while also imposing aggressive performance targets regarding pricing, quality, and timing of production.[7]

Just as most businesses have already learned how to activate and deploy assets they don't *own*, they are now becoming increasingly adept at doing so with assets they don't *control*, either. The 2015 Deloitte Supply Chain Leadership Survey confirms the value of gaining skills that promote *influence*. It finds that "leaders" distinguish themselves from "followers" in several areas. They are much more aggressive at using technical capabilities and powerful new technologies, like supplier collaboration and risk analytics, which can be critical in complex, dispersed networks (see figure 2). Leaders also tend to support diversity and inclusion and manage global and virtual teams significantly better than their peers (see figure 3). They are usually more adept at working with others: 80 percent of surveyed leaders rate their ability to negotiate and collaborate with partners highly, compared to less than half of followers.[8] These greater abilities and attitudes reflect in the bottom line: 73 percent of surveyed leaders reported financial performance significantly above their industry average, in contrast to less than 15 percent of followers.[9]

## Implications

Value webs are characterized by complex, connected, and interdependent relationships, where knowledge flows, learning, and collaboration are almost as important as more familiar product flows, controls, and coordination. To lead and secure advantage in this increasingly organic and networked environment, leaders will likely have to focus on three core developmental priorities.

## Engagement with more, often smaller, players

The emergence of value webs is enabling the conditions for small, highly focused suppliers to proliferate in global supply chains. Important and complex capabilities increasingly involve deep specialization that often flourishes in smaller, tightly niched firms. Barriers to entry are generally declining. Young, nimble, and entrepreneurial firms frequently have innovation advantages. Many of the best and brightest of the Millennial generation are showing themselves to value autonomy and independence, gravitating toward smaller businesses and more flexible employment arrangements. No surprise, then, that according to startup tracker Crunchbase, the average startup in a supply chain today is smaller by almost a third than those that participated in the decade 2000–2010.[10] Indeed, some suppliers are so tiny that their connections with large firms can appear more like talent sourcing than procurement.

For many corporations, these connections can bring many advantages, but also invite greater complexity. For the most part, supply chain functions of large businesses weren't set up to deal with a world of thousands of partners. Now they must adjust. So, for example, we see firms establishing or relying on new "platforms" to facilitate greater levels of connectivity, collaboration, and co-creation with other businesses. (As a familiar example of a platform, picture Amazon Services, which provides its customers with an e-commerce infrastructure for order-taking and fulfillment, allowing them to focus on their offerings.)

In China, Alibaba allows small businesses to build their own supply chains, acting as a facilitator of relationships between firms that otherwise would not or could not cooperate. In the United States, IBM launched Supplier Connection, a platform-based network that helps large firms manage their connections with smaller businesses.[11] Across many industries we see the rise of "value networks" that use cloud computing and social network platforms to enable many-to-many supplier connections. For example, Real Time Value Network has over 30,000 trading partners, allowing supply chain managers to more easily find the small players that can bring ideas and flexibility to their arrangements.[12]

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New software tools can also provide broader perspective and deeper insight into expanding value webs. Amgen, for example, which offers treatment for serious illnesses such as cancer and kidney disease, has seen its network expand substantially. "Originally most of our suppliers were closer to home," observes executive director of supply chain Patricia Turney. "More and more, we're finding that we are sourcing materials from really remote locations." So Turney has put tools in place to map the whole ecosystem, and a process to create a "war room" when disruptions threaten supply lines. A few months into implementation, she reports, "We already have some new insights into our tier 2 suppliers and where they're located that we didn't have before."[13]

## Reducing risk, raising resilience, deploying data

Patricia Turney's comments also serve to highlight the ways in which risk can be reduced in increasingly complex value webs. It seems to be working well for Amgen: As

Turney also observed, "We have a phrase . . . 'every patient, every time.' We've never shorted the market, never had a patient go without life-saving medicine. . . . [We have] 24/7 oversight."[14]

Since their inception, supply chains have generally been tightly associated with risk management and business continuity planning. Globally extended production and distribution arrangements are often subject to risk factors beyond anyone's control—from geo-political events to natural disasters. Dependency on the capabilities and integrity of others outside your organization, even if tightly contractually controlled, can create certain vulnerabilities. And, if it was ever possible to lay the blame for product deficiencies on suppliers, that is not likely to remain a credible excuse. For example, in 2013, millions of food products advertised as containing beef were withdrawn from shelves in Europe after they were found to contain horsemeat. The scandal highlighted deficiencies in the traceability of the food supply network, and dealt a blow to the finances and reputations of affected brands, retailers, and restaurants.[15] It is simply expected today that firms have clear visibility into the activities—and the integrity—of their vendors.

Increasingly complex, highly distributed networks can generate some new risks, but there is a paradox here. Many also have high levels of resilience and can be, in writer Nassim Taleb's phrase, "anti-fragile"—displaying self-organizing, flexible qualities surprisingly capable of reconfiguring to overcome shocks and disruptions.[16] These qualities are usually stronger when underpinned by strong, enduring relationships. Consider the experience of Renesas, a Japanese producer of microcontrollers, when the 2011 earthquake severely damaged its main production facility. After a swarm of workers from its suppliers and customers voluntarily showed up in sub-zero temperatures and got the plant up and running again, their value web was in many respects stronger for the experience.[17]

Designing resilience into supply chains and value webs will likely rise in importance, and be supported by new capabilities. For example, 3D printing technologies already enable some supply chains to reduce dependency on far-flung production arrangements. When British fighter jets flew for the first time with components made using 3D printing technology in early 2014, Mike Murray, head of airframe integration at BAE Systems, described a new-found freedom afforded by the technology. "You are suddenly not fixed in terms of where you have to manufacture these things," said Murray. "You can manufacture the products at whatever base you want, providing you can get a machine there."[18] Data is also likely to play an increasingly critical role, especially as the Internet of Things enables vast amounts to be collected and analyzed to create greater transparency and discover opportunities, efficiencies, and problems. However, in Deloitte's 2015 supply chain survey, only 46 percent of respondents rated their analytics competencies as currently very good, while 67 percent expected them to become more important in the next five years.

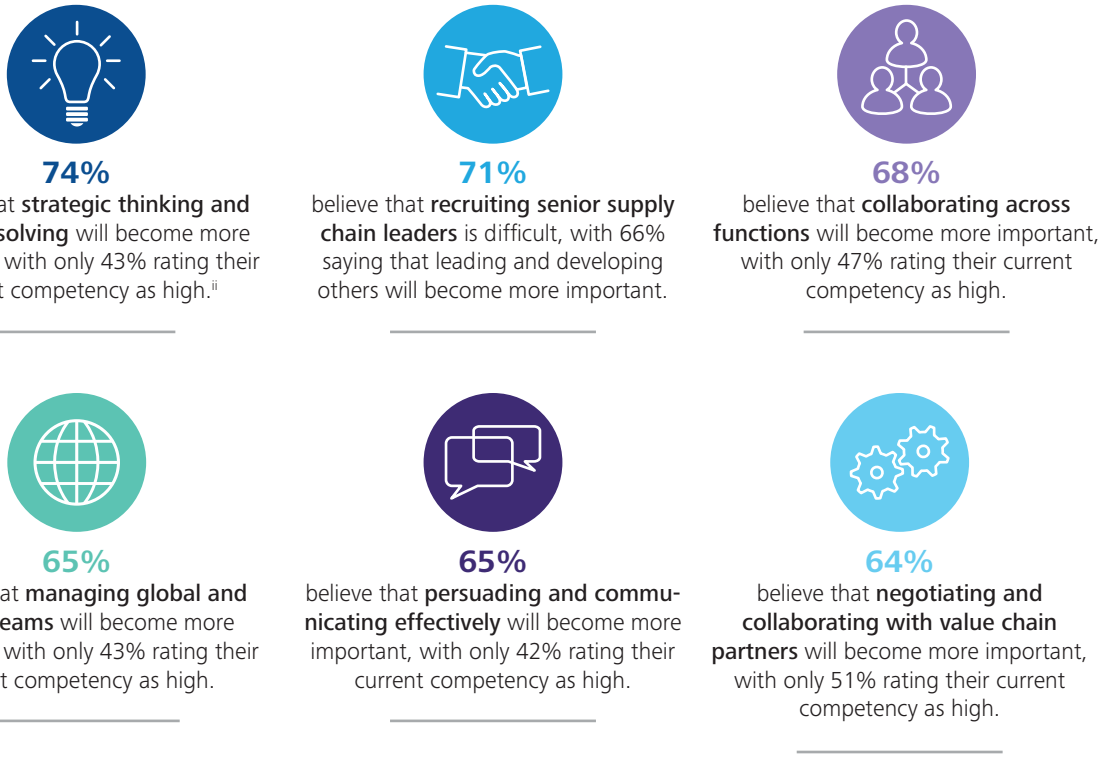
## Attracting and developing next-generation talent

Talent considerations are also on the rise. Value webs can be an increasingly important source of hard-to-access talent, especially as new and more open models proliferate. Development of the talent of partners is also rising in importance for many firms such as Nike, which are placing increased emphasis on providing shared training programs for suppliers' employees.[19]

The supply chain profession itself is also clearly evolving, and will require important new skills and capabilities: design of resilient networks; management of reciprocity-based relationships; adoption of technologies such as 3D printing; and analytics. No wonder the US Bureau of Labor Statistics has calculated that the number of logistics-related

**Figure 3. Skills requiring future investment as supply chains evolve**

Based on Deloitte's 2015 Supply Chain Leadership Survey of supply chain executives




[i] Respondents were asked if these competencies will become more or less important to their company's supply chain organization over the next five years.
[ii] Respondents were asked to rate their companies on these competencies; "high" includes ratings of "very good" or "excellent."

Source: 2015 Deloitte Supply Chain Leadership Survey.

Graphic: Deloitte University Press | DUPress.com

jobs will increase by 22 percent between 2012 and 2022.[20]

Recruiting for these positions may need to be creative. In Deloitte's 2015 supply chain survey, 70 percent of top-performing supply chain functions expect to use non-traditional recruitment methods in the coming years. In their training efforts, too, they will benefit from preparing veteran managers for deeper collaboration with other business functions and leadership and more central participation in the evolution of strategy.

The most effective supply chain leadership is already at a premium. In the Deloitte 2015 supply chain survey, 71 percent of executives claimed that it was difficult to recruit senior supply chain leaders,[21] and only 43 percent felt that their supply chain strategic thinking and problem solving was very good. With 74 percent surveyed also saying that such strategic thinking and problem solving will increase in importance, it seems there is no time to lose (see figure 3).

## What's next?

As the business landscape increasingly configures around dynamic, highly interactive ecosystems, supply chains will likely evolve substantially. Many larger firms will invest in their own supplier ecosystems, recognizing that feeding and nurturing them will help generate demand, innovation, and support in a variety of ways that cannot always be predicted. New mindsets are likely to take hold as the profession embraces more networked

and "web-like" arrangements. New leadership capabilities will be increasingly valued, as relationships based on reciprocity, mutual trust, and shared interests become increasingly vital and effective. Listen, for example to Kurt James, a supply chain leader at McDonald's supply chain:

> When hiring, we look for people with character traits uniquely suited to our supply chain—namely, an innate sense of fairness and an ability to consistently empathize with the challenges suppliers face in meeting our often aggressive deadlines, standards, and evolving needs.[22]

New mindsets are likely to take hold as the profession embraces more networked and "web-like" arrangements.

Substantial experimentation will likely occur, driven particularly by the increasing prevalence and predictive qualities of data. In the realm of social data, for example, "Nowcasting" is a growing field of social listening-enabled forecasting. A recent study analyzed Twitter posts to estimate influenza infection in New York City and proved far more accurate than traditional seasonal flu trend estimates.[23] When real-time data sources from across massive webs are brought together, new insights can emerge that enable, for example, far more accurate and localized demand forecasting. New value webs will form as 3D printing transforms multiple aspects of today's global supply chains, enabling operations to atomize in ways few can even imagine today. Amazon, for example, filed for patents in February 2015 for installing printers in delivery trucks—taking the concept of "real-time" to a new level.[24]

Many supply chain professionals will become more closely connected to colleagues who are creating "on-demand" talent models, or designing new, more open innovation systems. Consider major corporations such as Ford, AutoDesk, Intel, and Fujitsu that have forged partnerships with TechShop, a growing chain of "makerspaces," enabling them to connect with the fast-growing Maker Movement.[25]

All this will compel the supply chain profession that helped shape today's economy to adapt in turn to its new demands. As ecosystems become increasingly central to business strategy, the core value of the profession will lie less and less in getting the same things done ever more efficiently, and more and more in the strategic pursuit of creating new value, achieving breakthrough performance, sustaining growth, and—once again—changing the world.

# My take

*By Frank Crespo*

Frank Crespo is vice president and chief procurement officer for Caterpillar Inc., where he leads the company's procurement and logistics functions for products, parts, and services delivered across the $55 billion business.

As supply networks have gone global, complex organizations like Caterpillar find themselves coordinating the activities of thousands of suppliers, globally scattered, each with its own operating subtleties. By volume and variety, we have one of the largest, most complex supply networks in the world, with two-thirds of our suppliers tapped into complex chains of their own. That's why we made the conscious effort to stop referring to our supply network as a supply "chain." More than a name change, for us it was about getting our teams and suppliers to realize that everything has interdependencies. To be world class, especially with the ever-increasing clock speed of business, there must be synchronization.

The complexity and lack of linearity in a global supply network makes it essential to understand the signals and flows between network nodes. The flow of information is just as important and potentially disruptive as the physical flow of materials. But seeing the data is just the first step.

We must also understand what the facts mean and be able to quickly make the right business decisions based on those facts. Failure to do so can lead to actions based on assumptions, which then creates a firefighting mentality versus a proactive, preventive environment.

What Caterpillar is really driving toward is a lean, responsive, and resilient global supply network. While the work of getting there is never fully finished, our suppliers are not alone on that journey. Caterpillar places a great emphasis on collaboration across the network and we can point to the 2011 earthquake and tsunami in Japan for evidence of our shared progress. Many organizations took more than four months to recover from the disruptions. Caterpillar's supply network took fewer than 45 days.

To make it all work seamlessly, you must have complete buy-in. We spend a great deal of time internally reinforcing our vision at Caterpillar. We also spent a good portion of last year meeting with hundreds of suppliers around the world communicating that vision. One of the first things I told my team the day I arrived at Caterpillar is that it's all about visibility. No matter how good your talent is, without all stakeholders seeing and hearing the same things, you're not going to make the best decisions—whether about resources, prioritizations, or trade-offs.

The globalization of business brings a level of complexity that leaders today have likely never experienced. The way we tackle it, though, is simple. Start with the facts. Know what's going on in your facilities and what's flowing between them. Organize the supply network well, clarify the definitions of success, facilitate the movement of information, and a healthy supply network will follow. We have to know how to lead and coordinate a vast and decentralized web of interconnected suppliers, or risk being hostage to it.

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# Dynamic supply chain capabilities: how market sensing, supply chain agility and adaptability affect supply chain ambidexterity

Article (Accepted Version)

# Dynamic supply chain capabilities:
# How market sensing, supply chain agility and adaptability affect supply chain ambidexterity


**Abstract:**

**Purpose:** This paper positions market sensing, supply chain agility and supply chain adaptability as a coherent cluster of dynamic supply chain capabilities. The purpose of the paper is to understand how dynamic supply chain capabilities interrelate and their effect on supply chain ambidexterity.

**Design/methodology/approach:** Based on a survey of Pakistani manufacturing firms, a theoretically-derived model was tested in a structural equation model.

**Findings:** The results of the study show that a market-sensing capability is an antecedent of supply chain agility and supply chain adaptability. Furthermore, supply chain agility, directly, and supply chain adaptability, indirectly, affect supply chain ambidexterity. Supply chain agility therefore mediates the relationship between supply chain adaptability and supply chain ambidexterity.

**Originality/value**: The contribution of this study lies in: (1) identifying dynamic capability clusters relevant for achieving supply chain ambidexterity;(2) evaluating performance implications of dynamic capabilities in the supply chain, specifically supply chain agility and adaptability; and (3) proposing a unique measurement of supply chain ambidexterity in the light supply chain theory, and empirically evaluating the relationship between dynamic capabilities and supply chain ambidexterity.



**Keywords:** Market sensing, supply chain agility, supply chain adaptability, supply chain ambidexterity, dynamic capabilities view, survey

# 1. INTRODUCTION

Today's companies compete in an increasingly volatile and unpredictable marketplace (Christopher and Holweg, 2011, Dubey et al., 2018). To remain competitive, companies need to explore for new market opportunities and exploit existing efficiencies within their operations (March, 1991, Wu et al., 2017). Exploration includes the search for new possibilities, the discovery of innovative ideas, and the flexibility to respond to new opportunities as they arise (March, 1991). Exploitation refers to selecting, refining and implementing standardized procedures to achieve efficiencies in a firm's operations (ibid).

For a long time, scholars have argued that operations managers are faced with a trade-off between flexibility and efficiency – where prioritizing one is often to the detriment of the other (De Meyer et al., 1989, Kannan, 1998, Hayes and Wheelwright, 1984, Skinner, 1985, Skinner, 1969, Hill, 1993). The argument goes that companies should pursue either a low cost competitive strategy supported by efficient operational processes, or a strategy of differentiation supported by more flexible processes (Hill, 1993, Markides, 2006, Porter, 1996, 1980). According to this group of scholars, attempting to reconcile efficiency and flexibility results in the operation becoming stuck in-between, leading to high switching costs (Porter, 1980, 1996, Markides, 2006).

Yet, another group of scholars argues that organisations can be simultaneously flexible and efficient by developing an ambidexterity capability (Duncan, 1976, Adler et al., 1999, Gibson and Birkinshaw, 2004, Tushman and O'Reilly III, 1996). Ambidextrous organisations are ones that are aligned and efficient in the management of today's business demands, while also adaptive enough to changes in the environment so they will be around tomorrow (Gibson and Birkinshaw, 2004 p. 209). For example, Adler et al. (1999) found that by partitioning its operation, a Toyota subsidiary could exploit the cost advantages associated with repetitive tasks whilst simultaneously exploring for new flexible manufacturing systems during non-routine

work. Other OM scholars have found that companies with operational ambidexterity capabilities are able to explore new, and exploit existing, processes simultaneously – leading to enhanced operational performance (Kortmann et al., 2014, Patel et al., 2012, Tamayo-Torres et al., 2017).

The notion of operational ambidexterity has since been extended beyond the boundaries of the firm – to the supply chain (Blome et al., 2013a; Im and Rai, 2008; Kristal et al., 2010; Lee and Rha, 2016; Rojo et al., 2016). Kristal et al. (2010) define supply chain ambidexterity as a firm's strategic choice to simultaneously pursue both supply chain exploitation (efficiency) and exploration (flexibility) practices (Kristal et al., 2010 p. 415). The notion of supply chain ambidexterity runs counter to those scholars that suggest companies should select the right supply chain for their product; with primarily functional products using efficient supply chains and primarily innovative products relying on flexible supply chains (i.e. Fisher, 1997). Instead, supply chain ambidexterity means managers are not faced with an either/or decision, but can simultaneously have a flexible AND efficient supply chain for a particular product (Lee and Rha, 2016; Rojo et al., 2016).

To achieve such an ambitious goal, Lee (2004) argues that successful companies require supply chains that can rapidly respond to short-term changes in demand (agility) and adjust to long-term market changes by restructuring the supply chain (adaptability). Supply chain agility (SAG) is defined as the firm's ability to respond to market changes such as variation in demand patterns, in terms of quality, quantity, and variety, as well as to supply patterns, in terms of shortages and disruptions (Blome et al., 2013b). Supply chain adaptability is defined as the ability of the firm to make supply chain design changes– that are far more radical and long-term than changes pursued under the notion of supply chain agility – in the wake of sensed opportunities (Eckstein et al., 2015, Ketchen and Hult, 2007).

Because supply chain agility and adaptability are developed and renewed in response to changes in customer demand, these two constructs have been positioned as dynamic capabilities (see Eckstein et al., 2015; Whitten et al., 2012). Dynamic capabilities are higher-order capabilities that refer to a firm's ability to *sense* opportunities and threats in the marketplace, to *seize* opportunities as they arise and to *transform* assets and organisational structures as the organisation grows and market requirements change (Teece, 2007). Supply chain agility is positioned as a *seizing* dynamic capability because it allows the firm to identify opportunities and threats in the marketplace and to provide an agile supply chain response (Eckstein et al., 2015). Supply chain adaptability is positioned as a *transforming* dynamic capability, because the resource base and structure of the supply chain is transformed over the longer term in response to changes in the marketplace (Eckstein et al., 2015). As agility and adaptability are integrated and coordinated with supply chain partners, a complex adaptive system forms which is able to sense changes in the marketplace, seize new opportunities and transform the supply chain to satisfy customer demand (Whitten et al., 2012).

Importantly, we argue a firm's supply chain would have difficulty seizing opportunities in the marketplace and reconfiguring its operations in response, without the capability to sense these opportunities in the first place. Market sensing reflects the firm's routines related to actively learning about customers, competitors, supply chain members and the business environment that allows for understanding of market conditions as well as for prediction purposes (Morgan, 2012). Recent studies have investigated the direct and indirect effects of supply chain agility and adaptability on different measures of firm performance (Dubey et al., 2018, Eckstein et al., 2015). But despite these laudable efforts, the role of market-sensing capabilities has been largely ignored (Teece et al., 2016). To fill this gap in our understanding, this paper attempts to answer the following research question: *how do market sensing, supply chain agility and supply chain adaptability affect supply chain ambidexterity.*

We answer our research question by examining survey data collected from 277 manufacturing firms in Pakistan. Empirical research findings on companies in Pakistan are limited as a result of the difficulty of data collection; however, due to the uncertainty of the economic system, dynamic supply chain capabilities play an important role in firm survival. We therefore believe that Pakistan, like other dynamic markets, is an excellent context within which to investigate dynamic supply chain capabilities in comparison to more mature markets where firms adjust to significant changes less often. Data is analysed by means of structural equation modelling.

This study contributes to theory and practice in the area of dynamic capabilities in supply chains. According to Teece (2007), dynamic capabilities exist in the form of capability clusters consisting of sensing, seizing, and transforming/reconfiguration capabilities. Like Teece (2007), we position market sensing, supply chain agility and adaptability as a coherent cluster of dynamic supply chain capabilities that should be considered in conjunction rather than is isolation. We empirically show that supply chain agility has a significant short-term effect on supply chain ambidexterity, that supply chain adaptability has a significant long-term effect on supply chain ambidexterity and that market sensing acts a key antecedent for both variables. Combined, this dynamic supply chain capability cluster allows organisations to modify their products, services and supply chain structures according to market requirements over both the short and long-term. In making this argument, we respond to the call by supply chain theorists to identify dynamic capabilities relevant to the supply chain environment (Beske et al., 2014). Finally, we provide a new measurement of supply chain ambidexterity developed based on extant scales to better explain short and long-term performance versus traditional performance measures.

The remainder of the paper is organised as follows. Section 2 discusses the studies theoretical foundations, reviews the relevant literature and develops a hypothetical model of

the relationship between market sensing, supply chain agility, adaptability and ambidexterity. Section 3 provides a justification of the research design. Section 4 presents the study's findings and section 5 discusses the results. The studies implications for theory and management, along with its limitations, are discussed in Section 6.

## 2. LITERATURE REVIEW AND HYPOTHETICAL MODEL

### *2.1. Dynamic Supply Chain Capabilities*

We ground this study in the dynamic capabilities view of the firm. Dynamic capabilities are the organisation's ability 'to sense and then seize new opportunities, and to reconfigure and protect knowledge assets, competencies, and complementary assets with the aim of achieving a sustained competitive advantage'(Augier and Teece, 2009 , p. 412). Dynamic capabilities depict the firm's ability to modify its distinctive and co-specialised resources in order to respond to changing environmental conditions (Augier and Teece, 2009). They manifest in firms through the transformation of business processes, resource allocations and reallocations, and operations (Teece, 2007). Dynamic capabilities can lead to differences in the performance of firms, even if firms are similar in terms of resources and capability endowments (Easterby-Smith et al., 2009).Yet at their core, these capabilities are similar in the sense that they enable knowledge creation and dissemination, and continuous modification of organisational processes in response to environmental changes (Easterby-Smith et al., 2009).

The application of the dynamic capabilities view to strategic decisions in supply chain management is becoming increasingly common (Witcher et al., 2008, Allred et al., 2011, Fawcett et al., 2011, Blome et al., 2013b, Defee and Fugate, 2010). Dynamic capabilities in the supply chain emerge when firms engage their employees in understanding customer requirements and translate these requirements so that they are effectively communicated

throughout the supply chain (Handfield et al., 2015). Indeed, scholars have begun challenging the conceptualization that dynamic capabilities are bounded by the firm, and have extended our understanding beyond firm boundaries to acknowledge the presence of 'dynamic supply chain capabilities' (Dubey et al., 2018, Eckstein et al., 2015, Swafford et al., 2006).

For example, Swafford et al. (2006) argue that supply chain agility is a capability that allows the supply chain to *seize* opportunities once they are sensed. Supply chain agility is positioned by other authors as a fundamental capability needed to endure and flourish in volatile environments (Gligor and Holcomb, 2014, Braunscheidel and Suresh, 2009), as it allows for a flexible supply chain response (Gligor and Holcomb, 2012). Building on this argument, Blome et al. (2013b) put forward the idea that supply chain agility is a dynamic capability able to positively influence the operational performance of the firm. Supply chain agility can also be regarded as an extension of agile manufacturing which focuses mainly the firm (Yusuf et al., 1999, Brown and Bessant, 2003). Furthermore, supply chain agility is typically considered to extend the narrower concept of supply chain flexibility (Stevenson and Spring, 2007, Gligor and Holcomb, 2012).

Supply chain adaptability refers to a firm's ability to *reconfigure and transform* supply chain design according to expected market changes (Lee, 2004). Ketchen and Hult (2007) explain that supply chain adaptability is the willingness to reshape the supply chain when necessary, without ties to legacy issues or the way the chain has been operated previously. Stevenson and Spring (2007) suggest that supply chain adaptability is the property of a supply chain which allows the members to cope with dynamics associated with the supply chain. Eckstein et al. (2015) draw together this line of reasoning and suggest that supply chain agility and adaptability can be considered dynamic capabilities that result from the firm's ability to reconfigure firm-level and supply chain-level resources.

Interestingly, many of these studies examine the effects of supply chain agility and adaptability, either individually or combined, on firm performance (Blome et al., 2013b, Dubey et al., 2018, Eckstein et al., 2015, Lee, 2004, Lee and Rha, 2016), however the role of market sensing is largely ignored. This is a curious omission as it stands to reason that supply chain managers would need the ability to sense opportunities and threats in the marketplace in the first instance, in order to provide a flexible response (supply chain agility) and to restructure the supply chain over the longer-term (supply chain adaptability). Indeed, Day (1992; 1994) argues that firms involved in developing a better understanding of the market situation (market sensing) have a better chance of understanding and acting on uncertainties and market trends (Day, 1992, Day, 1994). Bharadwaj and Dong (2014) reaffirm that systematically undertaking market sensing activities to remain synchronized with market changes can facilitate the provision of superior value propositions.

It thus stands to reason that, like the dynamic capabilities of the firm (Teece, 2007), dynamic supply chain capabilities including market sensing, supply chain agility and supply chain adaptability exist in cluster. It follows that dynamic supply chain capabilities are interrelated and need to exist in combination to prove beneficial to the firm. We now turn our attention to understanding how market sensing, supply chain agility and adaptability interrelate and the resulting effects on supply chain ambidexterity.

### *2.2. Supply Chain Ambidexterity*

To become ambidextrous, firms need to harmonise the contradictory demands imposed by the environment (Raisch and Birkinshaw, 2008). These demands include balancing efficiency in exploiting current resource positions versus exploring and responding to future market conditions through search and experimentation activities (He and Wong, 2004). This simultaneous pursuit of seemingly conflicting goals has been termed organisational ambidexterity (Weber and Tarba, 2014).

Operations management scholars have acknowledge that a firm's internal operation can be both flexible and efficient if the right structures are in place (Adler et al., 1999, Kortmann et al., 2014, Patel et al., 2012, Tamayo-Torres et al., 2017). For example, Patel et al. (2012) found that firms with greater operational ambidexterity capabilities are able to respond to demand and competitive uncertainty by pursuing efficient and flexible manufacturing strategies. Tamayo-Torres et al. (2017) found that ambidexterity acts as an enabler across quality, speed, flexibility and cost dimensions, therefore driving manufacturing performance.

The concept of ambidexterity has since been applied within a supply chain context (Blome et al., 2013a; Im and Rai, 2008; Kristal et al., 2010; Lee and Rha, 2016; Rojo et al., 2016). For example, Kristal et al. (2010) explains that supply chains encompass a variety of sub-systems which can simultaneously pursue either efficiency or responsiveness objectives. Im and Rai (2008) found that knowledge sharing leads to relationship performance gains and that such sharing is enabled by the ambidextrous management of buyer-supplier relationships. Rojo et al. (2016) identify that building a supply chain ambidexterity capability can help firms to achieve an optimal level of supply chain flexibility. Likewise, Lee and Rha (2016) find that supply chain ambidexterity is important as firms mitigate the negative impact of supply chain disruptions, thereby enhancing business performance. To build an ambidextrous supply chain, Blome et al. (2013a) suggest that buyers can gain synergistic advantages by pursing both contractual supplier relationships to achieve cost efficiencies, and relational collaborations to realize flexibility benefits.

Unfortunately however, the majority of these studies examine the relationship between supply chain ambidexterity and firm performance without acknowledging the antecedents of supply chain ambidexterity.

### *2.3. The relationship between market sensing, supply chain agility and adaptability*

We suggest that supply chain ambidexterity requires a firm's supply chain to be simultaneously agile, so it can quickly respond to short term market changes, and adaptable so the resource base and structure of the supply chain can be reconfigured to achieve longer term efficiency gains. We stress there would be no need for an agile or adaptive response if, in the first instance, supply chain managers are unable to sense opportunities and threats in the marketplace.

Based on this line of reasoning, we hypothesise that market sensing acts as an antecedent of supply chain agility and adaptability. Support for this relationship can be found in the dynamic capabilities view, which suggests that the ability to sense market opportunities accurately is a pre-requisite of the development and deployment of other dynamic capabilities (Teece, 2007). Firms with well-developed market-sensing capabilities are more likely to be agile because they have a better understanding of supply chain partner activities allowing for proactive response to market uncertainty (Tse et al., 2016). Indeed, market sensing allows firms to become well prepared and to develop structures, technologies and policies to respond to market changes in an efficient manner (Ngai et al., 2011).

In fact, Eckstein et al. (2015) argues that the ability to sense marketplace changes is an important dimension of supply chain agility. Supply chain agility necessitates that firms respond promptly and adequately to unexpected changes in the market situation (Tippins and Sohi, 2003). This is not possible unless the firm has a clear understanding of the future implications of market opportunities (Teece et al., 2016). Faster and more accurate responses to business opportunities (i.e. supply chain agility) that thwarts competition and retains customers, is the outcome of the ability to better sense and disseminate market information (Day, 1992). Drawing together this line of reasoning, we hypothesize that:

*H1: Market sensing has a positive effect on supply chain agility.*

We go on to suggest that a firm's ability to understand and adjust quickly to marketplace changes depends on its adaptive capabilities (Day, 2014). Market sensing positively affects supply chain adaptability because understanding the magnitude of change or variability in the business environment is the first step towards building flexibility and efficiency into supply chain design (Christopher and Holweg, 2011). This argument is supported by Schoenherr and Swink (2015) who suggest that supply chain adaptability reduces the constraints on the firm's response to changing product or service requirements, by spotting new resources (e.g. raw materials) and problem solving (e.g. product commercialisation and launching).

An important contribution made by Lee (2004) highlights how supply chain adaptability transforms supply chain design in response to the 'structural shift' in the market. However, in order to achieve this transformation, Lee argues that this structural shift has to be perceived *ahead of time* so that long-term supply chain design decisions can be adjusted (Lee, 2004). This is achieved by sensing changes in the market through activities such as capturing market data, separating noise, and identifying key patterns. Based on this information, the firm decides on facility relocation, supply source changes, and relevant outsource manufacturing (Lee, 2004). It can thus be argued that a supply chain manager's ability to scan the marketplace, interpret and respond to the signals of change acts as a key trigger of supply chain adaptability (Reeves and Deimler, 2011).We therefore hypothesize the following:

*H2: Market sensing has a positive effect on supply chain adaptability.*

### *2.4. The relationship between supply chain agility, adaptability and ambidexterity*

We have argued that supply chain agility is the firm's ability to respond quickly to market changes and disruptions, both internally as well as with the support of its suppliers and customers (Braunscheidel and Suresh, 2009). By possessing a supply chain agility capability, firms are able to modify their routines according to changing market conditions, and seize

market opportunities in a timely manner (Swafford et al., 2006) without modifying the inherent structure of a supply chain's design (Eckstein et al., 2015). Becoming agile requires the ability to cater to sometimes conflicting requirements, such as innovation versus efficiency and meeting global versus local demand, etc. (Lewis et al., 2014). Supply chain agility improves the firm's responsiveness by integrating sensitivity to market changes, with the capability of using resources in response to these changes in a flexible and timely manner (Li et al., 2008).

In a somewhat counter-intuitive way, supply chain agility also makes a firm more cost efficient. Although both are somewhat conflicting objectives, such contradictions, as suggested by Adler et al. (1999), are embraced in the knowledge age. For example, Yang (2014) notes that in order to match supply with demand, firms make investments in the ability to customise products, make adjustments in production volumes, and produce a wide range of products. The collaboration between supply chain partners that results from the pursuit of these goals allows transaction costs and total resource inputs to decrease, leading to the reduction of supply chain costs. Supply chain agility also drives down costs through inventory reduction and effective integration with suppliers, while increasing responsiveness through rapid adaptation to demand (Mason et al., 2002). Therefore, it can be argued that supply chain agility provides the agile and efficiency gains of an ambidextrous supply chain. Thus, we propose:

*H3: Supply chain agility has a positive effect on supply chain ambidexterity.*

Importantly however, supply chain agility cannot be thought to positively affect the ambidexterity of a supply chain in isolation. In contrast to supply chain agility, which centres on short-term responses, supply chain adaptability requires longer-term changes to the structure and resource base of a firm's supply chain (Lee, 2004 , p. 4). Supply chain adaptability helps firms cope with longer-term challenges such as changes in product range and mix, markets served, service levels, and profit margins (McCullen et al., 2006).

In this study, we hypothesise that supply chain adaptability has a longer-term, positive impact on supply chain ambidexterity. Moreover, we suggest that supply chain adaptability affects both dimensions of supply chain ambidexterity positively. Firstly, supply chain adaptability influences efficiency because the flexibility built into the supply chain (by outsourcing, using flexible labour arrangements, etc.) requires that fixed costs be changed into variable costs, which over a period of time can reduce total supply chain costs (Christopher and Holweg, 2011). Furthermore, designing product ranges with higher levels of component commonality also reduces inventory carrying costs (Lee, 2004).

Secondly, supply chain adaptability positively influences responsiveness, as developing alternative supply bases through facility relocation helps to maintain quality levels and to guarantee steady service in times of changing markets and economies (Eckstein et al., 2015). Diversification in sourcing also helps to improve service levels and delivery performance (Christopher and Holweg, 2011). Similarly, innovativeness supports reduction in development lead times, design cycles and flexible design capabilities (Eckstein et al., 2015).

Like with supply chain agility, supply chain adaptability positively influences the efficiency and flexibility of the supply chain; it is just that the former is oriented towards short-term response, while the latter is focused on longer-term restructuring. Indeed, this line of reasoning supports our argument that having an ambidextrous supply chain means managers are not faced with an either/or decision, but can have a flexible and efficient supply chain for the same product (Lee and Rha, 2016, Rojo et al., 2016). We therefore hypothesize the following:

*H4: Supply chain adaptability has a positive effect on supply chain ambidexterity.*

### *2.5. Mediating Role of Supply Chain Agility*

Dynamic capabilities theory suggests that capabilities do not remain infinitely competitive (Protogerou et al., 2012). Over time, the processes underlying dynamic capabilities become imitable and require transformation (Teece, 2014). It follows that, in order to sustain competitive advantage in the long run, certain short-term changes have to be made. Based on this reasoning, we suggest that supply chain adaptability is the capability that influences the long-term sustainability of a firm's competitive advantage, while the influence of supply chain agility is shorter-term.

This argument is supported by Eckstein et al. (2015) who suggest that supply chain adaptability acts as an enabler of supply chain agility. Specifically, they state that the ability to reconfigure the supply chain according to market requirement (supply chain adaptability) acts as the basis for the firm to develop a supply chain agility capability (Eckstein et al. 2015). Supply chain agility requires the ability to quickly deal with demand-side changes, such as changing customer preferences, and supply-side changes, such as delivery failures (Blome et al., 2013b).A firm is able to cope with delivery failures if it has been involved in the continuous development of its supplier and logistics infrastructure (Lee, 2004). Similarly, a firm is able to deal with changing customer preferences if it has been monitoring these changes overtime (Lee, 2004). Accordingly, the long-term structural changes (supply chain adaptability) needed to achieve the dual motivations of efficiency and flexibility necessitate a series of short-term supply chain interventions (supply chain agility). Based on this line of reasoning, supply chain agility plays a mediating role in the relationship between supply chain adaptability and ambidexterity. Therefore, we posit:

*H5: Supply chain agility mediates the relationship between supply chain adaptability and supply chain ambidexterity.*

Drawing together these arguments, we advance the following hypothetical model (See Figure 1).

*---Insert Figure 1 here---*

## 3. RESEARCH METHODS

### *3.1. Research Design*

We follow a positivistic ontology believing that the major constructs of our works (e.g. supply chain agility and supply chain adaptability) are real and not subject to social construction. The underlying epistemology predicts that these constructs can be measured with quantitative methods which we do with the help of a survey. Therefore, we adopted a deductive research approach, as we are testing hypotheses that are underpinned by existing theories (dynamic capabilities) (Ketchen and Shook, 1996). In addition, related studies on dynamic capabilities and supply chain ambidexterity from a supply chain perspective have used the same methodology enabling generalisability of results (Blome et al., 2013b, Eckstein et al., 2015, Kristal et al., 2010). The unit of analysis for the study is the firm. The context of the study is the developing economy of Pakistan; a country experiencing an intense period of political and economic change (World Bank, 2017). A recent study showed that Pakistan is expected to grow at a rate of 5.97 per cent over the next ten years (Zahid, 2017). The country also faces challenges from Chinese firms that are expected to join the competition in Pakistani markets under the upcoming China-Pakistan Economic Corridor (CPEC).

### *3.2 Data Collection*

As an emerging economy, Pakistan presented several challenges with regards to data collection. Hoskisson et al. (2000) highlights some of the issues faced by strategy researchers in emerging countries such as: difficulty in collecting random and representative samples; lack

of reliability of the postal system; lack of trust between the respondent and researcher,; difficulty in gaining access to top management, and a lack of understanding of common management issues among practicing managers. Indeed, many studies conducted in emerging economies like Pakistan and India have reported similar issues (Ryan and Tipu, 2013, Jeswani et al., 2008, Ali et al., 2012; Malik and Kotabe, 2009). For example, Malik and Kotabe (2009) collected data from seven cities in India and Pakistan using convenience sampling, and cited that there were no updated or complete lists of firms available in either of the countries. Many other studies, in both these countries, have not used probability sampling methods (e.g. Ryan and Tipu, 2013, Jeswani et al., 2008, Ali et al., 2012) due to similar reasons.

Similar problems were also faced in this study. For example, there was no comprehensive database for identifying manufacturing organisations in the country. Instead, we constructed the list of organisations to be included in the sampling frame using various sources such as: manufacturing organisations listed on the Pakistan Stock Exchange; lists of managers available from Quality and Productivity Society of Pakistan; yellow pages and websites of associations for the leading industries. We made sure that no duplicate entries of firms were included, so that a comprehensive database of manufacturing firms in Pakistan was constructed. Email addresses from all these sources were combined, and multiple waves of emails were sent between February and July 2016. All surveys were accompanied by a cover letter that briefly introduced the research and highlighted the importance of the respondent's cooperation. Discounting the emails that remained undelivered, 3,375 emails were sent in total. In total, 277 usable responses (8.2 per cent response rate) were received, which, for email data collection in an emerging country is a decent figure, even though it comes with non-response bias issues.

We tested non-response bias using the methodology suggested by Armstrong and Overton (1977), comparing early and late respondents, with late respondents acting as a proxy

for non-respondents (Schoenherr and Swink, 2015). Comparison between early and late respondents was made based on three demographic variables: 1) years of existence of the respondent's firm; 2) sales of the respondent's firm; and 3) experience of the respondent using independent sample t-tests. The results showed that there was no significant difference between the two groups. The industry and respondent profiles are provided in Tables 1 and 2. The distribution of the firms in the sample closely resembles the distribution of local industry (Pakistan Bureau of Statistics, 2005-06). For example, 25.5 per cent of the respondents belonged to the textile sector, versus 26.2 per cent contribution in terms of output in the national economy. Similarly, 17 per cent of respondents were from FMCGs (versus 16.5 per cent); 4.3 per cent of respondents were from auto and auto-part manufacturing (versus 5.4 per cent);10.8 per cent of respondents belonged to chemical manufacturing (versus 12 per cent); and 2.9 per cent were from the electronics industry (versus 1.8 per cent).

--- Insert Table 1 & 2 about here ---

### 3.3 Measures

Following the advice of Schminke (2004), extant measures were used to develop survey instruments. A thorough literature review was conducted to identify scales from the previous studies, demonstrating suitable reliability and validity. Given the fact that the variables of interest in this study cannot be typically obtained from a firm's financial statements, perceptual measures were instead used to collect data from respondents. Perceptual measures were found to be adequate because the literature indicates a high correlation between subjective and objective measures of variables (Protogerou et al., 2012).The following section provides the details about these scales and their sources.

***Market Sensing Capability (MSC):*** relates to the ability of the firm to sense opportunities and threats in the market (Teece, 2007). The scale is adopted from Morgan et al. (2009) and consists

of five items measured on the scale of 1 (strongly disagree) to 7 (strongly agree). The scale elicited data on the efforts of the firm, and aimed at learning about customer needs, competitor strategies, distribution channels, market trends, and the broader market environment.

***Supply Chain Agility (SAG):*** identifies the firm practices that capitalise on market opportunities. This scale is based on the supply chain agility scale developed by Blome et al. (2013b) and is measured on the scale of 1 (strongly disagree) to 7 (strongly agree). It measures the firm's ability to adapt its offering quickly according to changing customer needs, the ability to cope with the changing demands and requirements to modify product portfolios, and the ability to cope with supply side problems.

***Supply Chain Adaptability (SAD):*** operationalised in this study as the ability to modify supply chain design. The construct is based on the supply chain adaptability construct from Lee's (2004) Triple-A supply chain. It consists of a 5-item scale developed in the Whitten et al. (2012) study, and is measured on the scale of 1 (strongly disagree) to 7 (strongly agree). As per the assertions of Lee (2004), the scale measures the ability of the firm to: spot new suppliers in developing countries; develop suppliers and logistics infrastructure; understand ultimate customers; develop flexible product designs; and understand the firm's product standing in the technology and product life cycles.

***Supply Chain Ambidexterity (SAM):*** Ambidexterity in organisation research is measured in various ways. The constructs have been formed as second-order reflective (Kristal et al., 2010) and second-order formative (Tamayo-Torres et al., 2017), by multiplying (Gibson and Birkinshaw, 2004), adding (Lubatkin et al., 2006), or subtracting (He and Wong, 2004) the two sub-dimensions. However, multiplying two dimensions has been by far the most used method of forming the construct (see Junni et al., 2013 for a detailed review).We measure SAM as an interaction of supply chain efficiency (SCE) and supply chain responsiveness (SCR). Both

scales are measured on the scale of 1 (far worse than competitor) to 7 (far better than competitor). The details about the items of the two scales are provided in the following.

- ***Supply Chain Efficiency:*** SCE measures the cost-based performance of the supply chain. The scale consists of five items adopted from Sezen (2008), who adopted it from Beamon (1999). The items ask the respondents to rate their firm's performance in comparison to their closest competitors, in terms of total costs of resources, distribution, transportation and handling, as well as the costs of manufacturing, inventory holding, and return on investment.
- ***Supply Chain Responsiveness:*** The SCR scale consists of five items adopted from Rajaguru and Matanda(2013). The items ask the respondents to rate their firm's performance in comparison to their closest competitors in terms of the ability to respond quickly and effectively to customer requirements, respond quickly and effectively to competitor tactics, and quickly develop new products.

### 3.4. Common Method Bias

Common method bias occurs due to resemblances in measurement methods resulting in biased reliability and validity estimates, and imprecise estimation of relationships between variables of interest (Podsakoff et al., 2003). Pre-emptive procedural remedies were taken in this study to avoid the problem of common method bias, as prior research has shown such measures to be more effective (Green et al., 2016). Guidelines suggested by Conway and Lance (2010), Podsakoff and Organ (1986), and Podsakoff et al.(2003) were followed in this respect. In terms of procedural remedies, dependent and independent variables appear in different sections of the survey and with different Likert-type scales; for example, strongly disagree–strongly agree versus far better–far worse. Furthermore, respondents were ensured that their responses will remain completely anonymous. Respondents were also given the choice of submitting the

survey without filling in their name and company name. The survey instrument was refined through two rounds of pilot surveys and opinions from experts, in order to remove any ambiguity in the questionnaire items that could bias the respondents in any way. Following the above guidelines, exploratory factor analysis was performed without a rotation. Three factors emerged from the solution, with the first factor accounting for less than 50 per cent of the variation. In the next step, all the variables in the research model were loaded on a single factor in a confirmatory factor analysis. This showed considerably poor results compared to the research model ( $\chi^2$=3.75, CFI=0.817, RMSEA=0.1) and did not achieve the basic threshold levels. Thus, it was concluded that common method bias is not a major concern in this study.

### 3.5. Assessment of Psychometric Properties

Confirmatory factor analysis (CFA) was used to establish the validity and unidimensionality of the constructs. Separate CFA was performed for dependent and independent variables. Model fit indices for both independent variable CFA ( $\chi^2$=1.39, $p$>0.05, GFI=0.969, CFI=0.992 and RMSEA= 0.034) and dependent variable CFA ( $\chi^2$=1.77, $p$>0.05, GFI=0.983, CFI=0.992 and RMSEA=0.053) were found to be adequate (Hu and Bentler, 1999). Factor loadings for all the constructs were either close to or above 0.7. Combined with significant p-values, this provides the evidence for convergent validity. Reliability of the constructs was established using Cronbach's alpha coefficients. Reliability coefficients for all the constructs were greater than 0.7, indicating reliability of the constructs. Table 3 provides the information about factor loadings and reliability measures for the constructs in the study.

--- Insert Table 3 about here ---

In order to establish discriminant validity, we compared the bi-variate correlations with the square root of AVE extracted (Fornell and Larcker, 1981). According to this criterion, if the correlation between a pair of constructs is less than AVE, discriminant validity is

established. It is evident from Table 4 below that correlations between all pairs of constructs are lesser than associated AVEs, indicating discriminant validity. Table 4 also provides means and standard deviations for the constructs in the study.

--- Insert Table 4 about here ---

## 4. RESEARCH FINDINGS

In this study, we developed a hypothesised model to identify the underpinning constructs of supply chain ambidexterity. To do so, we positioned market sensing, supply chain agility and supply chain adaptability as three dynamic supply chain capabilities. We then considered the interrelationship between these three constructs and their impact on supply chain ambidexterity. Furthermore, we considered the mediating role of supply chain agility in the relationship between adaptability and ambidexterity.

Before we tested our hypotheses using structural equation modelling, indicators were tested for the assumptions of constant variance, the existence of outliers, and normality by using plots of residuals by predicted values, rankit plot of residuals, and statistics of skewness and kurtosis. Multivariate outliers were assessed based on Mahalanobis distances of predicted variables. As the maximum absolute values of skewness and kurtosis were well within the limitations of past research (0.75 and 0.50, respectively) (Curran et al., 1996). In addition, also the above-mentioned plots did not show any concerning deviations. Finally, we also checked whether multicollinearity of variables was a problem, but as variance inflation factors were less than 1.97 (the recommended threshold is 10.0) we concluded that multi-collinearity was not a problem (Hair et al., 2014).

Figure 2 provides the results of the structural model. Path coefficients with solid lines indicate significant relationships ($p$<0.01), while the ones with dotted lines indicate insignificant relationships. Model fit was found to be adequate ( $\chi^2$=1.35, $p$>0.05, GFI=0.96,

CFI=0.99, and RMSEA= 0.036). Based on the results of the structural model, H1, H2, and H3 were significant, whereas support could not be found for H4. In order to test the mediation relationship posited in hypothesis 5, a bootstrapping technique (Hayes, 2013) was used. In order to test the hypotheses, indirect effect coefficients were generated using 5,000 bootstrap samples, along with a 95 per cent biased corrected confidence interval. Results showed that SAG significantly mediated the relationship between SAD and SAM ($\beta$=4.41, $p$<0.01). Results of the mediation test showed that indirect coefficient was significant ($p$<0.01). Therefore, H5 was supported.

--- Insert Figure 2---

## 5. DISCUSSION

Meta-analytic studies have called for more empirical studies investigating the implications of dynamic capabilities (Wilden et al., 2016). Even though there seems to be a consensus that dynamic capabilities should have a positive relationship with performance outcomes, Pezeshkan et al. (2016) suggest that empirical evidence regarding this relationship is mixed, at best. Given the popularity of dynamic capabilities as a research area, there is significant criticism surrounding this debate (Schilke, 2014). In support of earlier arguments by Teece (2007), we have gathered empirical data to show that, like firm-level dynamic capabilities, dynamic supply chain capabilities exist in clusters of sensing, seizing and transforming capabilities. Specifically, supply chain agility allows firm's to seize opportunities in the marketplace by providing a short-term supply chain response. Supply chain adaptability allows firms to provide a longer-term response to marketplace changes by transforming the resource base and structure of the supply chain.

Importantly, we found that supply chain agility and adaptability are only necessary if supply chain managers are able to sense market opportunities and threats in the first place.

After sensing opportunities and threats, managers can respond in two ways. In the short term, firms develop capabilities that allow them to modify their products and services quickly, and according to customer requirements both in terms of quantity and variety (supply chain agility). In the longer term, firms invest in the process of learning about their ultimate customers, understanding the life cycle of their products, and the continuous development of new suppliers (supply chain adaptability). Thus, market sensing not only helps supply chain managers to understand market changes, it also empowers them to improve decision-making regarding execution and reconfiguration of their capabilities.

These findings contribute to the existing literature by empirically showing that market sensing is an antecedent of supply chain agility and adaptability capabilities. This findings resonate with previous studies that have highlighted the importance of market sensing for supply chain agility (Tse et al., 2016) and supply chain adaptability (Aitken et al., 2002, Eckstein et al., 2015). With regard to dynamic capabilities theory (Teece, 2007), these results suggest that a sensing capability is the pre-requisite for seizing and reconfiguration capabilities.

We further identified a significant direct impact of supply chain agility, and an indirect impact of adaptability on supply chain ambidexterity. These results highlight the central role played by these dynamic capabilities in changing the market situation. Supply chain agility provides increased responsiveness and yields higher profitability, if exploited properly, and is thus a resource to fall back upon in turbulent times (Blome et al., 2013b). The ability to respond to changing market requirements is significant with regards to achieving market success. Conversely, the ability to sense market opportunities correctly, but the lack of capability to capitalise on them, would not improve performance and the opportunities would thus be lost (Roberts and Grover, 2012). Similarly, an insignificant direct relationship, and a significant indirect relationship, between supply chain adaptability and ambidexterity highlights the importance of successfully transforming supply chain design into short-term responses that can

bring immediate results. In accordance with Eckstein et al. (2015), our findings suggest that supply chain agility allows the firms to transform supply chain adaptability capabilities into superior performance levels.

## 6. CONTRIBUTION AND FUTURE RESEARCH DIRECTIONS

### *6.1 Theoretical and Managerial contribution*

While ambidexterity has become an important element in the wider supply chain discourse (e.g. Blome et al., 2013a, Kristal et al., 2010, Matthews et al., 2015), no consensus on how to measure supply chain ambidexterity exists. For example, Kristal et al. (2010) measures the ambidextrous supply chain strategy as a dichotomy between exploration- and exploitation-based practices. Blome et al. (2013a), on the other hand, base their ambidextrous supply chain governance construct on a contractual-relational governance dichotomy. Im and Rai (2008) base their construct of contextual ambidexterity on the adaptabilty-alignment dichotomy.

In this paper, we introduce a new way of measuring supply chain ambidexterity, including traditional measures of responsiveness and efficiency, and combine them in a multiplicative way in-line with prior research in the area (see Gibson and Birkinshaw, 2004, Hill and Birkinshaw, 2014). We believe that by integrating responsiveness and efficiency as measures, we capture the major trade-off that has been discussed in the supply chain context, allowing a unique and suitable supply chain specific contribution to theory. Also, instead of measuring ambidexterity based on classical performance measures, we provide a theoretical angle that captures the essence of dynamic supply chain capabilities, providing insights on how firms can achieve sustained competitive advantage in a supply chain context.

Finally, we challenge the common assumption that only one supply chain type (efficient/ responsive) is suitable for a particular product (e.g. Fisher, 1997, Lee, 2002). Instead, we suggest to managers that a product can have both a flexible and efficient supply chain if

underpinned by the dynamic supply chain capabilities of market sensing, supply chain agility and adaptability. The results of this study suggest to managers that dynamic supply chain capabilities exist in clusters that need to be invested in simultaneously to capitalize on efficiency and flexibility gains.

### *6.2. Limitations and Future Research Directions*

The findings of this study should be interpreted in light of its limitations. These limitations may also point out some avenues for future research. First, this study used self-reported perceptual data in order to measure both independent and dependent variables. While this is the dominant practice in most management research, and substantial efforts were made to achieve the highest possible level of data quality during the process of data collection and construct validation, self-reporting bias cannot be totally ruled out. Second, the study used a cross-sectional research design, thus the usual caveats of this design apply to this study. Findings of this study cannot be taken as conclusive evidence of the underlying causal relationships. Conclusive evidence can only be generated through longitudinal research.

Future research in the area may employ a longitudinal research design, or employ secondary (panel) data. However, as emphasised by Protogerou et al.(2012), these limitations do not invalidate the results. A single study is never enough to provide the final argument related to underlying relationships in the model being tested. Given that this study takes into consideration a fairly large dataset, it provides the basis for the logic of the dynamic supply chain capabilities- supply chain ambidexterity relationship. Models based on a cross-sectional design need to be developed in order to evaluate the pertinence of the research model before longitudinal designs can be used. Better understanding of this logic, however, will require these relationships to be studied using diverse types of evidence (qualitative/quantitative). Finally, we considered the interplay between various dynamic supply chain capabilities in terms of how these capabilities affect the overall performance of the supply chain. We found that a market

sensing capability positively and directly affects supply chain agility and adaptability. Combined, these dynamic supply chain capability clusters allow organisations to modify their products, services and supply chain structures according to market requirements both over the short and long-term. Therefore, future research should consider market sensing, supply chain agility and adaptability in conjunction rather than in isolation.

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# Supply Chain Capabilities, Risks, and Resilience

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# Supply Chain Capabilities, Risks, and Resilience[☆]

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**Abstract**

Supply chain resilience is an operational capability that enables a disrupted or broken supply chain to reconstruct itself and be stronger than before. This paper examines resilience using the dynamic capabilities approach, grounded in the Resource-Based View of firms. The purpose of this research is to provide insights for achieving resilience by mapping the relationships between the practices, resources, and processes over which a manager has control. A survey of 171 managers is used to test a conceptual model that proposes relationship between supply chain capabilities and resilience as well as the moderating role of supply chain risks. Variance-based structural equation modeling reveals that only tighter integration between echelons and increasing flexibility lead to added resilience. The perception of supplier risk helps motivate the supply chain manager to enhance integration capabilities and thus achieve higher resilience. Furthermore, the perception of external risks to a supply chain actually reduces the effort of deploying external capabilities to obtain resilience. Overall, the findings strongly support the view that resources, routines, and capabilities provide different results in terms of resilience depending upon supply chain risk factors.

*Keywords:* Resilience, Supply Chain, dynamic capability, survey

## 1. Introduction

Supply chain risk management remains a key managerial challenge that affects the performance of organizations (Altay and Ramirez, 2010). Characteristics such as tighter collaboration, increased complexity, reduced inventory levels, and ever-wider geographic dispersion have created greater vulnerabilities (Bode et al., 2011). Supply chain management literature is now beginning to explore how best to build resilience in supply chains, with increasing attention especially toward value chain fragmentation and geographical extension (Gulati et al., 2000). All economic disruptions, whether natural or man-made, carry unforeseen threats to the performance and profitability of supply networks (Hindle, 2008; The Economist, 2009).

In sociology and ecology, resilience characterizes an organization or a social body that is able to rebuild itself after having been substantially affected by an exogenous attack (Berkes et al., 2003). One example from the United States is that of Walmart's operations before and after the passage of hurricane Sandy in 2012 (Creighton et al., 2014). Resilience, as defined by Brandon-Jones et al. (2014), page 55, and Christopher and Peck (2004), page 4, is "the ability of a supply chain to

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return to normal operating performance, within an acceptable period of time, after being disturbed".

Given the literature and interest in resilience, it is surprising that the management practices required to achieve it are approached from so many different managerial viewpoints (e.g., operations, strategy, information systems, marketing, human resources) as exemplified in Li et al. (2008, 2009). In this paper, we consider the supply chain managers as the central decision-makers and organizers of the management processes within the supply chain. As such,they organize, deploy and control all the necessary investments, assets, resources, routines, processes, and systems to achieve the strategic goal of enabling the supply chain to be resilient. Grounded in the Resource-Based View (RBV) (Wernerfelt, 1984), the dynamic capabilities theoretical framework introduced in Teece and Pisano (1994) yields powerful results which can be brought to bear in the present setting. Teece (2007) defines a dynamic capability as the ability to dynamically integrate, build, and reconfigure lower-order competences to achieve congruence with changing business environments.

We apply this framework here to answer the following questions: (1) Given the risks being faced, what practices does a supply chain manager deploy to obtain such resilience? (2) How do environmental factors related to supply chains influence the effectiveness of these practices? With this dual focus, our research contributes to theory as well as practice by increasing understanding of how to enhance resilience and providing insights to determine the supply chain capabilities required to achieve greater resilience.

We next present a review of the literature and the theoretical underpinning of our paper, from which we derive a conceptual model. Next, we elaborate on the study's methodology, analytical approach, and the results of our empirical study. The concluding sections discuss the theoretical and practical implications of the findings, highlight limitations, and outline directions for future research.

## 2. Theoretical background and conceptual model

The dynamic capabilities approach has gained wide acceptance as a tool to explain performance across competing firms (Barreto, 2010; Teece et al., 1997). According to this perspective, superior performance stems from two types of organizational capability, namely, dynamic capability and operational capability (Cepeda and Vera, 2007; Helfat and Peteraf, 2003).

The literature has formulated the basic difference between dynamic capability and operational capability (Teece, 2007; Winter, 2003). Dynamic capabilities are a learned pattern of collective activity and strategic routines through which an organization can generate and modify operating practices to achieve a new resource configuration and achieve and sustain a competitive advantage (Teece et al., 1997; Teece, 2007). Barreto (2010) recommends that research should focus on the factors that may help (or hinder) firms to achieve the potential represented by their dynamic capabilities. It is important to recognise that the value of dynamic capabilities is context dependent (Wilden et al., 2013) and not a set recipe or formula for general effectiveness. Organizational response to environmental turbulence is faster as well as more effective (Chmielewski and Paladino, 2007) so ultimately enhances performance. Attaining competitive advantages requires efficient and effective sharing and deployment of resources between partnering organizations and supply chain partners (Rajaguru and Matanda, 2013).

By contrast, Winter (2003) argues that an operational capability provides the means by which a firm functions or operates to make a living in the present. Dynamic capabilities are considered to be of a higher order than operational capabilities, as

their role is to contribute to the firm's higher relative performance over time (Drnevich and Kriauciunas, 2011). An operational capability refers to a firm's ability to execute and coordinate the various tasks required to perform operational activities, such as distribution logistics and operations planning, which are processes and routines rooted in knowledge (Cepeda and Vera, 2007). This capability refers to a high-level routine or a collection of routines (named organizational routines or competences in Teece et al., 1997) that can be used to respond to unforeseen events affecting the ability of a supply chain to perform (Barreto, 2010; Eisenhardt and Martin, 2000). For example, given the increasing importance of timely and cost-effective product delivery, supply chain resilience is considered a critical capability to maintain the continuity of operations. Resilience as an operational capability requires both internal processes as well as those relative to the information flow, coordination, and collaboration with upstream and downstream partners.

To build and operate a resilient supply chain, it is helpful to have an in-depth understanding of the lower-order capabilities (or micro-foundations, as described in Teece, 2007) that are required.

Managerial systems, procedures and processes that undergird each class of capability define what Teece (2007) call organizational routines or competences and what Barreto (2010) sees as a requirement for supply chain operations. Henceforth named here lower-order capabilities, they are distinct from the capability itself (Teece, 2007). These lower-order capabilities along the supply chain constitute the practices among the different chain members using which the supply chain is able to absorb or recover from disturbances, and still maintain its ability to deliver value to final customers (Bhamra et al., 2011).

The dynamic capabilities approach makes it possible to characterize the operational capabilities

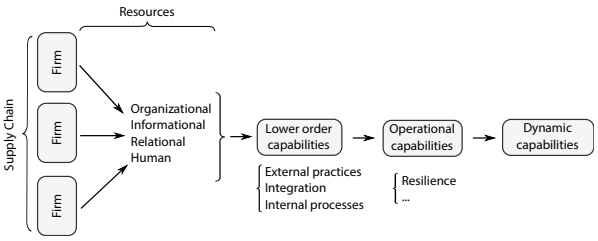


Figure 1: Theoretical model of the Resource-Based-View of a supply chain

that supply chain managers wish to enhance as well as the routines, procedures, and processes they apply at their firms and across their supply chains (see Figure 1). Brusset (2016) does the same: the author applies the dynamic capabilities approach to look into how agility as an operational capabilities is enhanced using lower order capabilities. We now switch focus to the relationship between those lower-order capabilities and the operational capabilities that characterize resilience.

### *2.1. Resilience in supply chains*

An important aspect for all supply chain managers is the capacity of their supply chain to withstand upheavals, disruptions and unforeseen events (e.g., Brandon-Jones et al., 2014; Bhamra et al., 2011). A supply chain that is still able to perform and deliver products and services under such circumstances is characterized as resilient (Blackhurst et al., 2011). This capacity is defined in Fiksel (2006) and in Pettit et al. (2010) as "the capacity for an enterprise to survive, adapt, and grow in the face of turbulent change". Resilience has broader implications than supply chain risk control. Since supply chains have increased in both length and complexity (Blackhurst et al., 2005), natural catastrophes, wars, strikes and economic upheavals severely impact performance (Chopra and Sodhi, 2004; Wagner and Bode, 2008). Hendricks (2005) states that it is critical for firms to enhance the resiliency (sic) in their supply chains and call for research into specific tactics that help firms develop

such capabilities.

Studies are concerned with the ability of the supply chain to return to its original state of operation after being disturbed (Pettit et al., 2010). Today's supply chains are more prone to disruptions caused by natural and man-made events (Wagner and Bode, 2008). Hence, the ability to recover quickly has become a topic of concern for practitioners and academics.

Having described resilience as an operational capability, we now characterize the lower-order capabilities available to the supply chain manager, which, when deployed across all members of the supply chain, should generate this capability. We then stipulate the corresponding hypotheses.

### *2.2. Lower-order capabilities and hypothesis development*

We define lower-order capabilities as the set of physical, financial, human, technological, and organizational resources (Grant, 1991) coordinated by organizational routines (Nelson and Winter, 1982) and deployed in an organization and across organizations.

The literature provides abundant descriptions of the practical managerial routines and processes deployed by a large number of supply chain managers. For the purpose of this study, we centered our attention on the organizational, informational, and human resources across organizations. Even though the relevant literature often does not mention the RBV, the resources mentioned clearly belong to the class of lower-order capabilities that we identified above. For example, a fully deployed second-generation material requirements planning (MRP II) system is composed mostly of procedures, information systems, and skilled operators, as well as tangible assets (computers, servers and wide area networks). This MRP has to be connected to other firms in the supply chain to exchange forecasts, delivery schedules, and other planning requirements (Akkermans et al., 2003). This lower-order capability, when combined with other similar practices, will contribute to a higher-order operational capability (Su and Yang, 2010). The practices that we consider as having influence on operational capabilities can be grouped as external, integration, and flexibility capabilities, which are described below.

*External capabilities:* These are the practices that in sum represent Efficient Customer Response policies (Skjoett-Larsen et al., 2003). Partners have to collaborate through systems such as Vendor Managed Inventory (VMI) and Collaborative, Planning, Forecasting, and Replenishment (CPFR) with retailers to enhance close cooperation among autonomous organizations engaged in joint efforts to effectively meet end-customer needs (Faisal et al., 2007).

The flow of accurate and real-time information in the supply chain is considered by many to be as important as the flow of goods. Information sharing can also provide flexibility and improve the responsiveness of the supply chain (Gosain et al., 2005; Agarwal et al., 2006). The information shared may include: end-customer demand, sales forecasts, order status, inventory levels, capacity availability, lead times, and quality. Sharing information can improve transparency, avoid lost sales, speed up payment cycles, create trust, avoid overproduction, and reduce inventories (for reviews, see Bhamra et al., 2011; Sahin and Robinson, 2002). Current inter-organizational information systems (IOIS) facilitate the sharing of real-time information in the supply chain and allow organizations to be more effectively coordinated throughout the network. These systems are named Advanced Planning and Scheduling (APS), Collaborative Planning, Forecasting and Replenishment (CPFR), and Efficient Customer Response. IOIS also have implications for the way that supply chains are designed and managed. One important example is the use of vendor managed inventory (VMI) systems where

an upstream supplier is able to react directly to the inventory and demand information from a downstream customer by adjusting the quantity and timing of deliveries (Kotzab, 1999). These practices enable a supply chain to be reconfigured when faced with unexpected and disrupting events. As characterized in Faisal et al. (2006) and Faisal et al. (2007), supply chains are affected by "information risks".

Hendricks (2005) empirically documents how glitches in supply chains affect operating performance, naming sources of glitches that run the gamut from parts shortages to reorganisational delays and information technology (IT) problems. Klibi et al. (2010) specifies how resilience in supply chains should be assessed in view of the disruptions being faced. The solutions they propose to enhance resilience require tighter integration of suppliers and distribution networks as well as building redundancy and flexibility. Mandal (2012) specifically identifies IT (an important component of external capabilities) as one of the sources for increased resilience in a supply chain. The resilience provided protects the supply chain against the vagaries of the market. Our first hypothesis is the following.

**Hypothesis 1.** *There is a positive relationship between the implementation rate of external capabilities ($\xi_1$) and the level of resilience ($\eta_1$) in supply chains.*

*Integration capabilities:* Supply chain integration has been defined "as the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organization processes. The goal is to achieve effective and efficient flows of products and services, information, money and decisions, to provide maximum value to the customer at low cost and high speed" (Naylor et al., 1999; Frohlich and Westbrook, 2001; Flynn et al., 2010). Even though the integration of manufacturers and clients has been studied in the context of China through the prism of power relationship commitment theory (Zhao et al., 2008), other literature such as Pagell (2004); Lin et al. (2006); Faisal et al. (2007); Rajaguru and Matanda (2013) view this capability as consisting of IT systems and practices that employ both information systems and the corresponding managerial practices and routines to enhance inter-organizational integration and coordination. Such integration of IT with supply chain processes enhances collaboration in the chain through continuous adjustments to the product lineup and inventories as well as sharing forecasts, sales data and inventory levels (Qrunfleh and Tarafdar, 2013, for an appreciation of the impact of Information Systems on supply chain performance). Collaborative platforms provide the possibility of exchanging information in real time (Boyson et al., 2003). The technologies that enable goods to be tracked and traced provide greater control over operations within the chain as well as timely notification and access to detailed information when events occur. This also contributes to suppliers' integration, thus increasing efficiency (Danese and Romano, 2011), especially as service levels can be monitored (García-Dastugue and Lambert, 2003).

Integration provides the capability to reduce the costs and risks of coordination and of transactions by providing managers an opportunity to understand the focal areas that need attention. Hence, they can minimize risks to real-time and free flow of information (Faisal et al., 2007). Mandal (2012) identified the dimensions or antecedents that IT professionals perceive as important for achieving resilience in the Indian context.

**Hypothesis 2.** *There is a positive relationship between the implementation rate of integration capabilities ($\xi_2$) and the level of resilience($\eta_1$) in supply chains.*

*Flexibility capability*: This last set of practices increases the responsiveness of a supply chain to

stimuli from end-consumers. It refers to the ability to evaluate and take needs into account quickly (Charles et al., 2011). The forecasting and planning processes within the supply chain are scaled up, resulting in enhancement of the supply chain's reactive capabilities by enabling it to predict final demand changes and adapt to them both in upstream and downstream operations (Olhager, 2013). Such practices, jointly named Sales and Operations Planning (S&Op), provide a vital link between lean manufacturing operations within the supply chain and responsive distribution and differentiation operations (Sauvage, 2003; Faisal et al., 2006).

These practices hold important promise in enabling risk prevention and recovery (Lavastre et al., 2012). By enabling better control of inventories and production schedules, planning and forecasting systems reduce the risks from both upstream and downstream events (Stadtler, 2005). These planning systems have long-, medium-, and short-term horizons and include master planning, requirements planning, and demand and distribution planning. Evidence of the use of such systems and routines to protect the supply chain has been found by Fleischmann and Meyr (2003) and Stadtler and Kilger (2005). This leads us to our third hypothesis:

**Hypothesis 3.** *There is a positive relationship between the implementation rate of flexibility capabilities ($\xi_3$) and the level of resilience ($\eta_1$) in supply chains.*

*Moderating Effects of Supply Chain Risks* Using the classification presented in the risk literature review by Heckman et al. (2015), we analyze the risk sources that might affect the supply chain manager's effort to increase the resilience of a supply chain depending on whether the risk source lies within or beyond the supply chain boundaries (Wagner and Bode, 2008; Waters, 2011). Internal risks stem from suppliers and customers. They are referred to as internal to reflect that they should be within the control of the supply chain manager. External risks are outside her or his control.

*External Supply Chain Risks*: Chopra and Sodhi (2004) highlight the importance of understanding the nature and effectiveness of supply chain risks to be able to set up or strengthen the firm's capabilities to more effectively manage those risks and thus become more resilient. In terms of risks outside a firm's supply chain, Walters (2006) illustrates the significant impact of external risks—such as economic, social, and political risks for supply chains—on the performance and qualities of a supply chain. We contend that macro-economic, social, and political risks will counteract the efforts deployed by the supply chain manager to increase the resilience of the whole chain. Such external risks can negatively affect how lower order capabilities will develop resilience (Bode et al., 2011; Altay and Ramirez, 2010).

*Internal Supply Chain Risks*: Supply chains represent vertical inter-organizational networks of firms that are closely linked to their up-stream and down-stream supply chain partners (Carvalho et al., 2012). As such, suppliers as well as customers have an impact on establishing supply chain (management) capabilities (e.g., Teller et al., 2016) as well as on resilience. Hwang et al. (2013) highlight the importance of supplier impact on risks affecting the capabilities of firms, for example, through a lack of reliability, lead times, or delivery problems. Tang (2006) and Chopra et al. (2007) explicitly argue that suppliers represent a source of risks to firms within a supply chain. Walters (2006) provides comparable arguments of customers posing potential risks to their up-stream supply chain partners, for example, if the customer goes into administration, generates variable demand, or has ordering problems. Consequently, risks related to suppliers and customers, that is, risks outside the firm but inside the supply chain affect how firms will be able to garner all the benefits from increasing their lower order capabilities to develop resilience.

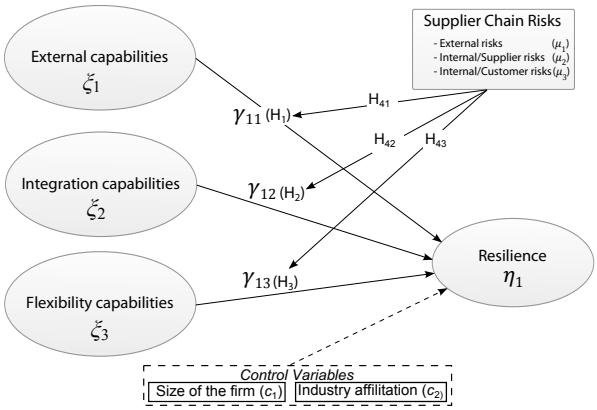


Figure 2: Conceptual model.

To conclude, we propose that supply chain risks related to both external factors and those related to up-stream and down-stream supply chain partners affect the relationship between supply chain capabilities and resilience. We thus propose the final hypothesis H4 as follows:

**Hypothesis 4.** *Supply chain risks (external risks ($\mu_1$), supplier risks ($\mu_2$), and customer risks ($\mu_3$)) affect the positive relationship between the implementation rate of (external ($\xi_1$, $H_{41}$), integration ($\xi_2$, $H_{42}$), and flexibility ($\xi_3$, $H_{43}$)) capabilities and the level of resilience ($\eta_1$) in supply chains.*

Our conceptual model comprises all four hypotheses, as depicted in Figure 2. Based on the dynamic capabilities approach, our model proposes the effects of capabilities on the resilience of a supply chain as well as risk factors that influence those effects.

We now turn to the empirical test of our conceptual model.

## 3. Methodology

### *3.1. Research design*

The design involves a survey among supply chain managers, using a single respondent in each organization as the analysis unit. We considered these managers as key informants (e.g., Campell, 1955) since – due to their role within their organizations – they have the most expertise and access to information on their organizations' capabilities, supply chains, and environments.

Our research views the organization as "embedded in a network of relationships that impact its performance" (Saraf et al., 2007), p. 327. We recognize that a multiple-respondent survey design would have been preferable, but chose a single-respondent design to improve acceptable response rate (Saraf et al., 2007), as suggested by Tang and Tang (2010) for studying inter-organizational phenomena. Even though the study has limited explanatory powers owing to the subjective nature of the data gathered, the use of subjective data is common in this type of research and considered acceptable (Chan et al., 1997). We opted for a web-based survey approach (Grant et al., 2005) due to the target population size, the number of questions, and the cost involved in contacting respondents. Answers were anonymised to allay respondent identification problems.

The population of supply chain managers was approached through an electronic mailing campaign to the 8,000 French tested e-mail addresses of a Supply Chain newsletter. The subscribers are opt-in readers with an interest in general supply-chain management news. Even though 366 replies were recorded, only 171 were valid for statistical analysis, a response rate of 2.1% of the identified population and 47% of the sample usable (Yu and Cooper, 1983). This response rate is comparable to other research within the field of supply chain management (e.g., Van der Vaart and Van Donk, 2008; Wagner, 2010).

Several economic sectors are represented by the sample, thus increasing the results' generality.The usable subset included firms operating in the following sectors: food and beverage (17.5%), retail (25.7%), and general manufacturing (24.0%). The sample reflects a dominant proportion of small to medium sized firms; 67.3% have less than 1,250 em-

ployees.

### 3.2. Common method bias

Since there was a single informant per organization, the potential for common method bias (CMB) was assessed. There is no single best method available to test CMB (Podsakoff et al., 2012). Furthermore, the choice of method is a subject of intense debate, as is the question of whether CMB can affect data (for a critical discussion see Richardson et al., 2009). We applied the Harman (1967) single-factor test of CMB (Podsakoff and Organ, 1986; Podsakoff et al., 2003), which revealed twelve distinct factors with eigenvalues above or near one that cumulatively explained 87.6% of total variance. According to this test, if common method bias exists, one of the following should be observed: (1) a single factor will emerge from a factor analysis of all survey items (Podsakoff and Organ, 1986); or (2) one general factor will emerge that accounts for most of the common variance existing in the data. The first factor explained 24.32% of the variance, which was not the majority of total variance and thus considered to be low enough.

### 3.3. Non-response bias

Because significant numbers of the targeted population failed to respond, we checked for possible non-response bias using a "time-trend extrapolation test" in which "late" versus "early" respondents are compared along key study variables (first suggested by Oppenheim, 1966). The assumption behind this test is that"late" respondents are very similar to non-respondents, since their responses would not have been recorded without follow-up efforts (Armstrong and Overton, 1977). The $t$-tests conducted showed no significant differences between "early" and "late" respondents along any of the key study variables.

### 3.4. Measurement

*Capabilities and Resilience:* The four theoretical constructs of our conceptual model—excluding the moderating and control variables—constitute latent variables requiring indirect measurement (see Table 3). We sifted through the nine references in literature that deal with resilience or one of the lower-order capabilities using empirical surveys (Lavastre et al., 2012; Mandal, 2012; Qrunfleh and Tarafdar, 2013, 2014; Richey et al., 2012; Kern et al., 2012; Moon et al., 2012; Hoffmann et al., 2013), and the survey presented in Wilden et al. (2013), which uses dynamic capabilities as second order constructs. The focus in each of these surveys is different from ours: often the supply chain manager is not considered to be the decision maker—given the questions or items, the respondent could be a production manager, a chief executive officer, or an IT chief information officer; or he or she responds to strategic or policy statements such as "we select the best quality supplier". Actual and practical usage of managerial tools and resources are not contemplated. In fact, there is a decided absence of scales based upon the set of physical, financial, human, technological, and organizational resources (Grant, 1991), coordinated by organizational routines (Nelson and Winter, 1982), and deployed in an organization and across organizations. Consequently, we determined that our study required a grounding in actual usage of such sets by supply chain managers in their daily work inside their organizations as well as in the relationships with suppliers and distributors or customers.

So, following Churchill (1979), we started with the domain specification of each construct and collected the relevant measurement items in the literature. However, rather than blindly applying previously utilized measurement items, we used them as a starting point, and revised them based on the feedback from five experts in the supply chain practice at CapGemini Consulting France. These prac-

titioners were aware of the scope and purpose of our study and thus were able to provide precise feedback on the measurement items. Using their feedback we were able to tailor each measurement item to most accurately measure the underlying construct. As such, we employed a grounded approach to make the items as accurate as possible, given our study context. This approach to develop the final items provides for a very high level of face and content validity, while increasing the practical relevance and applicability of the research. After receiving the feedback, we had to accommodate specific changes in the constructs, which the experts had criticized as being too complicated and having limited face validity. The measures for supply chain resilience were thus deductively and inductively developed with the help of practitioners.

A draft version of the survey questionnaire was pre-tested among experts and journalists from supplychainmagazine.fr. As a result of this pretest, some inconsistencies and unclear formulations were addressed. Given the numerous definitions of resilience available in the literature and the prevalent confusion in the minds of practitioners (Kidd, 2000), it was expected that a particularly wide cross-section would emerge. A broad consensus was achieved through a general discussion in which each participant described the effect of each practice on the overall supply chain and how this effect could be achieved and measured. In a subsequent pretest, the questionnaire was presented to five supply chain managers, whose remarks were then incorporated. When questioned about capabilities, the respondents were asked to rate their agreement, with a response range from totally disagree (rated 1) to fully agree (rated 5). For each capability, managers were asked to specify if it was "not applicable to their particular case" (rated 1), "under consideration" (rated 2), partly deployed (3), fully deployed but still only partially used (4), to fully deployed and in use (rated 5). The result is a list of 9 affirmations about capabilities found in their supply chains. A final updated list was drawn up that captures both the comments about clarity and simplicity as well as system- or process-related remarks about their capabilities. The list of all measurement items underlying the constructs of our conceptual model can be found in the appendix.

We consider all constructs in our model to be of a reflective nature. We base this decision on the notions of Jarvis et al. (2003): The direction of causality goes from the latent construct towards the indicators for all of our constructs. This is of particular importance for our dependent construct Resilience ($\eta_1$), given Lee and Cadogan (2013) critique on treating formative constructs as being dependent.

*Supply Chain Risks*: To measure the three supply chain risk variables we followed the notions of Walters (2006) and Heckman et al. (2015), who distinguish between risk that is external to the supply chain, including political, social, environmental and economic risks, and risk that is internal to the supply chain, which is related to suppliers and customers (see Table 3). Our questionnaire asks respondents to indicate the degree to which their supply chain is affected by the various dimensions of supply chain risk and thus treat these responses as manifest variables.

### *3.5. Control variables*

We consider two control variable that potentially influence the proposed effects in our conceptual model: company size ($c_1$, operationalised by the number of employees) and industry affiliation ($c_2$). The inclusion of the first control is supported by discussion on the different roles and practices of SCM in large as opposed to small organisations, and thus the notion that the size of a company affects the advantages gained from SCM (Arend and Wisner, 2005).

In terms of the second control Harland (1996) identified that the position of a company in a sup-

ply chain (= industry affiliation) affects the management of supply chains. Given the distribution of industry affiliation in our samples we use a dichotomous scale to measure our control variable, that is, the companies –represented by our respondents– are either affiliated to the manufacturing, retail or any other industry.

## 4. Analyses

### *4.1. Variance-Based Structural Equation Modeling*

This study uses variance-based structural equation modeling (VBSEM) (two main references are Wold, 1982, 1985), a technique for component-based structural estimation modeling. Variance-based SEM has distinctive features compared to covariance-based SEM (SEM-ML). VBSEM has less restrictive assumptions on characteristics such as measurement scales, sample size, and distributional assumptions (Chin, 1998b; Tenenhaus et al., 2005). Chin and Newsted (1999) observe that VB-SEM is generally better suited to studies in which the objective is prediction, or the phenomenon under study is new or changing. Instead of relying on overall goodness-of-fit tests, variance-based SEM tests the strength and direction of individual paths by statistical significance (Calantone et al., 1998). The sample size requirement for VBSEM is ten times the larger value of the following: (a) the block with the largest number of indicators, or (b) the dependent latent variable with the largest number of independent variables impacting it (Chin, 1998b). Tenenhaus et al. (2005), in a more theory-oriented paper that complements the work of Chin (1998b), compares both SEM-ML and VBSEM. Even though it is recognized that these methods give different results, for our purpose, VBSEM is more suitable given that the theory is still in development. Maximum Likelihood modeling techniques are better suited once confirmatory studies have been made (Lee et al., 2006). VBSEM allows for more exploratory investigations into the links between certain enablers and the traits of supply chains due to its less rigorous requirement of restrictive assumptions.

### *4.2. Evaluation of the measurement and structural model*

To systematically evaluate our VBSEM results, we first investigated the measurement model and subsequently the structural model (Hair et al., 2014). All $t$-values of the factor loadings are highly significant at $p < 0.001$ (see Table 3). Further, all loadings exceed the suggested size of 0.70 (Hulland, 1999). The internal consistency is also satisfactory for all factors (Cronbach's ($\alpha > 0.70$), and for all factors the composite reliability ($\rho$) meets the requirement of being above 0.70 (Fornell and Larcker, 1981). The degree of convergent validity proved to be acceptable, with the average variances extracted (AVE) higher than 0.50 (Bagozzi and Yi, 1988). With regard to the constructs' discriminant validity, the AVE is larger than the highest of the squared inter-correlations with the other factors in the measurement models (see Table 1). Additionally, all factor loadings on the assigned factor are higher than cross-loadings on the non-assigned factors Chin (1998a). To conclude, all constructs in the model show sufficient validity.

Table 1: Convergent validity, composite reliability and discriminant validity measures for capabilities

| Constructs | $\rho$ | $\alpha$ | $\xi_1$ | $\xi_2$ | $\xi_3$ | $\eta_1$ |
|---|---|---|---|---|---|---|
| External ($\xi_1$) | .855 | .781 | (.776) | | | |
| Integration ($\xi_2$) | .814 | .701 | .479 | (.723) | | |
| Flexibility ($\xi_3$) | .812 | .752 | .143 | .265 | (.730) | |
| Resilience ($\eta_1$) | .865 | .792 | .292 | .372 | .301 | (.785) |

Average variance extracted values (AVE) shown on the diagonal;
Squared correlation matrix for constructs below the diagonal;
$\alpha$, Cronbach's alpha; $\rho$, composite reliability;

*Structural model*: Unlike covariance-based SEM, its variance-based counterpart does not offer comparable global fit measures (e.g., Henseler and

Sarstedt, 2013; Hair et al., 2012). Rather than calculating goodness-of-fit measures as proposed by Tenenhaus et al. (2005); Hair et al. (2014) suggest investigating the coefficient of determination ($r^2$-value) and the significance of the structural path coefficient to use as primary evaluation criteria for the structural model. Our estimation shows an $r^2$-value of .221 which represents a satisfactory value. Furthermore, two out of three structural paths are significant and as such, represent medium-size effects according to Cohen (1988).

### *4.3. Model robustness test*

Next, we evaluate the impact of our two control variables ($c_1$, $c_2$) on the main associations in our model (see Figure 2), following the procedure applied by Robson et al. (2008). The direct impact of $c_1$ and $c_2$ operationalized by three dummy variables (for the manufacturing, retailing and other industries) on the dependent construct $\xi_2$ are all insignificant ($t$-values $\ll 1.965$) and very weak. When comparing the structural associations as proposed in our hypotheses by including or excluding the control variables in the model, we see that the coefficients change insignificantly on the third decimal place and the significance of the associations do not change.

These results suggest that the two control variables do not confound the proposed relationships in our conceptual model. Moreover, we can conclude that the structural associations are independent of the industry affiliation and company size. Since the two control variables lack explanatory power, we trimmed our model and excluded them from the following analysis.

## 5. Results

### *5.1. Structural effects*

The estimation results in Table 2 show that the effect of external capabilities on resilience is insignificant on a 5% level ($\gamma_{11}, .144; p > .05$). We therefore cannot support the first hypothesis. Nevertheless, the other two capability constructs, that is, integration and flexibility, impact resilience significantly ($\gamma_{12}, .246; \gamma_{13}, .214; p, < .01$). Consequently, hypotheses H2 and H3 are supported.

### *5.2. Moderating effects*

To test the proposed moderating effects we applied the product indicator approach, as suggested by, among others, Busemeyer and Jones (1983) and Kenny and Judd (1984). This means that for each moderating effect a product term is calculated using the indicators of a predicting variable (in our case, one of the three capability constructs, $\xi_1$, $\xi_2$ or $\xi_3$) and the moderator variables ($\mu_1$, $\mu_2$ or $\mu_3$) (Henseler and Chin, 2010). This term is then included as a (latent) interaction term and as such represents the moderating effects (see hypothesis H4) in the conceptual model. The impact of the interaction term on resilience ($\eta_1$) measures the significance and the size of the moderating effects.

Henseler and Chin (2010) recommend the product indicator approach for models such as that proposed in this paper, specifically, models where the purpose of the estimation is to (1) explain impacts, (2) describe interaction effects, and (3) focus on the prediction of endogenous constructs. Furthermore, the product indicator approach is regarded as superior to the frequently used multi-group analysis when the moderating variable is of a continuous nature. Multi-group analysis, and thus the test for invariance between coefficients, is most appropriate in the case of dichotomous moderating variables and experimental designs (Bagozzi et al., 1991).

In terms of external risks ($\mu_1$) the results show only a negative significant moderating effect ($-.213; p < .05$) on the association between External Capabilities on Resilience ($\gamma_{11}$). Thus, an increasing economic risk leads to a weaker impact of external capabilities on resilience. In terms of supplier risk ($\mu_2$), we found a significant moderating effect ($.214, p < .01$) on the relationship be-

Table 2: Estimation results

| Hypothesis (structural effects) | Coeff. |
|---|---|
| H1 ($\gamma_{11}$): External Capabilities ($\xi_1$)→ Resilience ($\eta_1$) | .144$^{ns}$ |
| H2 ($\gamma_{12}$): Integration Capabilities ($\xi_2$)→ Resilience ($\eta_1$) | .246$^{***}$ |
| H3 ($\gamma_{13}$): Flexibility Capabilities ($\xi_3$)→ Resilience ($\eta_1$) | .214$^{**}$ |
| Hypothesis (moderation effects) | |
| External to the supply chain: External Risks ($\mu_1$)‡ | |
| $H_{41}.\mu_1$: External capabilities ($\xi_1$) x External risks ($\mu_{11}$)→ Resilience ($\eta_1$) | -.213$^{*}$ |
| $H_{42}.\mu_1$: Integration capabilities ($\xi_2$) x External risks ($\mu_{11}$)→ Resilience ($\eta_1$) | .215$^{ns}$ |
| $H_{43}.\mu_1$: Flexibility capabilities ($\xi_3$) x External risks ($\mu_{11}$)→ Resilience ($\eta_1$) | .003$^{ns}$ |
| Internal to the supply chain: Supplier risks ($\mu_2$) | |
| $H_{42}.\mu_2$ : External capabilities ($\xi_1$) x Supplier risks ($\mu_{12}$) → Resilience ($\eta_1$) | -.176$^{ns}$ |
| $H_{42}.\mu_2$: Integration capabilities ($\xi_2$) x Supplier risks ($\mu_{12}$) → Resilience ($\eta_1$) | .214$^{**}$ |
| $H_{43}.\mu_2$: Flexibility capabilities ($\xi_3$) x Supplier risks ($\mu_{12}$)→ Resilience ($\eta_1$) | .011$^{ns}$ |
| Internal to the supply chain: Customer risks ($\mu_3$) | |
| $H_{41}.\mu_3$ : External capabilities ($\xi_1$) x Customer risks ($\mu_{13}$) → Resilience ($\eta_1$) | -.111$^{ns}$ |
| $H_{42}.\mu_3$: Integration capabilities ($\xi_2$) x Customer risks ($\mu_{13}$) → Resilience ($\eta_1$) | -.091$^{ns}$ |
| $H_{43}.\mu_3$: Flexibility capabilities ($\xi_3$) x Customer risks ($\mu_{13}$)→ Resilience ($\eta_1$) | -.128$^{ns}$ |

Notes: $t$-values calculated by applying a bootstrapping procedure with 1,000 sub-samples (Chin, 1998b); ns, non-significant; $^{*}$,$p < .05$; $^{**}$,$p < .01$; $^{***}$, $p < .001$;‡, derived measurement that combines the rating results related to social, political, economic, and environmental risks, through the calculation of mean values; coefficients of determination, $r^2_{\eta_1}$, .221.

tween Integration Capabilities and Resilience. This means that the effect becomes stronger as the supplier risk increases. Customer Risk turned out to have no moderating impact ($p > .05$) on any of the structural effects. We can conclude that External and Supplier Risk represent significant moderators as they affect at least one structural path in the model. Consequently $H_{41}$ and $H_{42}$ can be supported.

## 6. Discussion and concluding remarks

In this paper we provide insights into the lower-order capabilities that help a supply chain to achieve resilience. We provide a research framework that builds upon earlier literature about resilience in supply chains. Within a dynamic capability setting grounded in the Resource-Based View, we describe how lower-order capabilities developed using cross-functional and inter-organizational routines can provide a supply chain with higher-order operational capabilities.

Through our research we substantiate the theory-driven conceptual model of supply chain resilience, which is regarded as a major source of competitive advantage (Chang and Grimm, 2006; Li et al., 2008; Wisner, 2003). Starting from theoretical definitions of resilience in supply chains, we have operationalized them with supply chain managers, trait by trait. A conceptual model, embedded in the dynamic capability approach, was developed and tested using data from French supply chain managers. In summarizing the contributions of this paper, we distinguish between implications for theory and for practice.

*Implications for theory*

First, we conclude that in the view of supply chain managers, resilience is not easily enhanced, even though it is a highly desirable trait (Bhamra et al., 2011). In answer to the first question we asked in the Introduction, only integration and flexibility capabilities positively affect the resilience level of a supply chain. These findings resonate with those revealed through the Blackhurst et al. (2011) case study research. There, three major categories of factors were deemed to enhance resilience: human capital resources, organizational and inter-organizational capital resources, and physical capital resources. Of these, organizational resources were said to include defined communication networks, contingency plans, and supplier relationship management.

Second, we found that our results deviate from findings in the literature. As regards the results reported from the empirical investigation in Mandal (2012), the link between external capabilities and resilience cannot be corroborated, while the link between the supply chain infrastructure and integration and resilience is only partially validated. This may be due to the fact that the sample selection in Mandal (2012) is composed of IT professionals and not supply chain managers. We are unable to confirm the notions of Klibi et al. (2010) and see that the Efficient Customer Response type of external collaboration practices —as exemplified by Vendor Managed Inventories and Warehouse Management Systems— to streamline inventories across echelons have no impact on resilience.

Third, we selectively found moderating effects of supply chain risks on the relationships between capabilities and the resilience of a supply chain. More specifically, the question we asked in the Introduction was: How do environmental factors related to supply chains influence the effectiveness of these practices? The answer we provide here supports the notions developed in Walters (2006) in terms of risks external to the supply chain as well as risks internal to the supply chain related to suppliers. Interestingly, we find that customer risks do not play a significant role in affecting the proposed relationships in our model.

The size of the focal firm as a proxy for the extension of the supply chain has no influence on its

resilience, even though it should be a facilitating factor in the implementation of lower-order capabilities. This seems surprising for, as recognized in Waters (2011) several times, larger firms have more sophisticated tools and should thus be better placed to address market as well as environmental risks.

By applying the dynamic capabilities approach as a theoretical underpinning of our research, we have highlighted the link between specific lower-order capabilities and a supply chain's operational capability, namely, resilience. Additional research is required along three directions: (a) how to enhance specific supply chain capabilities; (b) how to combine those operational capabilities and how best to add learning capabilities that can be made dynamic; and (c) how to link such operational capabilities for the competitive advantage of a supply chain.

*Implications for practice*

In this paper, contrary to most papers dealing with the subject of resilience, we have positioned ourselves from the point of view of supply chain managers to understand how the actions, decisions, and practices they apply, the routines they set up, the collaborative and coordination effort and resources that they build upon contribute to the resilience of the supply chain to which their firm belongs.

Our results indicate that only some practices and asset and human deployments will provide an increased measure of this quality. Managers who combine and enhance both integration and flexibility capabilities will observe a level of resilience in their supply chain. This means that they must not only use information technology tools and routines to integrate their internal organization (through their ERP) but also use other supply chain management software to integrate their suppliers, customers, distributors, and logistics service providers. These efforts enhance collaboration by sharing forecasts and sales data and allowing continuous inventory adjustments. In conjunction with logistics service providers, using track and trace technologies for goods provides advanced tip-offs about events and glitches that affect service levels and quality. It is a notable result that the supply chains affected by high supplier risk concomitantly deploy these integration practices and resources.

Our results show that External Capabilities do not influence resilience. When we delve into the tools, practices, and routines involved, the following interpretation can be suggested: Supply chain managers do not have ample experience in applying efficient customer response policies, deploying both warehouse and transport management systems, streamlining inventories, as well as deploying vendor managed inventories. Hence the resilience effects have yet to be observed. The implementation of the routines and processes of Integration Capabilities, which involve the deployment of supply chain management software connected to the ERP—managing supplier performance, using business intelligence software to generate reports providing insights into the working of the supply chain as well as tracking goods—are all somewhat recent and require additional managerial capacities and training to be deployed effectively. Such practices may have not yet been mastered by all supply chains. This view is reinforced by the result that the influence of integration capabilities on resilience is higher when supplier risk is higher. That is, when a supply chain is subject to significant internal risks, the best line of conduct is to foster increased integration of the chain links so as to enhance its overall resilience.

Flexibility capabilities enhance resilience: Resilience can be augmented through the combination of alternative production and site plans, as well as by making plans more flexible and versatile. The pertinence of the deployment of these resources and routines increases with the incidence of external risks faced by the supply chain, such as raw material price hikes, political upheavals, or reg-

ulatory changes. Flexibility functions in several dimensions. The first dimension is the ability to meet new demands in terms of product type or quantities. The second is the ability to reconfigure the supply chain (upstream and downstream) by flexibly deciding whether to make or buy, to change locations, or to implement site specialization, while keeping tabs on a pool of suppliers. Unavoidably, such abilities in a supply chain go hand in hand with the supply chain manager's increased ability to detect and measure risks. A supply chain manager should deploy processes to identify and monitor risks and potential areas of trouble as a complement to the practices discussed above.

When controlling for the impact of the size of the firm, we found that the size of the focal firm is not an impediment to resilience, as even small businesses with limited resources can achieve the same level of resilience as larger firms. Neither could we distinguish an effect due to the economic sector. By extension, the focal firm can occupy any position in the supply chain (from manufacturer to retailer) without this position affecting its ability to enhance resilience.

## 7. Limitations and future research agenda

As with all research, this study has some limitations. The respondents to our survey were French managers, which results in a bias towards a Western European supply chain context. Future studies could be conducted in other country settings. Furthermore, we do not differentiate between different industries and supply chain stages (except as control variables), the study of which might yield additional insights. We applied a single-informant approach and thus rely exclusively on the perspective of supply chain managers. Using experts from other parts of the organization, such as marketing or finance, could complement our findings.

Our conceptual model only considers one moderator: supply chain risks. Further analyses of our data should include other moderators, such as firm or supply chain characteristics, to identify particular capability-resilience relationships.

Our approach is quantitative in nature. Qualitative interviews or focus group discussions with managers would help to understand better why external capabilities do not affect resilience whereas the other capabilities do.

Finally, further research is needed about the role of managerial expertise in building upon information technology as the means to embed managerial processes both within and across organizations so enhancing resilience. Information technology would need to be separated into more nuanced categories involving lower-order practices and routines (such as ERP, MRP II, collaborative platforms, tracking & tracing) or higher-order structures, such as information aggregation systems for business intelligence. In this way, researchers could better evaluate the potential impact of each set of practices on supply chain resilience.

## 8. Appendix

Table 3: External indicators and loading factors

| **Latent construct** Indicator | $\lambda$ | $t$-value | $p$-value |
|---|---|---|---|
| $\xi_1$: External Capabilities | | | |
| x11: deploying an Efficient Customer Response policy | .950 | 23.944 | <.001 |
| x12: deploying WMS and TMS | .804 | 13.132 | <.001 |
| x13: streamlining and resizing inventory in the distribution network | .644 | 7.089 | <.001 |
| x14: deploying a Vendor Managed Inventory policy | .666 | 6.836 | <.001 |
| $\xi_2$: Integration Capabilities | | | |
| x21:managing the performance of your suppliers in a collaborative way | .740 | 11.135 | <.001 |
| x22: integrating ERP with other SCM tools | .648 | 6.532 | <.001 |
| x23: deploying IT-based reporting tools | .784 | 16.870 | <.001 |
| x24: deploying tracking & tracing tools | .715 | 10.482 | <.001 |
| $\xi_3$: Flexibility Capabilities | | | |
| x31: setting up alternative production contingency plans | .903 | 23.989 | <.001 |
| x32: developing the versatility and flexibility of your sites | .791 | 11.888 | <.001 |
| x33:making production sites specialize per technology or product | .690 | 6.645 | <.001 |
| $\eta_1$: Resilience | | | |
| y11: Your supply chain system enables you to evaluate your process vulnerabilities constantly | .722 | 11.266 | <.001 |
| y12: You deploy alternative plans associated with identified risks | .829 | 21.426 | <.001 |
| y13: Your firm is able to evaluate the levels of risk facing your supply chain | .851 | 25.749 | <.001 |
| y14: Your supply chain organization allows you to increase visibility over all your chain | .730 | 10.081 | <.001 |
| *Supplier Risks* | | | |
| m11: Your supply chain is affected by external political risks | | | |
| m12: Your supply chain is affected by external social risks | | | |
| m13: Your supply chain is affected by external environmental risks | N/A | N/A | N/A |
| m14: Your supply chain is affected by external economic risks | | | |
| m2 : Your supply chain is affected by risks related to your suppliers | | | |
| m3 : Your supply chain is affected by risks related to your customers | | | |

Notions : All statements based on a five-point Likert scale (1, completely disagree, 5, completely agree)

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# Developing a maturity model for Supply Chain Management

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# Developing a maturity model for Supply Chain Management

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**Abstract:** The performance of a supply network decides the company's success and it is therefore, critical to develop a mature supply chain approach for the visibility of supply and demand collaboration. The aim of this research is to develop a Supply Chain Management (SCM) maturity model, which behaves as a maturity assessment tool that could meet the needs of companies' maturity level. The empirical part of the study introduces few impressive previously made supply chain maturity models, which also form a base for developing this model. Conceptual, analytical and decision methodological approaches were used as a research method.

**Keywords:** SCM; supply chain management; maturity model; logistics evaluation; competitiveness; management control; stakeholders; planning strategy.

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## 1 Introduction

The business controls are decidedly based on supply chain networks, which also influenced to the competitiveness both in domestic markets and in global operational environments. The focus has increasingly moved to competing network vs. network (Chroneer, 2005). As a whole, it can be said that the trend of logistics is to form the control of entirety between companies' operations where the material flow is optimal from the chain's participant's point of view and decisions are made thinking about the total benefit. Such being the case, developing logistics has an important role of strengthening competitiveness and partnerships and it also helps to achieve remarkable cost savings.

In literature, there are plenty of published papers, which explain and define the concept of Supply Chain Management (SCM) issues in general. According to Pastinen et al. (2003), SCM emphasises the view of extended value chain, in which different companies' value chains are connected to form a functional entity. Bridgefield Group (2005) presents supply chains as a linked set of resources and processes that begins with the sourcing of raw materials and extends through the delivery of end items to the final customer. According to the definition of SCM by the Global Supply Chain Forum, SCM is

> "the integration of key business processes from end user through original suppliers that provide products, services and information that adds value for customer and other stakeholders." (Chan and Qi, 2003; Gunasekaran et al., 2001)

SCM can only be talked if there is a proactive relationship between a buyer and a supplier and the integration is across the whole supply chain, not just first-tier suppliers.

The strategic objective of the supply chain is to maintain a compatibility relationship among upstream and downstream actors of the total supply network (Vanteddu et al., 2006). In reality, a supply chain is much more complex. For a company in the middle of the supply chain, the supply chain looks more like an uprooted tree, where the roots represent the supplier network and the branches represent the customer network. Successful SCM requires a change from managing individual functions to managing a set of integrated processes and further to start to compete chain vs. chain (or network vs. network) (Patterson, 2005).

Today's supply chains are facing increasing risks of demand and supply imbalance, liability, supply chain security and optimising the total cost (Lambert, 2004; Cohen and Roussel, 2005). Supply chain maturity implies stronger evolved processes and positive progress towards the goals of a company. The decision on maturity based on the

knowledge of information exchange and expertise within the company (Archer, 2006). This phenomenon captures the organisation's current maturity level across the five-level processes (plan, source, make, delivery and return) and its overall supply chain. It provides the assessment of organisations and guides an immediate measure, revealing areas that require attention to advance maturity, greater reliability, response, flexibility and financial performance.

The concept of maturity in supply chain network derives from the understanding that networks have life cycles that can be clearly defined, managed, measured and controlled throughout the time. When the maturity level is high, it means better control of output results, improved forecasting of goals, costs and performance and greater effectiveness in reaching defined goals (Poirier and Quinn, 2004). It can be discovered generally that the key enablers of a mature supply chain are lean and flexible operations, end-to-end visibility of supply and demand collaboration, event-based management and integrated technology. By creating mature supply chain operations, companies are better positioned to tackle changes in the supply chain environment. The supply chain maturity model is playing an important role when it is wanted to take the right actions for moving forward to the goal. This kind of model can be used to assess the current condition of the SCM processes and to help the companies to focus on the areas of improvement that makes sense for their current maturity stage (McCormack et al., 2003).

Maturity models of supply chain networks measure the maturity level of companies' suppliers that are the valuable framework for organisational leadership (Tiku et al., 2007). These models are used to evaluate the present situation of the companies based on the key competitive features, setting the goals pertaining to which factors are implemented next and identifying the factors, which are more critical for the necessary improvement actions and resource allocations.

This study introduces a few impressive models from which the companies are able to assess their current position in SCM maturity. Based on this, an applied model is developed for a SCM maturity model tailored just for the needs of the case company. The rest of the paper is organised as follows: in Section 2, we discuss an overview of maturity model while Section 3 highlights the different developed supply chain maturity models so far. Section 4 provides an executive summary of different developed maturity models and Section 5 introduces a new supply chain maturity model. Finally, Section 6 presents some discussion on supply chain maturity while Section 7 concludes the paper.

## 2 Maturity model: an overview

The literal meaning of the word maturity is ripeness, conveying the idea of development from some initial state to some more advanced state. The basic idea behind this is the notion of evolution, suggesting that the subject may pass through a number of intermediate states on the way to maturity. Basically, it can be said that definitions of maturity combine an evolutionary or experiential element with adoption of good practice. Furthermore, maturity implies that the processes are well understood, supported by documentation and training, is consistently applied in projects throughout the organisation and is continually being monitored and improved by its users (Fraser et al., 2002).

The concepts of process or capability maturity are increasingly being applied to many aspects of concerning supply chains, both as a means of assessment and as part of a framework for improvement. Basically, maturity models have been proposed for a range of activities including SCM, Enterprise Resource Planning systems, supplier relationships, R&D effectiveness, product development, innovation, product design, product development collaboration and product reliability for example Champlin (2002). The principal idea of the maturity models is that they describe, in few phrases, typical behaviours exhibited by a company or an organisation at a number of levels of maturity. With the maturity models, the company can also pinpoint their current maturity stage and view the next steps heading towards advanced practices.

Maturity approaches have roots in the field of quality management. One of the earliest approaches is Crosby's Quality Management Maturity Grid, which describes the typical behaviour exhibited by a company at five levels of maturity, for each of six aspects of quality management (Fraser et al., 2002). Perhaps the best-known derivative from this line of work is the Capability Maturity Model (CMM) for software that has been a model used by many organisations to identify the best practices useful in helping to increase the maturity of processes. The CMM takes a different approach however, identifying instead a cumulative set of the so-called Key Process Areas (KPAs), which all need to be performed as the maturity level increases. This is described as a 'staged' representation, and leads to the attribution of a single level for maturity in the range 1–5 (Carnegie Mellon Software Engineering Institute, 2005). Later on, in 2000, the CMM was upgraded to Capability Maturity Model Integration (CMMI). The CMMI is a process improvement approach that provides organisations with the essential elements of effective processes. It can be used to guide process improvement across a project, a division or an entire organisation (Kulpa and Johnson, 2003).

Although there have been proposed a number of different types of SCM maturity models, they all share the common property of defining a number of dimensions or process areas at several discrete stages or levels of maturity with a description of characteristic performance at various levels of granularity. This is also concerning all the developed maturity models of different subjects. Typology of the SCM maturity model can be generally speaking divided into two basic groups. These two groups can be characterised as maturity grids and hybrids or Likert-like questionnaires. The Likert-like questionnaire can be considered to be a simple form of maturity model when it is constructed in a particular way. In this case, the question is simply a statement of a good practice and the respondent is asked to score the relative performance of the organisation on a scale from 1 to *n*. This is equivalent to a maturity grid in which only the characteristics of the top-level practices are described. The SCM maturity models that combine a questionnaire approach with definitions of maturity are referred to be as hybrids. Typically, there might be an overall description of the levels of maturity but no additional description for each activity (Fraser et al., 2002).

## 3 Previously developed Supply Chain Management maturity models

There are several maturity models existing in literature to measure the maturity level of different fields such as software industry and project management. Along with software and manufacturing application, Vaidyanathan and Howell (2007) developed Construction Supply Chain Maturity Model (CSCMM). The objective of CSCMM was to provide

a roadmap for members to realise operational excellence, so that collectively the construction project can realise the benefits of improved performance. However, there also exists maturity models to measure the maturity standard of supply chain systems. PRTM Management Consultants (2005) developed four-level manufacturing supply chain maturity model, which describes how a company starting with functional automation can move to an enterprise-level automation and finally to effective cross-company collaboration across the entire manufacturing supply chain. The model provides a strategic direction for each manufacturing company.

It is of great importance to measure the maturity level of companies SCM system. In today's competitive business environment, it is recognised that continuous monitoring and improvement is essential for the business to thrive. Flexible, efficient and matured supply chains guide the business to maintain competitiveness and maximise customer and shareholder value (Lalwani and Mason, 2006). The maturity level is generally assessed in several ways such as web-based questionnaires, tests using financial data, and through joint discussions in workshops. The studies by Srai and Gregory (2005) and Foggin et al. (2007) both present lists of different maturity models within SCM issues, which span from simple two hours self-assessment tests to large cause and effect analysis, which require several weeks to fulfil.

Three research questions are presented in this paper. First research question is: "What kind of maturity models has already developed to assess the maturity and capability of supply chain participants?" The second research question is: "How the supply chain maturity models differ from each other?" The following SCM maturity models are presented here quite precisely owing to the nature of last research question: "What kind of maturity model can be developed based on the existing models which would meet the needs of the case company?" This requires an extensive viewpoint for developing a new supply chain maturity model. Based on our research on this subject, these SCM maturity models presented in this section are the well known and the most complete models. The models are described in a chronological order below:

### *3.1 Model 1A*

Charles Poirier has over the years developed two quite similar maturity models to picture the evolution of supply chain. These models are based on his decades of experience in the field and his work as a partner with one of the world's largest information technology and management consulting companies, Computer Sciences Corporation (Poirier, 1999; Poirier and Bauer, 2001). For his first model, Poirier (1999) has recommended the following four levels as a maturity model:

- *sourcing and logistics*: characterised by functional excellence and programmes like supplier reduction, inventory reduction and cost reduction
- *internal excellence*: use of activity-based costing and process management
- *network construction*: development of differentiated processes across the enterprise and cooperative planning with collaborators
- *industry leader*: wide use of technology tools, demand-supply linkages and a global perspective.

Table 1 details the four levels of maturity through which a company evolves as it strives to reach the advanced stages of SCM. A trip to the most advanced level must proceed through each of the preceding levels, as stages cannot be skipped (Poirier and Bauer, 2001). According to this model, the first two levels labelled 'internal' occur within the organisation, and the last two levels labelled 'external' occur when the company joins forces with external organisations. Arranged along the vertical side of the table are the key elements in SCM that are used to describe the evolution process (Poirier, 1999).

**Table 1** Levels of supply chain optimisation

| | *I* | *II* | *III* | *IV* |
|---|---|---|---|---|
| Driver | VP – Sourcing | CIO | Business Unit Leaders | Management Team |
| Benefits | Leveraged savings: FTE reduction | Prioritised improvements across network | Best partner performance | Network advantage: profitable revenue |
| Focus | Inventory: project logistics; freight: order fulfilment | Process redesign; systems improvement | Forecasting; planning; cust. Services; interenterprise | Consumer: network |
| Tools | Teaming: functional excellence | Benchmarks, best practices, activity based costing | Metrics, database mining, electronic commerce | Intranet, internet, virtual inf. systems |
| Action area | Midlevel organisation | Expanded levels | Total organisations | Full enterprise |
| Guidance | Cost data: success funding | Process mapping | Advanced cost models: differentiating processes | Demand/supply linkage |
| Reach | Major cost categories | Business unit | Enterprise | Global interface |
| Model | None | Supply chain intraenterprise | Interenterprise | Global market |
| Alliances | Supplier consolidation | Best partner | Partial alliances | Joint ventures |
| Training | Team | Leadership | Partnering | Holistic processing |
| | Internal | | External | |

*Source*: Poirier (1999)

## *3.2 Model 1B*

A couple of years after the first model were published; Poirier and Bauer (2001) proposed again a model of supply chain evolution. Differing from the previous model, this new model contains five levels but is otherwise similar to his four-level model. This model consists of the following five levels:

- *enterprise integration*: focused on functional processes
- *corporate excellence*: at the intra-enterprise level
- *partner collaboration*: begins the process of working with selected supplier and customers

- *value chain collaboration*: through e-commerce, internet and other cyber technologies
- *full network connectivity*: through integrating systems to the benefit of all partners.

These five levels describe how a company moves its supply chain effort to a position in which e-commerce characteristics are introduced, assimilated and used to advantage as a full network communication system.

**Table 2** E-business development framework

| *Maturity stage* / *Business application areas* | *Levels I/II* | *Level III* | *Level IV* | *Level V* |
|---|---|---|---|---|
| Information technology | Point solutions | Linked intranets | Intranet-based extranet | Full network communication system |
| Design, development product/service introduction | Internal only | Selected external assistance | Collaborative design-enterprise integration and PIM | Business functional view – joint design and development |
| Purchase, procurement, sourcing | Leverage business unit volume | Leverage full network through aggregation | Key supplier assistance, web-based sourcing | Network sourcing through best constituent |
| Marketing, sales, customer service | Internally developed programs, promotions | Customer-focused, data-based initiatives | Collaborative development for focused consumer base | Consumer response system across the value chain |
| Engineering, planning, scheduling, manufacturing | MRP<br>MRPII<br>DRP | ERP-internal connectivity | Collaborative network planning-best asset utilisation | Full network business system optimisation |
| Logistics and inventory management | Manufacturing push-inventory intensive | Pull system through internal/external providers | Best constituent provider-dual channel | Total network, dual-channel optimisation |
| Customer care and order management | Customer service reaction | Focused service-call centers | Segmented response system, customer relationship management | Matched care-customer care automation |
| Human resources | Internal sc training | Provide network resources, training | Interenterprise resource utilisation | Full network alignment and capability provision |

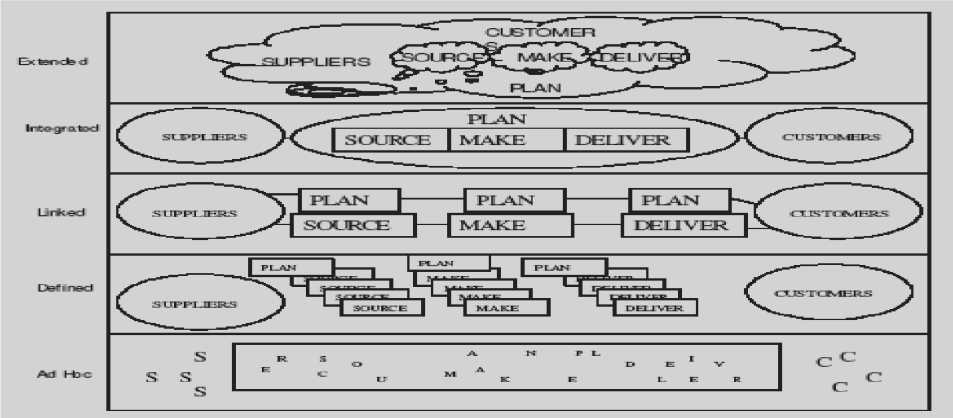
*Source*: Poirier and Bauer (2001)

## *3.3 Model 2*

DRK Research and Consulting LLC develops this supply chain maturity model, which has a foundation based on business process orientation concepts. These concepts are also based on Philip Crosby's development of a maturity grid for the five stages that companies follow in adopting quality practices as well as the CMM developed by Carnegie Mellon University in Pittsburgh for the software development process (McCormack et al., 2003).

The supply chain maturity model introduced here allows companies to quantitatively identify their position within a framework of maturity and industry benchmarked best practices. This model focuses on the five KPAs: *plan, source, make, deliver and return*. Figure 1 represents the view of process maturity that relates to the Supply Chain Operations Reference model.

**Figure 1** The Supply Chain Management maturity model view




*Source*: McCormack et al. (2003)

## *3.4 Model 3*

The Performance Measurement Group and PRTM Management Consultants (2005) jointly developed the supply chain maturity model from a combination of benchmarking experience and fields of knowledge. This model is used to assess the stage of capability for each of four processes *(plan, source, make and deliver)* defined by the Supply Chain Operations Reference model and also for what is classified as 'overall' SCM practices that govern the strategy and link the processes together.

This maturity model helps companies to break down their current supply chain practices for maturity and makes the companies to focus on their critical processes that will increase overall maturity (PRTM Management Consultants, 2005). The stage of maturity is derived from a qualitative assessment, which uses more than 270 questions and characterise supply chain practices in four areas (*plan, source, make, and deliver*), which address the overall supply chain practices. These areas are further broken down with specific questions and multiple-choice answers to cover the scope that is presented in Table 3.

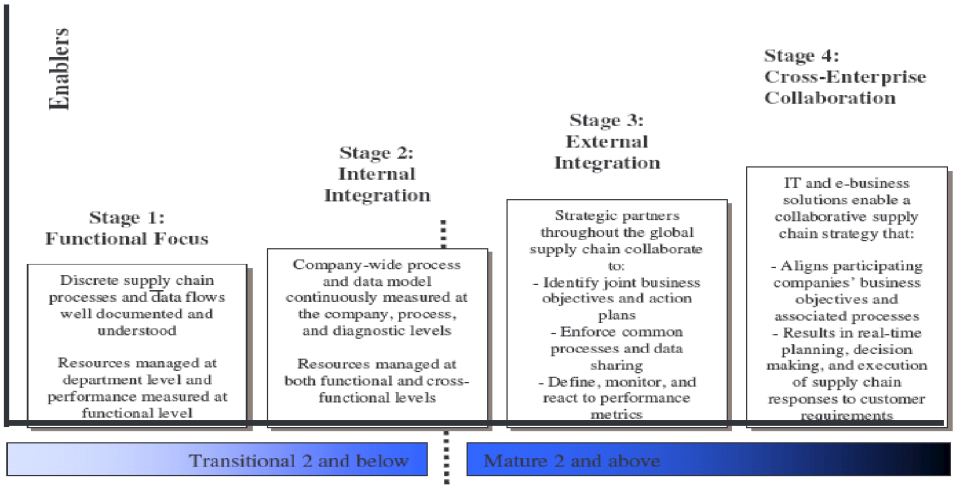
Figure 2 illustrates SCM maturity model, jointly developed by Performance Measurement Group and PRTM, which points out the maturity stages from 1 to 4 and separates mature practices from immature practices.

**Table 3** Operational elements in the Supply Chain Management maturity model

| | |
|---|---|
| Plan | Planning strategy |
| | Demand planning |
| | Supply planning |
| | Demand/Supply balancing and decision making |
| Source | Sourcing strategy |
| | Sourcing processes |
| | Supplier development/management |
| | Sourcing organisation and infra structure |
| Make | Manufacturing strategy |
| | Production scheduling |
| | Materials issue, movement, and tracking |
| | Manufacturing process control |
| Deliver | Deliver enablement |
| | Order entry and scheduling |
| | Warehousing, transportation, and delivery |
| | Invoicing and cash collection |
| Overall | Overall supply chain strategy |
| | Overall supply chain performance and management |
| | Overall supply chain processes |
| | Overall supply chain organisation |

*Source*: PRTM Management Consultants (2005)

**Figure 2** Stages of supply chain process maturity (see online version for colours)




*Source*: PRTM Management Consultants (2005)

### *3.5 Model 4*

Handfield and Straight (2004) developed a Supply Chain Capability Maturity Model (SCCMM) that aims to assist executives to determine the relative level of maturity of their enterprise supply chain business processes and to define what the organisation needs to do to positively affect the bottom line. This model is based on accumulated knowledge, documented research, in-depth interview and observation of best practices across global organisations and covers the broad range of business processes including design, source, make, deliver, sell/market and service.

**Table 4** Key areas of the Supply Chain Capability Maturity Model

| | *Design* | *Source* | *Make/Mfg* | *Market/Sell* | *Deliver* | *Service* |
|---|---|---|---|---|---|---|
| *Strategic* | Customer/ Supplier design collaboration | Supply base rationalisation and allocations | Rationalise manufacturing/ distribution network | Promotion strategy rationalisation | Negotiate contracts or outsourcing partnerships | Rationalise spares network |
| | Product line/mix rationalisation | Supplier Relationship Management (SRM) | Capacity rationalisation | Rationalise sales channels | Select logistics partners | Select inv stocking points |
| | New product requirements analysis | In/Outsourcing rationalisation | Long-term expansion | Market analysis | Rationalise transportation network | Service facilities rationalisation |
| | DFx | Indirect materials strategy | MRO strategy | Marketing spend | Reverse supply chain | Establish service level expectations |
| | Phase In/Phase Out | | Order management | Partner products | | |
| | | Supplier selection and contract negotiation | | Branding | | |

*Source*: Handfield and Straight (2004)

An organisation can use this assessment tool to derive quantitative scores from qualitative information on business processes. This assessment provides a benchmark of organisation's supply chain maturity as well as identifies areas for improvement. This model has also a very detailed approach to measuring and defining the relative maturity of these processes ranging from ad hoc to defined, linked, integrated and extended. Using a combination of self-assessment with structured interviews, a company can begin to understand the key areas of opportunity, as well as the key areas of potential risk. An example of the major modules associated with core strategic processes is shown in Table 4.

### *3.6 Model 5*

Ayers (2004), a principal of CGR Management Consultants, has established a supply chain maturity model with five stages of maturity. With this maturity model, users can self-assess their current situation and stage of maturity. The model also offers

to view plans for moving to the next stage. The structure of an entire maturity model is described precisely in Table 5. In this table, the left-side column represents five SCM tasks, also known as knowledge areas. Along the top are presented maturity stages 1–5. Table 5 is also explained at each stage for each task and described what it takes to achieve that stage (Ayers, 2004).

**Table 5** Stages of SCM maturity

| *SCM Tasks* | *I Dysfunctional* | *II Infrastructure* | *III Cost Reduction* | *IV Collaboration* | *V Strategic Contribution* |
|---|---|---|---|---|---|
| Strategic supply chain planning projects | No strategy exists to guide supply chain design | Supply chain awareness takes hold, however managers still view the company as standalone | Supply chain is viewed as a nonstrategic cost center for internal cost reduction | Joint strategic initiatives are pursued on a limited basis with suppliers and customers | Activity systems are implemented for strategic advantage |
| Internal collaborative relationships projects | Internal department measures, goals and objectives conflict with supply chain excellence | The organisation is functionally focused. Initiatives are departmental | Cross-functional initiatives begin, limited to the company and focused on cost reduction | Supply chain has moved into a single function, which manages multi-company relationships | The organisation has established multi-company infrastructure for important chains |
| Forging supply chain partnerships projects | Relationships with suppliers and customers are arm's length at best, antagonistic at worst | Collaboration up and down the supply chain is limited to transaction data | Efforts are limited to supplier initiatives focused on cost reduction, not revenue increases | Partners collaborate but roles are static. Partners pursue sphere strategies | Members of the supply chain expand their value contributions |
| Managing supply chain information projects | Basic information needed for decision-making is missing | Technology improvements focus on individual departments and maintenance | Systems efforts support cost reduction within the organisation. May or may not be process justified | Two-way information exchange supports transactions and mutual decision-making | Technology is a key element integrated into supply chain activity systems |
| Making money from supply chain projects | Cost reduction and process improvement is a hit-and-miss affair. Efforts-often hurt more than they help | Reductions are internal and measured through department budgets. Service is not an issue | Cost-reduction efforts cross departments but are limited to internal efforts | Supply chain cost reduction is limited to logistics and other operating costs | Cost reduction across the supply chain is the target. Benefits are shared among partners |

*Source*: Ayers (2004)

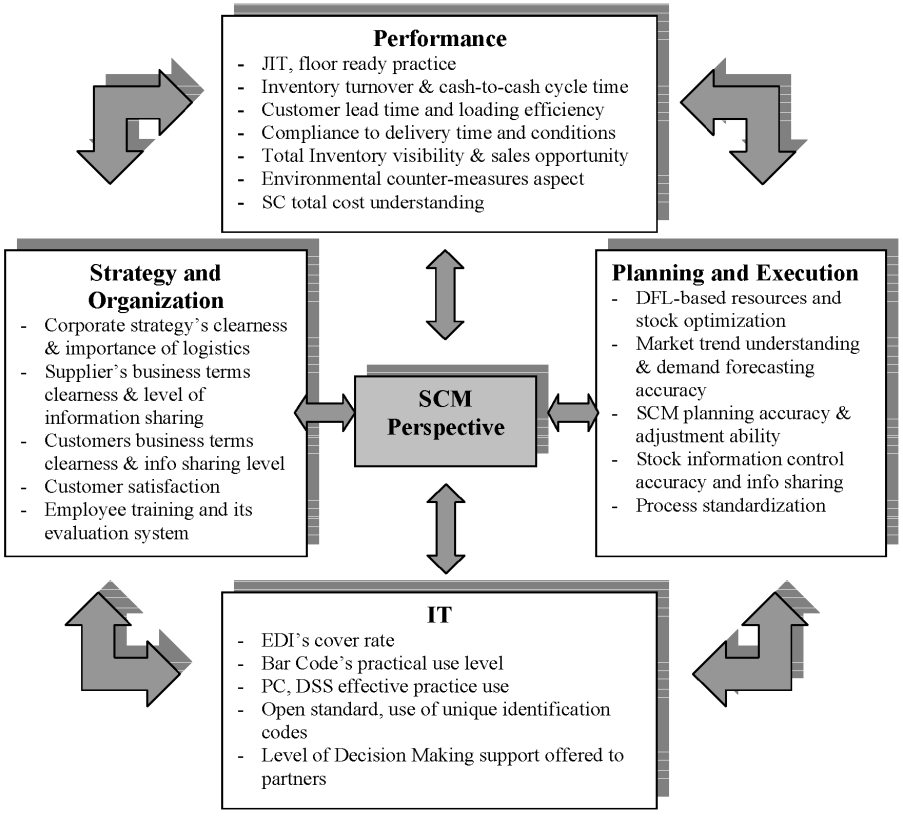
### *3.7 Model 6*

A fierce competition and changing circumstances in marketplace has been a driver to recent interest in logistics and SCM. This has also been governing the development of

SCM Logistics Scorecard model jointly developed with Takao Enkawa, Professor of Tokyo Institute of Technology and Japan Institute of Logistics Systems (Enkawa, 2005). The SCM Logistics Scorecard, a simplified benchmarking method, evaluates company's activities and effectiveness from a SCM point of view with assessment questions. This assessment tool consists of 22 parts, which are divided into four SCM core areas such as strategy and organisation, planning and execution, performance, and information technology. Besides the core areas, the Scorecard has also extended to contain some economical key ratios. Figure 3 describes the structure of a Scorecard model.

With the Scorecard subjective awareness of strengths and weaknesses can be determined through a self-assessment. The user evaluates its maturity on each area and items on Scorecard's five-level scales, resulting information of company's positions within an industry and overall industries. The Scorecard also provides suggestions of company's SCM operations and financial bottom-line improvements.

**Figure 3** SCM Logistics Scorecard's structure including core areas and sub-areas




*Source*: Enkawa (2005)

## 4 Executive summary of the developed maturity models

The preceding sections offered an introduction to the SCM maturity models that have been developed approximately during the years 1999 and 2007. The name of these

six models varies on from supply chain evolution, e-business development framework and supply chain maturity model to SCM Logistics Scorecard but all of these models can also be commonly called the SCM. These six models also have a common goal. They all divide supply chain practices in a different capability or maturity levels and aim to pinpoint the company's current position in maturity model on the way to the advanced capabilities. All these six models are based on years of supply chain benchmarking experience and field knowledge. These models have also been used for years, so they are tested, tried and proved. Almost every developer of these models is the consulting company, which has made half of the models commercial.

Owing to the commercial nature of the models, the inclusive information about those is not available naturally. According to the maturity models, which have been presented here, there are two different methods to measure the company's maturity and position in a maturity model. A company can either self-assess the current maturity stage based on step-by-step detailed defined model or a company can use a specific set of questions, which include questions from each of the supply chain key areas, to find out the current stage of maturity. Half of the models take advantage of the method used in the Supply-Chain Operations Reference model, which divides supply chain in KPAs. This kind of method is using exactly those above-mentioned models that contain the set of question-type determination of maturity stage. We have pulled all together in Table 6, which summarises these six SCM maturity models.

From the above descriptions, maturity models can be classified into two different approaches such as grids and hybrids/Likert-type questionnaires. We have pulled together the information of different approaches of the SCM maturity models in Table 7. This table also divides the models in stages and describes each stage.

**Table 6** Summary of the Supply Chain Management maturity models

| | *Model 1* | *Model 2* | *Model 3* | *Model 4* | *Model 5* | *Model 6* |
|---|---|---|---|---|---|---|
| The development company | Computer Sciences Corporation | DRK Research and Consulting | PRTM Management Consulting & PMG | Supply Chain Resource Consortium | CGR Management Consultants | Tokyo Institute of Technology Japan |
| The person that have developed the model | Charles C. Poinier | Kevin McCormack | PRTM | Robert Handfield and Kevin McCormack | James Ayers | Takao Enkawa |
| The method how to determine the maturity stage | Company self-assess the current maturity stage based on detailed model | Company fill in a questionnaire to find out the maturity stage | Company fill in a questionnaire to find out the maturity stage. Questionnaire is not publicity available | Company fill in a questionnaire to find out the maturity stage | Company self-assess the current maturity stage based on detailed model | Company self-assess the current maturity stage based on detailed model |
| Stages of a model | 4 & 5 stages | 5 stages | 4 stages | 5 stages | 5 stages | 5 stages |
| | Enterprise integration → Full network connectivity | Ad Hoc → Extended | Functional focus → Cross Enterprise collaboration | Ad Hoc → Extended | Dysfunctional → Strategic Contribution | The stages are not named |

**Table 6** Summary of the Supply Chain Management maturity models (continued)

| | *Model 1* | *Model 2* | *Model 3* | *Model 4* | *Model 5* | *Model 6* |
|---|---|---|---|---|---|---|
| Special characteristic | Simple model and detailed defined stages provides fast and easy determination of a maturity stage | The model acts also as a visual score card of the current situation and areas of opportunity | The model provides a good starting point for evaluating existing supply chain capabilities and selecting the critical best practices | The model acts also as a visual score card that can help explain some of the interfunctional linkages and their weakness that may exist | The simple model offers a fast assessment of the current state for design of SCM project processes | Gives some suggestions to improve company's SCM operations and financial bottom line |
| | Company evaluates their progress against the model in specific key business application areas | The model focuses on the four key process areas: plan, source, make and deliver | The model is used to assess the stage of operational capability for each of four operational elements: plan, source, make and deliver | The model covers the business processes areas such as design, source, make, deliver, market and service | Company evaluates their progress against the model in five SCM knowledge areas | Company evaluates their progress against the model in four supply chain core areas and 22 items of them |

**Table 7** Approaches of the models

| *SCM Maturity Model & Reference* | *Maturity stages* | | | | | *Approach* |
|---|---|---|---|---|---|---|
| Computer Sciences Corporation (1st.) | I<br>Sourcing and logistics | II<br>Internal excellence | III<br>Network construction | IV<br>Industry leader | | Maturity grid<br>10 issues, detailed description at each stage |
| Computer Sciences Corporation (2nd.) | I<br>Enterprise integration | II<br>Corporate excellence | III<br>Partner collaboration | IV<br>Value chain collaboration | V<br>Full network connectivity | Maturity grid<br>8 issues, detailed description at each stage |
| DRK Research and Consulting | I<br>Ad Hoc | II<br>Defined | III<br>Linked | IV<br>Integrated | V<br>Extended | Maturity grid/ Likert Hybrid<br>6 issues, brief description at each stage plus 5 point scale |
| PRTM Management Consulting & PMG | I<br>Functional focus | II<br>Internal integration | III<br>External integration | IV<br>Cross-Enterprise collaboration | | Maturity grid/ Hybrid checklist<br>5 areas. 20 issues, brief description at each stage |

**Table 7** Approaches of the models (continued)

| *SCM Maturity Model & Reference* | *Maturity stages* | | | | | *Approach* |
|---|---|---|---|---|---|---|
| Supply Chain Resource Consortium | I<br>Ad Hoc | II<br>Defined | III<br>Linked | IV<br>Integrated | V<br>Extended | Hybrid checklist<br>6 areas 105 issues, brief description at each stage |
| CGR Management Consulting | I<br>Dysfunctional | II<br>Infrastructure | III<br>Cost reduction | IV<br>Collaboration | V<br>Strategic contribution | Maturity grid<br>5 supply chain tasks, detailed description at each stage |
| Tokyo Institute of Technology Japan | I | II | III | IV | V | Maturity grid/ hybrid<br>4 areas, 22 issues, detailed description at each stage |

All of these models are basically somewhat similar, only the observed subject areas of supply chain are varying. It is important to recognise that companies should progress in sequence through the stages of those models by building on the practices they have solidly established at each stage. In order for a company to be considered mature for a given maturity stage, it must be effectively using a majority of its practices from that stage.

## 5 Development of new Supply Chain Management maturity model

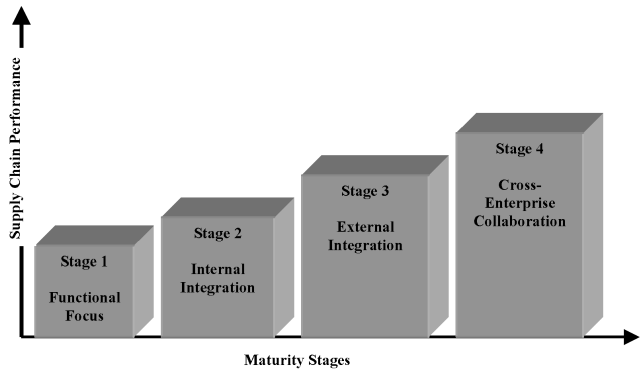
It is justified to use PRTM Management Consultants and The Performance Measurement Group's supply chain maturity model as a base when developing a new model because the previous model is developed using knowledge gained from more than a decade of supply chain benchmarking experience and field knowledge of current and future practices in different industry segments. At the same time, when this research aims to develop a completely new model tailored just for the needs of case company, it also uses one of the previously made models as a base also adopting characteristics from other models. Such being the case, all the sub-questions features are combined in this forthcoming model.

Building of such a model starts by developing and defining the maturity stages for the applied model. After that, the target assessment areas or KPAs are decided and determined. Now, when the base for the model has been created, it is time to formulate the actual assessment tool, a questionnaire for assessing the maturity of different supply chain process areas and practices of supply chain participants. The initial aim has been to build the model to be as simple as possible including the instructions of how to use the tool in practice.

### *5.1 Developing and defining the maturity stages*

During the creation of this proposed model, four stages called *functional focus, internal integration, external integration and cross-enterprise collaboration* were considered to be applicable. Figure 4 illustrates the ABB Corporate Research Center's (ABB, 2007) four stages SCM maturity model where stage 4 describes the most mature state whereas the most immature state stands in stage 1. In other words, this model is based on an idea where a highly mature supply chain is one that has achieved advanced capability across each stage of the model. The following sections give general definitions to each of the four stages of newly developed maturity model and at the same time, it is illustrated on how the practices in each stage are influencing to the structure of the whole value chain.

**Figure 4** The maturity stages of ABB corporate research centre's Supply Chain Management maturity model




*Stage 1: Functional focus*

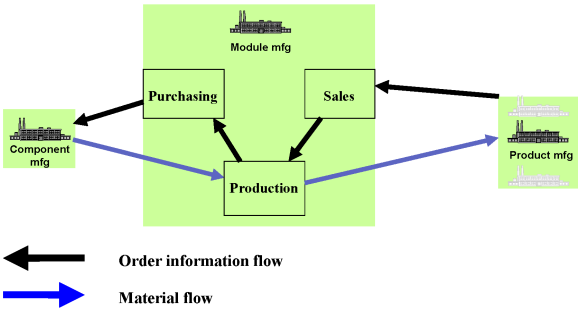
Discrete supply chain processes and data flows are well documented and understood. Organisational roles, responsibilities and supplier partnerships are not well defined. Basic information, which is not available across the organisation, is electronically collected from many different databases with limited access. Functional departments within an organisation are focusing on improving their own process steps and use of resources, performance is also measured at functional level. Managers are typically focusing on their individual department's costs and functional performance. Figure 5 depicts functional focus where the order of information flows systematically through sales, production, purchasing and end in a supplier. In other words, demand/ supply information flows internally but there are no integrated processes across plants (ABB, 2007).

*Stage 2: Internal integration*

Division or company-wide processes are now defined; this allows individual functions to understand their roles in complex supply chain processes. Process-specific information is collected and shared within the factory using integrated systems and internal databases. At this point, supplier partnerships are already well defined and classified. Resources are managed at both functional and cross-functional levels; also resource requirements are typically balanced across the organisation. Figure 6 represents internal integration where order information flows simultaneously from sales to production, purchasing and finally

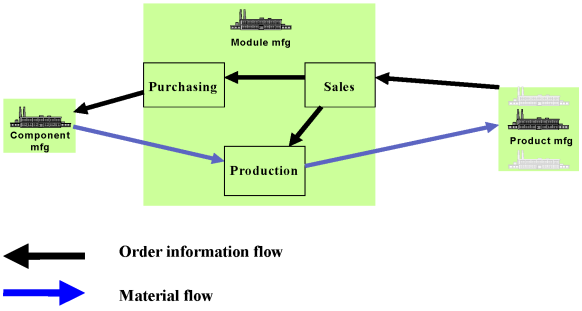
end to supplier. In internal integration, demand and supply planning processes are aggregated across the company.

**Figure 5** Functional focus (see online version for colours)




*Source*: ABB (2007)

**Figure 6** Internal integration (see online version for colours)




*Source*: ABB (2007)

*Stage 3: External integration*

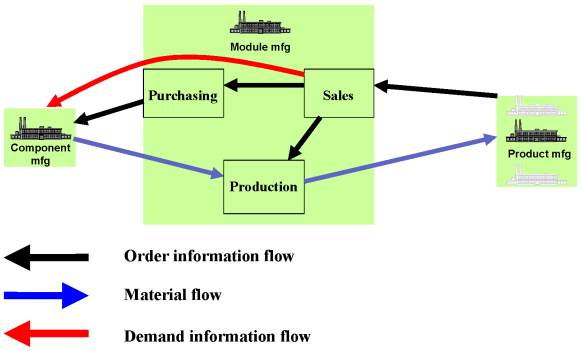
Stage 2 practices are now extended to the points of interface with customers and suppliers. Strategic customers and suppliers are identified, as well as key information the company needs from them to support its business processes. Also, effective collaboration processes with key customers are implemented and information is collected and shared electronically with the value chain parties. Figure 7 pictures external integration where the company has adopted automated links to customer demand and this information is shared directly to the suppliers, in addition that the order information flows simultaneously from sales to production and purchasing.

*Stage 4: Cross-enterprise collaboration*

Information technology plays an important role at this stage. Customers and suppliers work to define a mutually beneficial strategy and principles and they set real-time performance targets. Information technology now automates the integration of the business processes across these enterprises supporting of an explicit supply chain strategy. There is a real-time information visibility across the entire value chain where the supply chain improvement tools are also used effectively (Matopoulos et al., 2007). Figure 8 shows the most mature state, cross-enterprise collaboration,

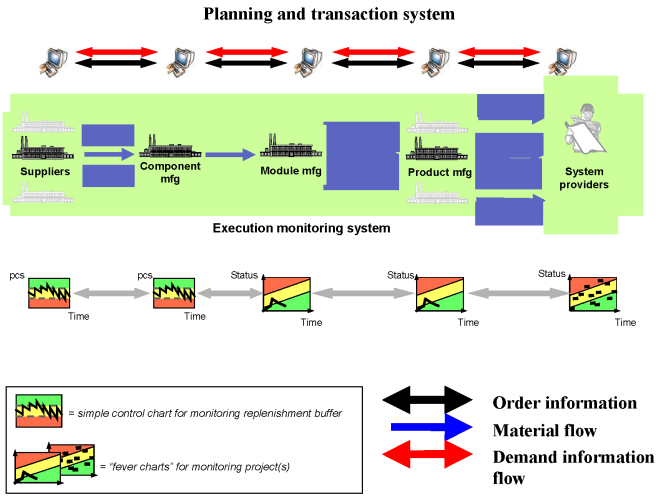
where internet-enabled processes or integrated systems allow all participants in the supply chain to view the same demand information simultaneously.

**Figure 7** External integration (see online version for colours)




*Source*: ABB (2007)

**Figure 8** Cross-enterprise collaboration (see online version for colours)




*Source*: ABB (2007)

## *5.2 Defining the questions for questionnaire*

From the integration of factories and smooth cooperation point of view, three important things can be seen in ABB: How the information is shared in a supply chain, how this information is used in decision-making situations and how the physical materials move in a supply chain (ABB, 2007). These three notable matters formed the base for developing the right questions to the maturity assessment tool to pinpoint the company's maturity stage of different supply chain practices. The assessment questions were founded on both of our own judgement and knowledge, so that the developed maturity assessment tool could meet as much as possible, the needs of the studied research company ABB Corporate Research Centre. The questionnaires were revised and updated with the help of ABB Corporate Research Centre's consultants in Vaasa, Finland.

The maturity assessment tool is built up so that each sub-area contains questions/statements from each of the four maturity stages and for each stage there are directed two questions/statements. The maturity assessment tool is composed of 128 questions. There are two possible ways to choose the answers to the questions. The user can choose either the point of *dominant practices* that are practices that are well established and used across the organisation or future practices that are practices that are already defined in the organisation but not fully implemented yet. Future practices may also be practices that the company has planned to carry out in a near future.

The practices stated in each of four stages are organised so that they proceed in consequential order so that practices in stage 1 are the most immature while the practices in stage 4 are the most mature. In other words, questions at each stage are aimed to be defined so that the progress should happen in sequence through each stage by building on to the practices that have established at each stage. Attempts to advance without a base of firmly established practices are not recommendable. The main idea is to achieve effective functional focus and internal integration before attempting to adopt any substantial externally integrated processes. In the above consequences, a company is considered to be mature for a stage in which majority of practices is effectively used.

One of the key principles is that set of questions in a maturity assessment tool is used in a way that the target company can assess their dominant and future practices in each sub-areas as well as in each stage of the tool. An example of this is illustrated in Table 8 with using the planning practice's sub-area called planning strategy. Throughout the whole assessment tool, the stages are organised in reverse order starting from asking the questions in stage 4 proceeding down to stage 1. The aim is to avoid or pass the notice of possible embarrassment of immature organisations to be placed in low maturity stages along this assessment tool. On the other hand, when all the practices are gone through starting from the most mature practices, the organisation gets conveying information of those mature practices that the organisation should be trying to reach.

**Table 8** An example of planning strategy from maturity assessment tool (see online version for colours)

| Question | Dominant practices | Future practices |
|---|---|---|
| **Stage 4** | | |
| Integrated systems enable the **real-time information sharing** between factories | ☐ | ☐ |
| There is **real-time information visibility** across the entire value chain | ☐ | ☐ |
| **Stage 3** | | |
| Advanced Supply Chain Collaboration (ASCC) is used to increase the transparency in the supply chain and to improve the partnerships with suppliers | ☐ | ☐ |
| Specified and agreed **information is collected and shared electronically** with the value chain parties **in a agreed periods of time** | ☐ | ☑ |
| **Stage 2** | | |
| Integrated systems and internal databases are used | ☑ | ☐ |
| Process specific information is **collected and shared within the factory** | ☐ | ☑ |
| **Stage 1** | | |
| There are many different databases with **limited access** and there are also separate and limited access software for product configuration and project management | ☑ | ☐ |
| Basic information is **collected electronically** but is not available across the organisation | ☑ | ☐ |

### *5.3 Presentation of the outcomes*

It is extremely important that the outcomes or results are presented by illustrations and they are easy to interpret. So, visualisation had a significant role when we were planning the possible ways to present the outcomes of the maturity assessment tool. Based on the company's responses in each 16 sub-areas, the results can then be presented in a way as illustrated in Table 9. This way of representation allows fast and easy interpretation and comparison of outcomes, showing the current maturity stage in each sub-areas. Table 9 plots the company's dominant and future practices in each sub-areas based on the answer choices so that spots in the middle of the grid point out half stages, whereas the spots in the right side of the grid point out the whole stages. Results in this table are imaginary.

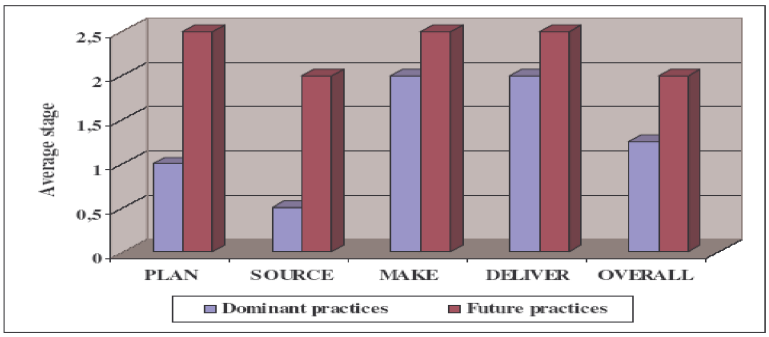
**Table 9** Dominant and future practices at each stage (see online version for colours)

| | | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|---|---|---|---|---|---|
| PLAN | Planning strategy | • | | ⊙ | |
| | Demand planning | | • | ⊙ | |
| | Supply planning | | • | ⊙ | |
| | Demand/Supply balancing and decision making | • | ⊙ | | |
| SOURCE | Sourcing processes | • | ⊙ | | |
| | Supplier management | • | ⊙ | | |
| | Sourcing organisation and infrastructure | • | ⊙ | | |
| MAKE | Manufacturing strategy | | • | ⊙ | |
| | Production scheduling | | • | ⊙ | |
| | Manufacturing process | | • | ⊙ | |
| DELIVER | Order management | | • | ⊙ | |
| | Warehouse management and delivery | | • | ⊙ | |
| | Invoicing | | • | ⊙ | |
| OVERALL | Overall value chain metrics | | • | ⊙ | |
| | Overall value chain development | • | ⊙ | | |
| | Overall value chain results | | • | ⊙ | |

• = Dominant practices ⊙ = Future practices

Table 9 is dominant and future practices on average scores can be presented from each of the SCOR areas by using a chart as described in Figure 9. This table helps organisations to outline the whole situation in each area's dominant and future practices. It enables the comparison between different areas too.

**Figure 9** Average stage for dominant and future practices by SCOR element (see online version for colours)



After a while doing the maturity mappings of different organisations or companies, the average and best in class results can then be easily formed. The results then can also be presented as in Table 10, which shows the target company's maturity in each sub-areas and the average scores that the leaders have.

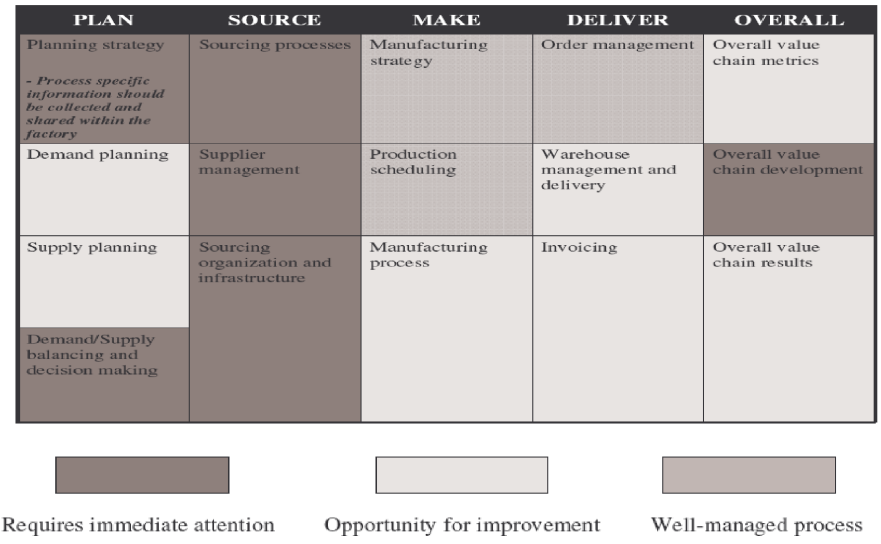
**Table 10** The Company's own maturity scores, average and best in class results (see online version for colours)

| | | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|---|---|---|---|---|---|
| PLAN | Planning strategy | • | | ☆ | |
| | Demand planning | | • | ☆ | |
| | Supply planning | | • | ☆ | |
| | Demand/Supply balancing and decision making | • | | ☆ | |
| SOURCE | Sourcing processes | • | | ☆ | |
| | Supplier management | • | | ☆ | |
| | Sourcing organisation and infrastructure | • | | ☆ | |
| MAKE | Manufacturing strategy | | • | ☆ | |
| | Production scheduling | | • | ☆ | |
| | Manufacturing process | | • | | ☆ |
| DELIVER | Order management | | • | ☆ | |
| | Warehouse management and delivery | | • | ☆ | |
| | Invoicing | | • | | ☆ |
| OVERALL | Overall value chain metrics | | • | ☆ | |
| | Overall value chain development | • | | ☆ | |
| | Overall value chain results | | | ☆ | |

• - Your company —— - Average ☆ - Best in class

The maturity assessment tool's results or outcomes can be further presented in a way, which is illustrated in Figure 10. There, the areas plan, source, make and deliver are presented and they are further broken down to all 16-sub areas. More detailed information concerning functions or practices, which for example requires immediate attention, can be added into this table by using Table 8's answer choices as an example.

**Figure 10** Results presented in a form that helps to highlight the critical areas (see online version for colours)



## 6 Discussion

Global businesses are continuously moving towards outsourcing to make balance with the present customisation era. The outsourcing, which is related to supplier's involvement, becomes an increasingly powerful trend in modern multinational companies (Manzini et al., 2007). It is necessary to control and manage effectively with these suppliers maturity standard to compete with diversified product range and increasing customer awareness. The required level of integration among upstream supply chain and downstream customer's requirements must be achieved to meet the strategic objectives of the manufacturing companies (Vanteddu et al., 2006).

The maturity model framework proposed above is a new way of thinking and organising the disparate supply chain efforts around business processes, tools and standards by recognising the need for a conscious strategy around organisation. The proposed maturity model will be dynamic by definition and evolving. As the organisation matures, we need to develop the benchmarking further to assess a company's maturity level based on the various assessment criteria listed above. Companies' different performance criteria need to be updated in a regular interval that matches the expectations from a certain maturity level. They can look to consistent processes, performance and expectations because of achieving certain maturity standard. The benefits of achieving this will be of tremendous value to improving the processes in the industries supply chain network as a whole.

The evidence pointing to improved business performance through supply chain maturity is significant but has often been a subjective assessment. According to recent researches on this area, linking SCM maturity to performance can provide some of the answers, at least at the high level. In accordance with the research by McCormack et al. (2003) aim to relate financial bottom-line performance to SCM maturity and link this performance to maturity stages, which show that there is a dramatic difference between bottom maturity stages and top stages. SCM costs as a percent of total revenue, for example are 3% lower at the upper stages than lower stages. The cost of goods sold is almost 12% lower and profit is 2% higher in upper stages. According to the research, it is also seen that top maturity stages had an average increase in sales of 20% year to year while the lower stages had only 6%. This strongly suggests that the SCM maturity model can be used as an indicator of financial performance.

In the above consequences, research is going on to develop new and improved maturity models for supply chain evaluation that can contribute to the continuous improvement of companies supply chain maturity level. In addition, evaluating and certifying a supply chain maturity will be a new dimension in the application and benchmarking of cross-company maturity models. Future research could be involved to validate the proposed maturity model to enhance its benchmarking criteria. Research also needs to develop this model to correlate with several criteria to business performance such as cost, quality and efficiency of production line.

## 7 Conclusions

A supply chain maturity model can be considered as a methodology that is related to definition, measurement, management and the controlling of business process. Higher level of maturity indicates the superior performance of an organisation (Poirier, 2006).

This paper has presented results from qualitative research that investigated the level of supply chain maturity of ABB supply chains, and studied the relationship mapping between supply chain process maturity and its performance. In respect of business leadership, supply chain maturity models have wide application for performance measurement and continuous process improvement within an organisation. The maturity models are valuable tools for the leadership of companies supply chain systems through determining the stages of maturity and setting the goals of maturity improvement. A new applied maturity model for the manufacturing SCM has been proposed in this paper. The model provides a framework to assess both where the company is today along the maturity stage and how it can goes to more advanced maturity levels.

The resulted maturity assessment tool contains 128 questions to be able to point out the maturity of practices. Such being the case, the tool might prove to be quite toilsome with all of those questions but, on the other hand, it also allows a very specific determination of the maturity state in different supply chain areas and practices. The resulted maturity assessment tool will certainly develop and become more accurate further for the part of the questions, during the usage of the tool. The tool also allows a different kind of usage; it can also be used like a self-evaluation tool, which carried through without an external auditor where the target company assesses its own practices for example, by using simple stage definitions or the grid. Used like this, it does not give the most accurate results of the company's current maturity stage but allows still a fast and easy evaluation.

Although the developed tool is quite helpful for companies but still there are some limitations for its application. In this maturity model, we investigate the studied company's supply chain maturity by asking questionnaires, which could be biased from the real values that make the outcome in question. This model also did not consider the cost estimations during planning and implementation stages of companies supply chain maturity. This tool can only be used for evaluating some of the areas in supply chain for example, just planning practices or sourcing practices. However, using the tool as a whole, offers naturally the most extensive picture from the maturity of practices.

This maturity assessment model aims to place the company in a specific maturity stage, based on the answers in questionnaire. In order for having more detailed information on the used practices and their maturities in companies and for being able to help companies to focus their improvement efforts on the critical processes that will increase their supply chain maturity, the maturity assessment questionnaire could be expanded to include more and more specific questions or statements in each stage. One interesting research area would also be to study what kind of benefits more mature companies are enjoying compared with less mature companies. For example, can there be found any correlation between supply chain maturity and superior performance when using this model?

Until today, there is not any supply chain maturity model able to manage properly the typical complexities encountered in the management of supply chain networks although several efforts are taken for improving and expanding the individual performance evaluation into companies' suppliers, distributors and customers. Future research could be considered to identify the barriers of the application of any maturity model for companies' supply chain performance measurement and possible improvements. The costs involvement in planning and implementing maturity models are also need to be investigated critically.

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Supply Chain Strategies, Capabilities, and Performance

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EDWARD A. MORASH

# Supply Chain Strategies, Capabilities, and Performance

*Abstract*

*The choice of a supply chain strategy and value focus should be supported by specific enterprise capabilities and ultimately result in intended logistical performance. For excellent firms, a demand focus on customer service and proactive quality is more apparent at both the capability and performance levels than a supply focus on cost, productivity, distribution, and speed. Reasons are offered. Strategic intent and normative value congruency for competitive advantage also mean that customer closeness strategies such as customized logistics and agility tend to be supported particularly by demand-side capabilities, while operational excellence strategies such as time-based strategies (e.g., JIT) or lean networks tend to be supported more by supply-side capabilities. While on-time performance and absence of loss-and-damage are minimum order qualifiers, other logistical performance outcomes are order winners depending on the chosen value discipline. "Doing it right the first time" is more important than problem recovery, yet service failures do provide valuable information for problem diagnosis, organizational learning, and future improvements. Similarly, advanced notification of problems to customers and total performance measurement like overall customer satisfaction are also characteristic of best-in-class firms.*

A review of managerial literature and practice reveals that supply chain strategies, capabilities, and performance are increasingly important topics for practitioners and researchers alike.[1] Supply chain capabilities are the building blocks for supply chain strategy and a source of competitive advantage for firm success. This strategy/capabilities/performance paradigm or framework is schematically represented in Figure 1. Two major classes of supply chain strategies are operational excellence and customer closeness.[2] Each of these distinct strategies will be discussed in turn with examples. They will also be evaluated empirically by the present research in the context of supporting supply chain capabilities and resultant performance.

Operational excellence strategies can support business strategies of overall cost leadership through total cost reduction, efficient and reliable supply, and high levels of basic service.[3] Operational excellence is sometimes referred to as a supply management focus in logistics strategy literature,[4] and is represented in Figure 1. It has been stated that "companies pursuing operational excellence are indefatigable in seeking ways to minimize costs, to eliminate intermediate production steps, and to reduce transaction and other 'friction' costs."[5] Suppliers are frequently selected based primarily on cost, reliability, and ease of doing business, while production and logistics systems are operated for efficiency and zero defects. The output emphasis of the supply chain is on "hassle-free" basic products and services that are standardized rather than customized.[6] However, when quality problems do occur, problem recovery may be especially important to satisfy customers, possibly even beyond a trouble-free outcome.[7]

One would expect operational excellence to be supported by supply chain capabilities such as low logistics costs, distribution coverage and

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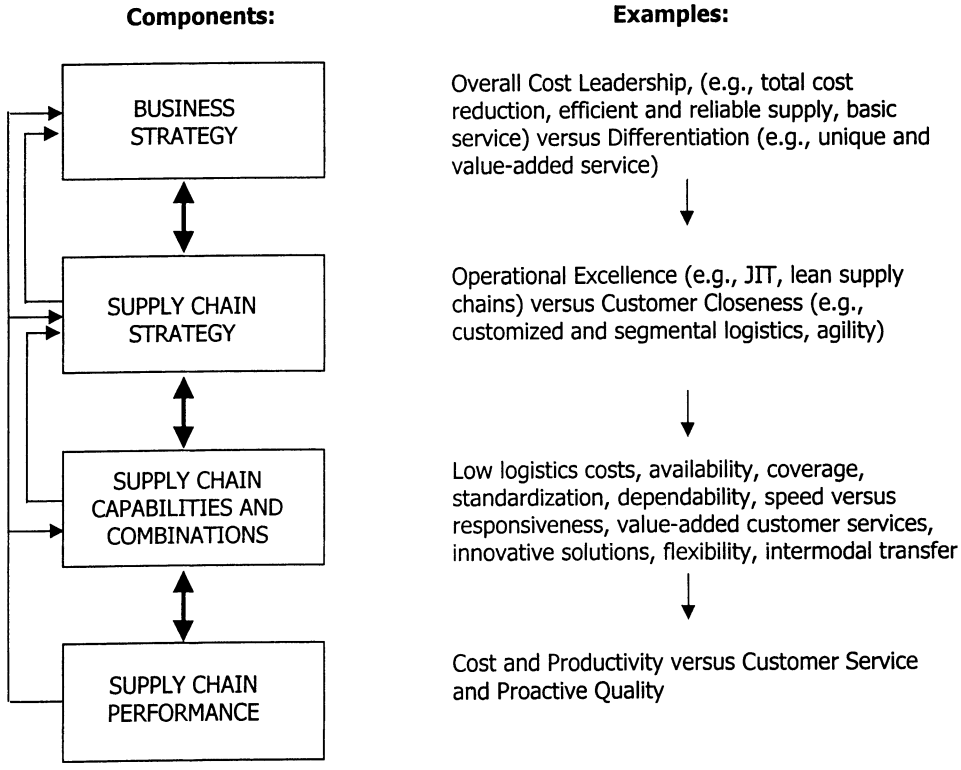
***This research is part of the larger and ongoing logistics best practices research stream being conducted at Michigan State University.***

**Figure 1. Model of Supply Chain Strategy, Capabilities, and Performance**




availability, dependability, standardization of operations, time-definite deliveries, and delivery speed. A sampling of these capabilities is shown in Figure 1. As such, the objective of operational excellence is usually to lead an industry in price, reliability, convenience, and speed.[8] For customers, this means efficiently delivering reliable products and services at competitive prices and with minimal difficulty and inconvenience.[9] This reflects total cost minimization for customers, not only because of lower prices but also because of reductions in customer costs from optimal order fulfillment and supply chain time compression. As such, operational excellence may emphasize using total supply chain cost as a marketing weapon both to retain existing downstream customers and to attract new customers.

Examples of operational excellence include time-based strategies[10] such as just-in-time (JIT) deliveries[11] and lean supply chains.[12] These strategies are shown in Figure 1. Time-based and lean strategies will be investigated in the present research as to their relationships with supporting supply chain capabilities. JIT supply chains emphasize time-definite deliveries (i.e., known leadtimes of low variability). This can reduce buffer inventory and safety stocks. JIT may also involve more frequent deliveries of smaller shipments, which can increase inventory throughput or velocity. In turn, this can lower in-transit inventory and cycle stocks. Other contemporary logistics operations that can facilitate JIT and thereby also reduce inventories include cross-dock operations, synchronizing and sequencing transportation with production, delivering commodities to exact points on the production line using flexible transportation equipment and containers, in-transit acceleration and deceleration to regulate the flows, and direct delivery.

Turning to lean networks, lean supply chains reduce all types of waste, errors, unnecessary assets, and cycle times by continuously seeking perfection and operational efficiencies throughout the supply chain network.[13] Types of logistics-related waste that can add cost but no value include waiting, rectification of mistakes,

excess processing, unnecessary warehousing, extra handling, excess transport and terminals, and excess stock.[14] Innovative logistical solutions may involve outsourcing, using postponement strategies, redesigning processes, optimally locating facilities, reducing or redeploying network assets, and having resident suppliers' production lines and employees physically on premise through early supplier involvement and development (i.e., JIT II for resident buyers or JIT III for resident production).

### Customer Closeness

The second major category of supply chain strategies relates to customer closeness,[15] which will also be investigated in this research. Customer closeness strategies can support business strategies of differentiation through high levels of value-added customer service, proactive quality (i.e., "do it right the first time"), and collaborative communications and interactions with customers. Customer closeness is sometimes referred to as a demand management focus in supply chain strategy literature,[16] and is represented in Figure 1.

Customer closeness means selling the customer not just a product or service, but rather total customer satisfaction through augmented solutions that include ongoing help, high levels of support, and interactive advisory service.[17] Firms following this strategic approach increasingly become experts on their customers' businesses and continuously elevate the relationships. This may mean advancing through levels of customer service, to customer satisfaction, to customer success (the three S's). As "internal consultants" within their customer's organization, they continually search laterally for additional opportunities to improve supply chain processes and to add value.[18] Rather than just meeting customer expectations, they try to stay ahead of these expectations by guiding the customer to appropriate change. In total, such proactive demand management attempts to go beyond the typical market offerings and outcomes of standardized variety, reactive problem solving and recovery, and even mere satisfaction of existing customer expectations. Managerially delighting the customer means that the unexpected should gradually become the expected.[19]

One would expect supply chain strategies involving customer closeness to be supported by demand-management capabilities such as responsiveness to key customers, special value-added customer services, customization and innovative solutions, flexibility, proactive quality and communications, intermodal transfers, and again dependability. This is schematically illustrated in Figure 1. Customer closeness also requires interactive long-term relationships with a firm's customers, suppliers, and partners. There is recognition by cooperating firms that the supply chain is part of the total product offering and that they must act in a concerted way to assure value for final consumers.[20] There is also an emphasis on using the supply chain as a proactive marketing weapon to achieve growth objectives. For example, some supply chain firms do marketing research on the needs of their customers' customers.[21] There is an awareness that if their customers succeed, then everyone in the supply chain will grow.

Major examples of customer closeness as supply chain strategies include customized logistics and agility, which are shown in Figure 1. Logistical customization and agility strategies will be evaluated in the present research in terms of identifying their relationships with potential supporting capabilities. Extant logistical strategy literature suggests that customized logistics tailors supply chain capabilities and value-added services to specific customer needs.[22] These distinct and responsive offerings represent specific solutions directed at what individual customers or segments want, rather than general solutions reflecting what the market wants.[23] However, this does not necessarily mean a proliferation of logistical capabilities. Supply chain firms can offer a predetermined service menu of capabilities, value-added services, and attributes.[24] From this service menu, customers can choose their preferred services and attributes. Although the combination may be unique to each customer, the inputs and capabilities themselves are not unique since they were thought out, prespecified, and developed beforehand.

Agility takes this one step further by quickly and flexibly adjusting supply chain capabilities and their combinations to changing customer needs and evolving competitor offerings over time.[25] This may require a flexible and dynamic supply chain network that can recombine, reconfigure, and resequence logistical capabilities and participating firms in changing and creative

ways. Since transportation and third-party logistics firms may operate throughout the supply chain, they may be in the best position to coordinate and integrate capabilities in the network. Information on customer required capabilities and performance tracking become critical to success, possibly necessitating high levels of communications and collaborations with customers.

### Supply Chain Performance, Strategic Intent, and Value Congruency

Supply chain performance is the "bottom line" for supply chain strategies such as customer closeness versus operational excellence and their enabling capabilities. Further, supply chain capabilities eventually devolve into supply chain performance. These relationships are summarized in Figure 1. They imply that there should be a normative "fit" or value congruency between supply chain strategies, capabilities, and performance; e.g., a supply management focus on operational excellence or a demand management focus on customer closeness. Managerial strategic intent means that this value congruency should permeate everywhere in the supply chain and ultimately in performance. It has been stated that the choice of a value discipline focus "shapes everything a company does, colors the whole organization, and defines the very nature of a company."[26]

Four major types of supply chain performance are logistical cost and productivity versus customer service and quality. The first two can be classified as primarily supply-focused performance, while the latter two can be characterized as primarily demand-focused performance. Descriptive strategy literature on value disciplines suggests that firms must first meet industry standards or minimum acceptable levels on all four of these performance dimensions in order to be order-qualified. However, beyond these minimum standards or thresholds, firms can and should focus primarily on one value discipline.[27] This value focus will prevent dilution of firm resources, assets, employee attention, and market image or message. Furthermore, to be successful, this theory predicts that the chosen value emphasis should be apparent and consistent at both the capability and performance levels.[28] This managerial strategic intent reflects value congruency and is implied in Figure 1. For example, if best practice firms stress a supply-focus on operational excellence, then this should be apparent in both their capabilities and performance. In contrast, if excellent firms stress a demand-focus of customer closeness, then this focus should be visible in both their capabilities and performance. Again, minimum supply-side and demand-side threshold standards to qualify as potential suppliers should be achieved first and be visible for excellent firms in their data. However, their dominant supply chain focus should be much more visibly pronounced across their strategies, capabilities, and performance. This supply chain value congruency will be evaluated in the present research.

Based on the previous literature review and theory, the following research questions are tested:

### Research Questions

1. Is there evidence of value congruency across supply chain strategies, capabilities, and performance for leading firms? For example, is there a supply focus on operational excellence versus a demand focus on customer closeness congruency?

2. Are supply-side or demand-side capabilities and performance more important for supply chain success?

A. Are cost and productivity or customer service and quality more important?
B. Are some capabilities "order qualifiers"?

3. Which capabilities support which supply chain strategies?

A. Which capabilities support strategies of operational excellence versus customer closeness?
B. Which capabilities support time-based and lean network strategies versus logistics customization and agility strategies?

4. Is proactive or reactive quality more important for supply chain success?

A. Is problem avoidance or problem recovery more important?

B. Do excellent firms evaluate problem recovery as more important to customer satisfaction than the original outcome, as suggested in some literature?

5. What are the characteristics of performance measures evaluated as most important and available to excellent firms?

A. e.g., sophisticated or basic measures?
B. e.g., attribute specific or total performance measures such as total cost or total quality?

## METHODOLOGY

To address these research questions and to investigate supply chain strategies, capabilities, and performance, the research methodology had four phases. The research had other related research objectives as well, as determined by the multiple member research team. In the first phase, a survey instrument was developed and mailed to approximately 7,000 firms in the United States and Canada in order to assess supply chain management practices and trends. The survey instrument was first individually field pretested for content validity and reliability with executives from numerous participating firms in both countries. An expert panel of twenty leading supply chain practitioners was also used to review the questionnaire and to make additional recommendations. Based on both types of feedback, the survey instrument was modified and improved. The scale items were of the Likert-type and are indicated at the bottom of each table.

The survey instrument was mailed to almost the entire memberships of the leading logistical professional association in each country: the Council of Logistics Management (CLM) in the United States and the Canadian Association of Logistics Management (CALM) in Canada. However, certain member groups such as consultants and educators were excluded from the mailing since the focus of the research was on firm level best practices. These two professional associations have broad industry, group, and geographic memberships, and represent most major firms in their respective countries.

The questionnaire was mailed to the top-level member executive of each company as identified by the respective professional association, along with the professional association's cover letter of support. A total of 6,887 surveys were mailed and 1,358 were returned, for a response rate of approximately 20 percent in each country without follow-up. Investigation of characteristics of respondents and non-respondents did not identify significant differences.

The second phase of the research was completion of a 24-page, multi-survey workbook by a select group of 111 companies. These firms were selected based on the expert panel judgment that the firms exhibited world class best practices in supply chain management and logistics. Thus, multiple source informant agreement was utilized.

The third research phase consisted of in-depth interviews with these same 111 companies. These interviews were conducted in each country by logistics and supply chain management professors. An index of excellence was developed by the research team, and each interviewer rated each of their companies in ten areas of logistical and supply chain expertise based on their interview notes and other information on the company. The range of scores was 70 to 185 points out of a possible 200 points. Thus, each firm received an index excellence score. The top third on this index can be termed the best-of-the-best or the best-in-class benchmark.[29] This benchmark group is also referred to in this study as the top third excellent firms. Extant benchmarking literature defines the top third group as the most managerially relevant and the best benchmark since maximum learning results from studying the best-of-the-best firms, rather than those of moderate success or those "stuck in the middle."[30] The goal of leapfrogging the competition is also sometimes put forth as additional justification. Thus, comparisons are made between the top third and bottom third firms in order to differentiate and clearly identify distinct best practices. The fourth phase of the research consisted of additional survey replications so that trends could be assessed over time.

## RESULTS

### Importance of Supply Chain Capabilities

Table 1 shows the importance rankings for seven major types of supply chain capabilities, which can be thought of as core competencies. Customer service and quality rank first and second in importance, respectively. Information support and distribution flexibility are in the

middle, while low logistics cost, productivity, and delivery speed rank lower in importance. Thus, in general, demand-side capabilities of customer service and quality tend to be ranked more important for supply chain success than supply-side capabilities such as cost, productivity, and delivery speed. However, the absolute level of scores possibly implies that firms must meet minimum acceptable levels on all of these capabilities to be order-qualified or to be certified as acceptable suppliers.

**Table 1. Importance of Logistical Capabilities for Supply Chain Success**

| Supply Chain Capabilities: | Mean Score | Rank |
|---|---|---|
| 1. Customer service | 1.11 | 1 |
| 2. Quality | 1.16 | 2 |
| 3. Information systems support | 1.57 | 3 |
| 4. Distribution flexibility | 1.78 | 4 |
| 5. Low logistics cost | 2.04 | 5 |
| 6. Productivity | 2.37 | 6 |
| 7. Delivery speed | 2.45 | 7 |

Scale: 1=important, 5=unimportant

### Relationships Between Supply Chain Capabilities and Firm Excellence

At a more detailed supporting level, supply chain capabilities were also looked at in greater depth for the previous general categories of capabilities or core competencies using a different questionnaire. Table 2 shows the correlation of performance on 26 different supply chain capabilities, with an excellence index that is described in the methodology section. The definitions of these 26 capabilities that were provided to respondents are shown in Appendix 1.

Demand-side capabilities again consist of customer service and quality variables. As shown in Table 2, six of the seven customer service capabilities are positively and significantly related to firm excellence. Order flexibility followed by value-added services show the strongest relationships to the firm excellence index. For the quality category, the four proactive capabilities (i.e., "do it right the first time") are significantly related to the firm excellence index, while the three reactive capabilities are not. The four proactive capabilities in decreasing order of statistical strength include delivery dependability, order fill consistency, avoiding disruptions in supply, and problem avoidance. Similarly, advanced customer notification of problems is also positively related to firm excellence. However, the reactive quality capabilities do *not* achieve statistical significance with firm excellence and include problem and complaint resolution, product substitution, and product recall. Thus, none of these problem recovery capabilities are statistically associated with firm excellence.

For supply-side capabilities, low logistics cost and standardization of operations are marginally yet significantly related to firm excellence. In turn, none of the five distribution capabilities nor the two logistical speed capabilities are significantly related to firm excellence.

In summary, the more demand-oriented capabilities of customer service and quality are most strongly related to firm excellence. However, for the quality category, it appears to be primarily the proactive capabilities that are significantly related to firm excellence, rather than reactive quality capabilities or problem recovery. In turn, supply-side capabilities of low logistics cost and productivity are less strongly related to firm excellence, while distri-

**Table 2. Pearson Product-Moment Correlations Between Supply Chain Capabilities and Firm Excellence**

| Supply Chain Capabilities:[a] | Correlation With Excellence Index | p-value |
|---|---|---|
| **A. Customer Service** | | |
| 1. Responsiveness to key customers | .214[d] | .035 |
| 2. Value-added services | .289[c] | .005 |
| 3. Logistics service differentiation | .159[d] | .088 |
| 4. Customer service flexibility | .247[c] | .014 |
| 5. Order flexibility | .397[b] | .001 |
| 6. Customization during logistics | .193[d] | .059 |
| 7. Innovative solutions | .080 | .247 |
| **B. Quality** | | |
| 1. Delivery dependability (proactive) | .268[b] | .001 |
| 2. Order fill consistency (proactive) | .218[d] | .029 |
| 3. Problem avoidance (proactive) | .155[d] | .091 |
| 4. Avoid disruption in supply (proactive) | .178[d] | .062 |
| 5. Problem and complaint resolution (reactive) | .140 | .113 |
| 6. Product substitution (reactive) | .088 | .226 |
| 7. Product recall (reactive) | .107 | .181 |
| **C. Information** | | |
| 1. Advanced problem notification (proactive) | .186[d] | .053 |
| 2. Advanced shipment notification (proactive) | .099 | .197 |
| **D. Logistics Cost and Productivity** | | |
| 1. Low logistics cost | .179[d] | .068 |
| 2. Standardization of operations | .151[d] | .099 |
| 3. Simplification of operations | .053 | .325 |
| **E. Distribution** | | |
| 1. Widespread distribution coverage | .127 | .139 |
| 2. Selective distribution coverage | .120 | .155 |
| 3. Location flexibility | .106 | .185 |
| 4. Delivery time flexibility | .013 | .455 |
| 5. Reverse logistics timing | .129 | .153 |
| **F. Logistical Speed** | | |
| 1. Delivery speed | .122 | .147 |
| 2. Expedited delivery | .144 | .108 |

[a]Scale: 1=performance worse than competitors; 5=performance better than competitors
[b]$p \leq .001$; [c]$p \leq .01$; [d]$p \leq .10$

bution and logistics speed are not related at all in this analysis.

### Benchmarking Supply Chain Capabilities of Best-in-Class Firms

For a managerial orientation, Table 3 provides a different but related benchmarking analysis. It compares the capability performance of the top third excellence index firms with the bottom third. The top third benchmarked firms are the best-of-the-best benchmark,[31] as discussed in the methodology section. From a managerial perspective, what is important and of prime interest to management

**Table 3. Supply Chain Capabilities of Top Third Excellence Index Firms Versus Bottom Third**

| Supply Chain Capabilities:[a] | Mean Performance | |
|---|---|---|
| **A. Customer Service** | **Top Third** | **Bottom Third** |
| 1. Responsiveness to key customers | 4.07[d] | 3.61 |
| 2. Value-added services | 3.82[c] | 3.33 |
| 3. Logistics service differentiation | 3.59 | 3.28 |
| 4. Customer service flexibility | 3.76 | 3.50 |
| 5. Order flexibility | 4.06[b] | 3.12 |
| 6. Customization during logistics | 3.33[c] | 2.82 |
| 7. Innovative solutions | 4.00[d] | 3.61 |
| **B. Quality** | | |
| 1. Delivery dependability (proactive) | 4.35[c] | 3.78 |
| 2. Order fill consistency (proactive) | 4.24 | 4.17 |
| 3. Problem avoidance (proactive) | 3.82[d] | 3.44 |
| 4. Avoid disruption in supply (proactive) | 3.94[d] | 3.50 |
| 5. Problem and complaint resolution (reactive) | 4.06 | 3.78 |
| 6. Product substitution (reactive) | 3.59 | 3.33 |
| 7. Product recall (reactive) | 3.94 | 4.06 |
| **C. Information** | | |
| 1. Advanced problem notification (proactive) | 3.65[c] | 3.06 |
| 2. Advanced shipment notification (proactive) | 3.35[d] | 2.94 |
| **D. Logistics Cost and Productivity** | | |
| 1. Low logistics cost | 4.17 | 3.83 |
| 2. Standardization of operations | 4.00[c] | 3.29 |
| 3. Simplification of operations | 3.41 | 3.18 |
| **E. Distribution** | | |
| 1. Widespread distribution coverage | 4.24 | 4.00 |
| 2. Selective distribution coverage | 3.82[c] | 3.12 |
| 3. Location flexibility | 3.65 | 3.35 |
| 4. Delivery time flexibility | 3.94 | 3.94 |
| 5. Reverse logistics timing | 3.53 | 3.43 |
| **F. Logistical Speed** | | |
| 1. Delivery speed | 3.71[c] | 3.06 |
| 2. Expedited delivery | 4.00 | 3.94 |

[a]Scale: 1=performance worse than competitors; 5=performance better than competitors
[b]$p \leq .001$; [c]$p \leq .01$; [d]$p \leq .10$

is benchmarking against the best-of-the-best firms, rather than against those of moderate success or those "stuck in the middle."[32]

The benchmarking results in Table 3 are analogous to Table 2, and provide additional corroboration of results for management. In general, the more demand-side capabilities in the categories of customer service, proactive quality, and advance information to customers again more successfully distinguish top third excellence index firms than do reactive quality or supply-side capabilities. Specifically, proactive information capabilities of both advance notification of problems and advance shipment

information now also significantly distinguish top third firms. For supply-side capabilities, standardization still does, but low logistics cost does not, significantly differentiate between the two groups in this particular analysis.

### Importance and Availability of Demand-Side Performance Measures

Eventually supply chain strategies and supporting capabilities devolve into performance outcomes as represented in Figure 1. At the performance outcome level, Tables 4 and 5 evaluate demand-side and supply-side performance measures, respectively. Table 4 benchmarks the demand-side performance measurement practices of top third firms versus the bottom third on customer service and quality performance measures. Again, the relevant managerial benchmark is the best-in-class performers.[33] As such, both availability of performance information and its managerial importance are evaluated against these top firms.

Table 4 shows that the first four customer service performance measures and the first six quality measures statistically differentiate top third firms from the bottom third on either information availability or importance. For example, top third excellence index firms attribute both greater importance and information availability to fill rate, complete orders, and credit claims. These measures are available to over 90 percent of top third firms and

**Table 4. Availability and Importance of Demand-Side Performance Measures for Top Third Excellence Index Firms Versus Bottom Third**

| | Percent Having Information Available | | | Average Importance Rating[a] | | |
|---|---|---|---|---|---|---|
| **Performance Measures:** | **Top Third %** | **Bottom Third %** | **Top Third Rank** | **Top Third %** | **Bottom Third %** | **Top Third Rank** |
| **A. Customer Service Measures** | | | | | | |
| 1. Fill rate | 96.9[b] | 61.1 | 1 | 4.50[b] | 3.73 | 2 |
| 2. Stockouts | 93.8[d] | 77.8 | 2 | 4.52 | 4.19 | 1 |
| 3. Cycle time | 90.6[d] | 72.2 | 4 | 4.16 | 3.82 | 7 |
| 4. Complete orders | 90.0[b] | 52.9 | 5 | 4.26[c] | 3.71 | 6 |
| 5. On-time deliveries | 93.6 | 89.5 | 3 | 4.43 | 4.47 | 3 |
| 6. Backorders | 79.3 | 76.5 | 6 | 3.92 | 3.80 | 9 |
| 7. Customer complaints | 71.0 | 79.0 | 7 | 4.35 | 4.28 | 5 |
| 8. Overall satisfaction | 58.1 | 55.6 | 8 | 4.39 | 4.41 | 4 |
| 9. Sales force complaints | 42.9 | 33.3 | 9 | 3.94 | 3.64 | 8 |
| 10. Response time to inquiries | 41.9 | 29.4 | 10 | 3.73 | 3.93 | 11 |
| 11. Response accuracy | 32.3 | 22.2 | 11 | 3.80 | 4.00 | 10 |
| **Mean Importance** | | | | 4.18 | | |
| **B. Quality Measures** | | | | | | |
| 1. Number of credit claims | 93.3[c] | 70.6 | 2 | 3.82[c] | 3.15 | 8 |
| 2. Picking/shipping accuracy | 90.8 | 74.8 | 3 | 4.43[d] | 3.94 | 1 |
| 3. Shipping errors | 90.6[d] | 73.7 | 4 | 4.20 | 4.17 | 5 |
| 4. Document/invoicing accuracy | 84.4[b] | 35.0 | 7 | 4.21 | 3.79 | 4 |
| 5. Order entry accuracy | 80.0[b] | 45.0 | 8 | 4.19 | 4.00 | 6 |
| 6. Overall reliability | 70.0[b] | 29.4 | 9 | 4.35 | 3.92 | 2 |
| 7. Number of customer returns | 96.8 | 88.9 | 1 | 3.87 | 3.60 | 7 |
| 8. Delivery consistency | 87.8 | 77.8 | 5 | 4.24 | 4.17 | 3 |
| 9. Damage frequency | 87.5 | 75.0 | 6 | 3.80 | 3.56 | 9 |
| **Mean Importance** | | | | 4.12 | | |

[a]Scale: 5=important; 1=unimportant
[b]$p \leq .001$; [c]$p \leq .01$; [d]$p \leq .10$

can be characterized as basic performance measures. In contrast, more esoteric measures such as backorder performance, complaints from the salesforce, and response time to customer inquiries do not distinguish top third from bottom third firms in Table 4.

Some customer service and quality measures in Table 4 appear to be minimum hurdles in that they are available a to very high percentage of bottom third firms. These include on-time deliveries, number of customer returns, delivery consistency, and damage frequency. Apparently, these basic attributes are order qualifiers to be even considered as a potential supplier or partner. Thus, they would not significantly differentiate between groups.

The far right column of Table 4 also shows the relative importance rankings given by top third firms to measures of customer service and quality, respectively. In general, the most important rankings tend to be for basic, proactive, positive, and total performance measures. Specifically, the top four out of eleven customer service measures in descending order of importance are stockouts, fill rates, on-time delivery, and overall customer satisfaction. These basic and primarily proactive performance attributes reflect whether the firm's customers got what they wanted, where and when they wanted it, and in the condition they wanted it. In turn, the top four quality measures out of nine, in decreasing order of importance to top third firms, are picking and shipping accuracy, overall reliability, delivery consistency, and invoicing accuracy. These quality attributes are also proactive measures that represent positive performance (i.e., "do it right the first time"). In contrast, the less important quality variables are primarily reactive and negative performance measures and include shipping errors (ranked fifth), number of customer returns (seventh), number of credit claims (eighth), and damage frequency (ninth and last). It should also be noted that both overall customer satisfaction and overall reliability are total performance measures that are ranked very important by best-in-class firms, the implications of which will be discussed in the conclusions section. In summary, the customer service and quality performance rankings show that basic, proactive, positive, and total performance measures are deemed most important by benchmarked top third firms.

However, it is also interesting to compare importance rankings of top third firms with their information availability rankings in Table 4. Specifically, the least important quality ranked variables are some of the most highly tracked quality measures. In terms of information availability, these quality rankings include number of customer returns (ranked first in availability), number of credit claims (second), shipping errors (fourth), and damage frequency (sixth). Thus, despite being less important, these reactive quality measures are tracked at a relatively high level by the best-in-class firms. This finding will be discussed subsequently in the conclusions section and relates to service failures being particularly useful and easy sources of information.

**Importance and Availability of Supply-Side Performance Measures**

Table 5 benchmarks the top third firms on the importance and information availability of supply-side performance measures in the categories of cost and productivity. Both the first six cost measures (out of seventeen) and the first six productivity measures (out of nine) significantly distinguish the benchmarked top third firms from the bottom third firms on either greater importance or greater information availability. All twelve of these cost and productivity measures are basic performance measures. In contrast, more esoteric and sophisticated performance measures such as cost of returned goods, cost of service failures, and cost of customer segments do not significantly distinguish top third from bottom third firms.

Turning to the importance rankings of top third firms for cost in the far right column of Table 5, total cost and cost trend analysis rank first and second, respectively. These measures are followed in importance by outbound freight cost, cost per unit, comparison of actual cost versus budget, and cost as a percentage of sales, in that order. It is informative to note that each of these first six highest ranked cost measures is a basic and relative measure that allows for easy comparison with a readily available standard or its own incorporated benchmark. For example, total cost typically has a comparative objective function of simul-

**Table 5. Availability and Importance of Supply-Side Performance Measures for Top Third Excellence Index Firms Versus Bottom Third**

| | Percent Having Information Available | | | Average Importance Rating[a] | | |
|---|---|---|---|---|---|---|
| **Performance Measures:** | **Top Third %** | **Bottom Third %** | **Top Third Rank** | **Top Third %** | **Bottom Third %** | **Top Third Rank** |
| **C. Cost Measures** | | | | | | |
| 1. Outbound freight cost | 100.0 | 94.9 | 1 | 4.40[b] | 3.67 | 3 |
| 2. Cost as a percentage of sales | 96.8[d] | 84.2 | 3 | 4.33[d] | 3.95 | 6 |
| 3. Direct labor | 96.5[d] | 83.9 | 4 | 4.03 | 3.76 | 7 |
| 4. Administrative cost | 93.6 | 84.1 | 6 | 3.70[d] | 3.33 | 14 |
| 5. Warehouse order processing | 87.5 | 80.2 | 8 | 3.90[c] | 3.31 | 9 |
| 6. Inbound freight cost | 77.4 | 79.0 | 13 | 4.00[c] | 3.50 | 8 |
| 7. Direct product profitability | 62.5[b] | 36.8 | 14 | 3.81 | 3.79 | 10 |
| 8. Cost of backorder | 33.3 | 27.8 | 17 | 3.71[c] | 3.18 | 13 |
| 9. Comparison of actual versus budget | 98.5 | 96.5 | 2 | 4.34 | 4.40 | 5 |
| 10. Total cost | 93.8 | 95.2 | 5 | 4.56 | 4.35 | 1 |
| 11. Cost trend analysis | 92.8 | 90.3 | 7 | 4.41 | 4.42 | 2 |
| 12. Cost of damage | 87.5 | 80.1 | 9 | 3.55 | 3.26 | 15 |
| 13. Inventory carrying cost | 86.7 | 73.7 | 10 | 3.79 | 3.39 | 11 |
| 14. Cost per unit | 83.9 | 83.3 | 11 | 4.38 | 4.06 | 4 |
| 15. Cost of returned goods | 81.3 | 75.2 | 12 | 3.45 | 3.17 | 17 |
| 16. Cost of customer segments | 41.9 | 55.2 | 15 | 3.52 | 3.94 | 16 |
| 17. Cost of service failures | 40.6 | 47.4 | 16 | 3.78 | 3.73 | 12 |
| **Mean Importance** | | | | 3.98 | | |
| **D. Productivity Measures** | | | | | | |
| 1. Warehouse labor productivity | 90.6 | 79.9 | 1 | 4.13[d] | 3.65 | 2 |
| 2. Comparison to historical std. | 87.5 | 73.7 | 2 | 3.93[c] | 3.29 | 4 |
| 3. Units shipped per employee | 83.8[b] | 57.9 | 3 | 4.07 | 3.86 | 3 |
| 4. Total productivity index | 78.1[c] | 57.6 | 4 | 4.15[c] | 3.57 | 1 |
| 5. Equipment downtime | 65.6[b] | 27.8 | 6 | 3.64[b] | 2.92 | 7 |
| 6. Orders per salesperson | 50.2[c] | 55.6 | 9 | 3.00[c] | 3.54 | 9 |
| 7. Units per labor dollar | 67.7 | 57.8 | 5 | 3.60 | 3.77 | 8 |
| 8. Order entry productivity | 65.6 | 52.9 | 7 | 3.69 | 3.29 | 5 |
| 9. Transport labor productivity | 64.5 | 73.6 | 8 | 3.68 | 3.69 | 6 |
| **Mean Importance** | | | | 3.76 | | |

[a]Scale: 5=important; 1=unimportant
[b]$p \leq .001$; [c]$p \leq .01$; [d]$p \leq .10$

taneously minimizing the sum of several cost tradeoffs. Thus, minimizing total cost is relative to itself or to its previous calculation as a standard (i.e., as long as the first derivative of the cost function is less than zero). For productivity importance rankings in the bottom right section of Table 5, a total productivity index is ranked first by top third firms, followed by warehouse labor productivity, units shipped per employee, and comparison to historical standard. Again, these high rankings reflect basic and relative performance measures in that they have internal or easily available benchmarks. Similar to the previous customer service and quality results, total cost (ranked first for cost) and total productivity index

(ranked first for productivity) are total performance measures that are especially important to top third firms. The implications will be elaborated upon subsequently in the conclusions section.

It is again worth comparing the importance rankings with the information availability rankings of the benchmarked top third firms. Analogous to the earlier reactive quality results, Table 5 shows that some of the least important cost measures are tracked by a large percentage of top third firms. Specifically, "cost of damage" is ranked fifteenth in importance and "cost of returned goods" is ranked seventeenth and last, yet both are available to more than 80 percent of the top firms. Thus, similar to the previous reactive quality findings, these reactive or negative performance measures appear less important than "doing it right the first time," but apparently provide quite useful information to top firms regarding problems.

**Value Congruency and Strategic Intent**

As discussed in the introduction, value congruency predicts that what excellent firms do at the capability level should be visibly consistent with what these same top firms do at the performance level. Indeed, managers' strategic intent should culminate in value congruency or consistency across all levels of strategy, capabilities, and performance, as implied in Figure 1. Table 5 shows that the top third firms' mean importance rating for all cost performance measures is 3.98, while for all productivity measures it is 3.76. In contrast, Table 4 shows that the mean importance rating for all customer service measures is 4.18 and for all quality measures is 4.12. Thus, viewing performance measures as a whole, demand-side measures in the areas of customer service and quality are viewed by top third firms as more important than supply-side performance measures. These results are consistent with the earlier findings for supply chain capabilities, and thus support the expected value congruency for leading firms. In essence, top third firms evaluate both demand-oriented capabilities and demand-oriented performance measures as most important for supply chain success.

Value congruency also predicts that supporting demand-oriented capabilities should be most strongly associated with customer closeness strategies. In contrast, supporting supply-oriented capabilities should be more strongly associated with operational excellence strategies. However, it is again worth noting the expectation that firms must meet minimum standards of acceptability on both demand-side and supply-side capabilities in order to be order qualified as an acceptable supplier or partner before focusing on one value discipline; and that this should also be visible in their data.

Table 6 shows the correlation coefficients for 1,358 United States and Canadian firms on demand-side capabilities and supply-side capabilities with supply chain strategies. As expected, demand-side capabilities are much more strongly related statistically to customer closeness strategies of both logistics customization and agility than to the operational excellence strategies. In contrast, the supply-side capabilities are more strongly related to operational excellence strategies of both time-based and lean network strategies. In essence, these findings provide additional strong support for value congruency and strategic intent. The results in Table 6 also reveal support for minimum acceptable thresholds or capabilities.

**Distinguishing Capabilities**

Value congruency and strategic intent also predict that similar capabilities should distinguish a particular supply chain strategy from other strategies. Table 6 allows one to compare the capabilities that especially distinguish different supply chain strategies. As might be expected, a customization strategy is characterized by tailored services and responsiveness to customers (i.e., capabilities 1 and 2 in panel A of Table 6). However, customization is also especially distinguished by customer participation in strategy formulation. As such, compared to agility, customization is more strongly related to obtaining customer input into strategy, sharing risks with customers, and measuring customer satisfaction (i.e., variables 5, 6, and 7). In contrast, agility is distinguished by frequent interactions, collaborations, and communications with customers. As such, compared to customization, agility is more strongly related to frequently contacting customers, customer involvement in alliances, frequent visits with customers, and information systems for service improvements (i.e., variables 8, 9, 10, and 11 in

**Table 6. Pearson Product-Moment Correlations Between Supply Chain Strategies and Capabilities**

| Supply Chain Capabilities: | Customer Closeness Strategies | | Operational Excellence Strategies | |
|---|---|---|---|---|
| **A. Demand-Side Capabilities** | Customization | Agility | Time-Based | Lean Network |
| 1. Responsiveness to customers | .567[a] | .301[a] | .081 | .029 |
| 2. Tailored services | .344[a] | .316[a] | .090[c] | .041 |
| 3. Flexibility for special requests | .246[a] | .253[a] | .101[c] | -.017 |
| 4. Customer service | .190[a] | .182[a] | -.031 | .032 |
| 5. Customer input into strategy | .343[a] | .207[a] | .097[c] | .089 |
| 6. Share risk with customers | .349[a] | .180[a] | .113[b] | .072 |
| 7. Measure customer satisfaction | .343[a] | .255[a] | .032 | .014 |
| 8. Frequently contact customers | .175[a] | .285[a] | .070 | .112[b] |
| 9. Customer involvement in alliances | .278[a] | .301[a] | .177[a] | .108[c] |
| 10. Visit customers frequently | .193[a] | .222[a] | .052 | .086 |
| 11. Information systems for service improvement | .148[a] | .211[a] | .041 | .003 |

| | Operational Excellence Strategies | | Customer Closeness Strategies | |
|---|---|---|---|---|
| **B. Supply-Side Capabilities** | Time-Based | Lean Network | Customization | Agility |
| 1. Flow through cross-docking | .291[a] | .196[a] | .136[b] | .123[b] |
| 2. Lead time improvement | .189[a] | .145[a] | .124[b] | .171[a] |
| 3. Quick replenishment | .223[a] | .203[a] | .110[c] | .160[a] |
| 4. Performance measurement | .316[a] | .166[a] | .069 | .098[c] |
| 5. Inventory reduction | .179[a] | .165[a] | .054 | .124[b] |
| 6. Least total cost | .117[b] | .343[a] | .134[a] | .104[c] |
| 7. Efficient inventory deployment | .142[a] | .264[a] | .111[c] | .110[c] |
| 8. Postpone inventory movement | .101[c] | .163[a] | .059 | .047 |
| 9. Resident suppliers | .088 | .206[a] | .042 | .004 |
| 10. Information technology | .148[a] | .249[a] | .144[a] | .149[a] |
| 11. Process improvement | .158[a] | .134[a] | .042 | .087 |

[a]$p \leq .0001$; [b]$p \leq .001$; [c]$p \leq .01$; $n = 1358$

panel A). Remaining demand-side capabilities of flexibility for special requests and customer service significantly support both customization and agility strategies about equally.

Turning to operational excellence in panel B of Table 6, time-based strategies place greater emphasis on inventory throughput or velocity. As such, compared to lean networks, time-based strategies are more strongly related to flow-through cross docking, lead time improvement, quick replenishment, and performance measurement (i.e., variables 1, 2, 3, and 4 in panel B of Table 6). In contrast, lean network strategies place greater emphasis on minimizing total cost in the network by eliminating waste, slack resources, and avoidable assets. As such, compared to time-based strategies, lean networks are more strongly related to least total cost, efficient deployment of inventory in the network, postponement of forward inventory movement, resident suppliers (i.e., supplier employees or operations located on customer premises), and information technology (IT). These capabilities are represented by variable numbers 6, 7, 8, 9, and 10 in panel B of Table 6. Remaining supply-side capabilities of inventory reduction and process improvement significantly support both time-based and lean network strategies about equally.

In total, certain supply chain capabilities

especially distinguish and support particular supply chain strategies as predicted by strategic intent and value congruency theory and literature. These distinguishing capabilities include strategic customer participation for customization, frequent customer interactions and collaborations for agility, increased inventory velocity for time-based strategies, and total cost minimization for lean network strategies.

## CONCLUSIONS

Supply chain strategy is an increasingly important topic in an environment of deregulation, inter-firm cooperation and partnerships, strategic alliances, and technological advancements. Similarly, a new paradigm of supply chain strategies supported by particular capabilities and resulting in related performance is clearly gaining in interest to both practitioners and academicians alike. As such, strategic intent and value congruency predict that there should be a value consistency or normative fit between supply chain strategies, capabilities, and performance; e.g., a demand focus on customer closeness or a supply focus on operational excellence.[34] This focus becomes part of the competitive advantage of the supply chain that should foster member firms' success. Further, value congruency recommends that once firms have developed minimum supply-side and demand-side capabilities to be order qualified, they should then concentrate on those capabilities and performance metrics that support their chosen value focus. To do otherwise would waste time and resources and would dilute the firms' message and image in the marketplace.[35] In the present research, on-time performance and the absence of loss, damage, and customer returns appear to be minimum order qualifiers. In turn, other capabilities that distinguish the best-of-the-best firms from other firms in this study can be interpreted as order winners for the chosen value emphasis. Significant demand-oriented examples include value-added services and order flexibility, while significant supply-oriented examples include standardization of operations and low logistics cost.

This study does find strong evidence of value congruency between supply chain strategies, capabilities, and performance. First, for excellent firms, a demand-side focus on customer service and proactive quality is more apparent and important at *both* the capability and performance levels than a supply-side focus on cost, productivity, distribution, and speed. Second, demand-side capabilities and demand-side performance are most strongly related to the firm excellence index. Third, demand-side capabilities are most strongly related to customer closeness strategies such as customized logistics and agility. In contrast, supply-side capabilities are most strongly related to operational excellence strategies such as time-based strategies (e.g., JIT) and lean networks. Fourth, particular types of capabilities distinguish and support individual supply chain strategies. On the demand side, customer participation in strategy formulation distinguishes customization, while continuous interactions, collaborations, and communications with customers characterize agility. On the supply side, inventory velocity and supply synchronization distinguish time-based strategies, while minimum total cost in the network typifies lean networks. In total, these findings support strategic intent and normative value congruency across supply chain strategies, capabilities, and performance.

The question must be addressed as to why a demand-side value focus should be much more apparent and important amongst excellent firms than a supply-side focus. The suggested answer is that only one or two firms in an industry can achieve a minimum cost advantage from supply-side capabilities. In contrast, differentiation through customer closeness can be achieved in a multiplicity of ways using demand-side capabilities. Demand-side capabilities can be reconfigured, recombined, and resequenced to meet changing requirements of specific customers, to segment and appeal to particular market segments, or to create competitive advantages that can serve as entry barriers to potential competitors and new entrants. Thus, demand-side competitive advantages may be easier to attain, be more difficult to imitate, and be more sustainable.

In this study, the most important demand-side capabilities for customer service are found to be order flexibility and value-added services, while for quality, delivery dependability is especially important. However, for all quality measures together, only the proactive capabilities that reflect "doing it right the first time"

are characteristic of excellent firms. In addition to delivery dependability, these include order fill consistency, problem avoidance, and avoiding disruptions in supply. All of these proactive capabilities avoid problems in the first instance. This may also help to explain why excellent firms are found to place greater reliance on positive performance measures rather than negative performance measures. In contrast, reactive quality capabilities that reflect problem recovery do not distinguish excellent firms. These include product substitution, product recall, and problem and complaint resolution. Thus, despite current academic and practitioner enthusiasm for the concept of problem recovery, it does not distinguish excellent firms in this study.

Similarly, for demand-side performance measures, reactive and negative performance measures are evaluated as less important by excellent firms than proactive and positive performance. However, it is interesting to note that some reactive performance measures such as number of customer returns, number of credit claims, and cost of damage are tracked at much higher levels (i.e., information is readily available) than their indicated importance would dictate. The suggested explanation for this disparity is that although "doing it right the first time" is most important to excellent firms, service failures can provide valuable and easy sources of information to diagnose and resolve problems, to improve services, and to avoid future problems.[36] Analogously, some descriptive managerial literature refers to information on service failures as "golden nuggets of truth" that provide opportunities to learn from mistakes.[37] There is also evidence in this study that although trouble-free performance is best, advance notification of problems to customers is a characteristic of excellent firms.

Additional characteristics of performance measures that are stressed by excellent firms include basic rather than sophisticated measures, relative measures that have built-in comparison standards or readily available benchmarks, and total performance measures. Basic measures especially evaluate whether the firms' customers receive the right things, at the right place, at the right time, and in the right condition. For total performance measures from each of the four performance categories, the measures and their importance rankings are total cost (ranked first in importance out of 17 cost measures), total productivity index (ranked first for productivity), overall reliability (ranked second for quality), and overall customer satisfaction (ranked fourth for customer service). Thus, total performance measures are uniformly important and especially characteristic of excellent firms.

There are several reasons why total performance measures would be particularly important to excellent firms. First, a total performance measure may best reflect the supply chain's overall value commitment to customers[38] and its actual level of attainment, as well as its competitive market strategy. Second, sole use of individual attribute measures can suboptimize or be misleading. For example, reduction of costs in one category can raise costs even more in another category. More broadly, reduction of costs for one supply chain member could raise costs by a greater amount for the customer or another supply chain member. The advantage of a total performance measure such as total cost is that it can potentially consider as many as possible of these cost tradeoffs simultaneously. Similar logic would apply to total performance measures that consider customer service, quality, or productivity tradeoffs. Third, viewing attribute-specific performance measures in isolation can overstate performance and create a false sense of success. For example, 90 percent performance on each of three attributes (e.g., 90 percent on-time, 90 percent fill rate, and 90 percent damage-free) is not 90 percent overall performance but rather only 73 percent total positive performance (i.e., $90^3$). Thus again, total performance measures are particularly important for accurately assessing overall performance.

For the future, some supply chains are currently experimenting with "mass customization" strategies.[39] This is almost an oxymoron and is difficult to achieve. Mass customization can be thought of as a hybrid or combination of operational excellence with customer closeness strategies. As such, it attempts to obtain maximum supply-side operating efficiencies while at the same time being particularly responsive to changing demand requirements. Demand requirements can be for manufacturers, distrib-

utors, or final customers; but ideally, they should be for the supply chain as a whole using demand-based information (e.g., through collaborative forecasting, real time point-of-sale or point-of-usage information, linked and continuous replenishment, combined ERP with EDI, etc.) Examples of mass customization include postponement strategies that attempt to postpone either final production (form), forward inventory movement (temporal), or break-bulk and assembly (spatial). A major benefit is inventory reduction throughout the supply chain. For a mass customization value focus, the overriding capability or core competency appears to be flexibility. Flexibility can be seen in such creative and emerging supply chain practices as agile manufacturing; modular product design; side-loading trailers; production line milk-runs; collapsible, returnable, and reconfigurable containers; merge-in-transit; flexible products through delayed sorting, kitting, or subassemblies; demand flow-through warehousing; intermodal transfers and containerization; in-transit acceleration or deceleration; distribution center or third-party light manufacturing; and direct-store delivery systems. Information technology is a crucial enabler for most of these flexible and integrative practices. These creative and emerging mass customization strategies and practices are trends that deserve future research and continuing observation.

It is intended that this study will both add to our knowledge and help to integrate the strategies, capabilities, and performance literatures. This study's emphasis on excellent firms also provides useful benchmarking guidance for managers. The present research has the advantage of studying supply chain strategies, capabilities, and performance across multiple industries without the usual limitations on generalizability of previous studies that focus on only one industry. Furthermore, this strategy/capabilities/performance paradigm is investigated for different types of supply chain strategies, which is also an improvement over prior research. Nevertheless, as with any study, additional research would be desirable and necessary. First, it would be useful and interesting to know how different supply chain strategies and their supporting capabilities are related to "bottom line" and "top line" type financial performance. Similarly, it would be helpful to know how interactions among various supply chain strategies and different business strategies are related to overall business success. It is hoped that the present research makes an initial contribution to this line of inquiry.

## ENDNOTES

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### Appendix 1. Supply Chain Capabilities

1. **Responsiveness to key customers:** The ability to respond to the needs of and wants of key customers.
2. **Value-added services:** The ability to perform additional services that add value for the customer.
3. **Logistics service differentiation:** The ability to differentiate logistical service offerings from those offered by competitors.
4. **Customer service flexibility:** The ability to accommodate special customer service requests.
5. **Order flexibility:** The ability to modify order size, volume, or composition during logistics operation.
6. **Customization during logistics:** The ability to handle product modifications while in the logistics system.
7. **Innovative solutions:** The ability to develop creative logistical solutions for specific situations, emergencies, or customers.
8. **Delivery dependability:** The ability to meet quoted or anticipated delivery dates and quantities on a consistent basis.
9. **Order fill consistency:** The ability to provide desired quantities on a consistent basis.
10. **Problem avoidance:** The ability to proactively seek solutions to logistics problems before they occur.
11. **Avoid disruption in supply:** The ability to accommodate supply disruption in a manner that does not adversely affect customers.
12. **Problem recovery and complaint resolution:** The ability to quickly resolve logistically-related customer problems and complaints.
13. **Product substitution:** The ability to substitute product or service offerings in the event of a delay or stockout (versus backorder or line cancellation).
14. **Product recall:** The ability to accommodate product recalls.
15. **Advanced problem notification:** The ability to notify customers in advance of delivery delays or product shortages.
16. **Advanced shipment notification:** The ability to notify customers in advance of delivery when products will arrive.
17. **Low logistics cost:** The ability to achieve the lowest total cost of logistics through efficient operations, technology, and/or scale economies.
18. **Standardization of operations:** The ability to provide a consistent approach to performing key logistics work.
19. **Simplification of operations:** The ability to simplify the overall logistical process.
20. **Widespread distribution coverage:** The ability to comprehensively and effectively target a given distribution region.
21. **Selective distribution coverage:** The ability to effectively target selective or exclusive customers.
22. **Location flexibility:** The ability to service customers from alternative warehouse locations.
23. **Delivery time flexibility:** The ability to accommodate delivery times for specific customers.
24. **Reverse logistics timing:** The ability to perform reverse logistics operations in a timely manner.
25. **Delivery speed:** The ability to reduce the time between order receipt and customer delivery to as close to zero as possible.
26. **Expedited delivery:** The ability to expedite shipments or partial shipments.

sustainability

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*Article*

# Sustainable Supply Chain Capabilities: Accumulation, Strategic Types and Performance

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**Abstract:** This paper explores the cumulative sustainable supply chain (SC) capabilities and their effects on supply chain performance, including economic, environmental, and social performance. Using empirical analyses with data from 198 small- and medium-sized suppliers in Korea, this paper provides evidence about the cumulative sustainable SC capabilities, indicating that economic, social, and environmental capabilities in the supply chain mutually reinforce each other rather than traded off. This study also presents the positive effect of cumulative sustainable SC capabilities on supply chain sustainability performance. This paper identifies four distinctive groups of cumulative capabilities: the laggard, environmental-focused, social-cautious, and all-round. This study provides a better understanding about sustainable capabilities and important guidelines for managers of suppliers and buyers who wish to build strong social/environmental management capabilities without compromising economic capability throughout the entire supply chain.

**Keywords:** sustainable supply chain capability; triple bottom line; cumulative capabilities; sustainability performance; supply chain management; empirical study

## 1. Introduction

The last decade has witnessed the emergence of sustainability issues as one of the most important business concerns in a firm's supply chain. An increasing number of firms have realized that what it may go wrong if the supply chain is ignored when facing global sustainability challenges [1]. The leading international brands, such as Nike, Marks and Spencer (M&S), and IKEA have increasingly reexamined their supply chains and moved forward in their effort to build a more sustainable supply chain, by not only monitoring their suppliers' compliance, but also fostering their capabilities to properly address various environmental and social challenges [2].

The triple bottom line, indicating the combination of economic, social, and environmental performances, continues to spread out throughout the industries [3]. To increase such triple bottom line, environmental and social criteria must be integrated into performance objectives for the management of not only individual firms, but also the entire supply chain [4] because firms' performance heavily relies on their supply chain. This is why the management of environmental and social issues in the supply chain, namely sustainable supply chain management (hereafter sustainable SCM), has been increasingly paid much attention. A number of researchers have examined sustainable SCM on the environmental side [5–9] and on the social side [10], and also on both sides [11,12]. However, several important aspects have received relatively little attention.

First, although evidence has been documented that sustainable SCM linked to performance for both supplier management [13] and the broader supply chain [14], little research has explicitly considered sustainable SCM as "capabilities" that can create a firm's competitive advantage. Recently, a few studies appeared to address sustainable SCM based on the resource-based view, in terms of social management capabilities [10] and supplier environmental capabilities [5,6,15]. Second, few studies have considered environmental, social, and economic aspects in SCM, simultaneously [16–18]. Sustainable SCM exists as a separate stream of research, indicating the majority of ongoing SCM research overlooks the environmental and social consequences of supply chain actions [18]. Moreover, sustainable SCM research barely addresses the economic dimension in the sustainable SCM literature because the economic side of sustainability has generally been assumed as being covered by conventional management publications. However, sustainable SCM should simultaneously capture these three intrinsically related dimensions of the triple bottom line: economic, social, and environmental aspects.

Third, previous studies have focused on examining the effects of sustainable SCM, in particular green SCM on firm performance. However, the relationships between those three economic, social, and environmental dimensions of sustainable SCM have been neglected. Such relationships can be an important element of sustainable SCM strategy. For example, if high performance in the social dimension is necessarily traded off for low performance in the (conventional) economic dimension, and the firms should decide which dimension of sustainability has to be achieved. However, sustainable SCM might have cumulative capabilities; each of them reinforces the development of the other capabilities. This unexplored question is analogous to the debate about the cumulative capabilities theory in operations management [19,20].

Given these gaps in the literature, the focus of this study is on whether those economic, social, and environmental supply chain (SC) capabilities are cumulative capabilities, existing simultaneously in a mutually reinforcing fashion, or traded off. This paper also explores other relevant important research questions. For example, what is the relationship between cumulative sustainable SC capabilities and supply chain performance? Are there particular sequences of the development of such cumulative sustainable capabilities? In addressing these questions, this paper makes three contributions. First, drawing from related literatures, including operations strategy, SCM, and sustainable SCM, this study develops the concept of sustainable SC capabilities. Second, some propositions, regarding cumulative sustainable capabilities and their effects on performance, are suggested. Third, the study provides an empirical analysis of these relationships.

## 2. Literature Review and Propositions

### *2.1. Sustainable Supply Chain Capabilities*

This study leverages the resource-based view (RBV) and adjacent theoretical lenses, such as dynamic capability theory, absorptive capacity, and social capital, to emphasize the competitive nature of sustainable SCM. First, the RBV, arguing that the differences in firms' behaviors and performance are fundamentally dependent on the unique assembly of internal resources and capabilities, which are valuable, rare, imperfectly inimitable and non-substitutable [21,22], has been extended to explain whether, how and when SCM can be source of sustained competitive advantage [23,24]. For example, Barney [25] argues that heterogeneous purchasing and supply chain management capabilities can be a resource that firms can use to generate more accurate expectations about the future value, by noting there are numerous examples of where this has occurred, such as Wal-Mart and Toyota. Second, Hunt and Davis [26] clarify the possibility of SCM as a valuable resource by extending a firm's internal resources to external ones such as relational resources, which can be productive launching points for SCM research. Their "resource-advantage" theory is quite parallel to the relational view or social capital theory [27] because all of them propose that a firm's critical resources and capabilities may extend beyond a firm's boundaries [23]. For example, supply chain capabilities, referring to a firm's ability to

identify, utilize, and assimilate external resources to facilitate the entire supply chain activities [28], can accumulate valuable assets and resources embedded within, available through, and derived from the network of relationships. Such inter-organizational assets, namely social capital and/or relational resources, result in a firm's competitive advantage and higher performance [23,26]. Third, recent studies increasingly emphasize the dynamic nature of supply chain capabilities. From a supply network perspective, dynamic capabilities can be understood as the unique sets of inter-organizational routines, processes, relationships and special skills derived from exchanges of information and knowledge between supply chain partners [24]. For example, the supply management alignment capability, referring to the ability of procurement to formally define internal needs and ensure communication and understanding of these expectation by key suppliers [29], and supply chain absorptive capacity, referring supply chain information acquisition, new product development assimilation, supply chain transformation, and operational application of this information [30] are positively related to a firm's financial performance as well as network agility performance. Overall, supply chains vary in critical competences such as their ability to learn, innovate, and respond quickly to changing market conditions. Differences organizational resources can explain why some supply chains outperform competitors [26]. A recent preliminary survey [31] also reports that a number of leading SCM scholars strongly agree that resources possessed by a firm and even more so, within a firm's supply chain, are important to effective SCM and thus to higher performance of the entire supply chain.

By extending these arguments on (conventional) supply chain capabilities to the social and environmental dimensions, this paper proposes three sustainable supply chain (SC) capabilities: the economic, environmental, and social SC capabilities. First, based on the supply chain capability literature, the economic SC capability can be characterized as a set of important activities involved in the supply chain process, such as information sharing and collaboration, as well as essential elements of inter-organizational relationships, such as mutual trust and long-term partnership. Information sharing is usually identified as one of the most fundamental abilities in the supply chain process and integration [30,32,33], because it is very effective in enabling buyers and suppliers to share and communicate expectations and performance, and thus, in motivating supply chain partners to enhance their capabilities [29,34]. A collaborative capability, involving more direct interactions and integrated activities between buyers and suppliers [24,28], such as technology co-development and collaborative problem solving practices has been reported as critical means to effectively transfer operational and organizational knowledge to other supply chain partners [35] and implement various improvement initiatives [34].

Second, environmental SC capability refers to a firm's ability to manage environmental issues in the supply chain [36]. Third, social SC capability can also be defined as being analogous to the environmental SC capability [10]. As Pagell and Shevchenko [18] point out, extant sustainable SCM research has been focused on harm reduction in unsustainable supply chains rather than harm elimination such as zero emission throughout the entire supply chain (*i.e.*, a truly sustainable supply chain). Zero emission or regenerative impacts on social and environmental systems would be the ultimate goal of sustainable SCM; however, this could be achieved stepwise, from currently unsustainable supply chains to less unsustainable supply chains and to truly sustainable supply chains. In this study, we characterized environmental and social SC capabilities as the extents of inter-organizational activities between a buyer and its supplier in response to the social and environmental issues in order to generate positive impacts as well as reduce current negative impacts on social and environmental systems. Collectively, these activities encompass monitoring and collaboration practices [6,8]. Monitoring practices include the gathering and processing of supplier information, the establishment of supplier assessment criteria, and the evaluation of the environmental and the social performance of supply chain partners and their products. In terms of the social SC capability, establishing a supplier code of conduct and auditing represent the most widely used activities. Many global firms have introduced a supplier code of conduct that generally addresses child labor, forced labor, human rights, diversity and safety, and used it as one of the most

important criteria for evaluating suppliers [37]. Recent years have witnessed a number of suppliers pursing certification related to social responsibility, such as Social Accountability (SA) 8000 [10]. In terms of the environmental SC capability, adopting environmental procurement policies is a typical practice. Environmental supplier selection processes facilitates communication between supply chain partners, and therefore, enhance supply chain responsiveness to surging environmental issues, such as climate change. Suppliers have also implemented environmental management systems (EMSs), and validated them by securing international certifications, such as ISO 14001, the international standard of environmental management [36].

Collaborative practices composing of the environmental and social SC capabilities tend to focus more on building the supply chain's potential capability than on achieving short-term results [8]. Collaboration requires direct interaction between the supply chain partners to improve their social and environmental performance, and involves knowledge and experience sharing, and co-development of environmental friendly products/processes. In addition, large buying firms sometimes provide their suppliers with environmental education programs and technical assistance to improve the environmental and social performance of the supply chain [10,36].

### *2.2. Cumulative Sustainable Supply Chain Capabilities*

The cumulative capabilities theory was proposed as an alternative to the "trade-off theory" in explaining the patterns of manufacturing capability development in operations strategy research. These capabilities usually represent quality, cost, dependability, speed, and flexibility [38]. Cumulative capabilities describe high performance in multiple capabilities simultaneously, whereas the term "trade-off" represents that high performance in one capability is necessarily traded off for low performance in others [20]. Tradeoffs between capabilities, even though not all, have been still reported and retained its importance in the literature [39]; however, this perspective is considered less than universal todays mainly because of the necessitates of global competition and development of advanced manufacturing technologies [40].

The term "cumulative sustainable SC capabilities" is used here to describe a situation in which a supply chain has a high level of sustainable SC capabilities more than one dimension. It is worth noting that there are often tradeoffs among the three sustainable SC capabilities at the level of the individual initiative. For instance, newly adopted monitoring and/or support activities in environmental and social areas may increase the cost of enforcement, coordination, and compliance in the initial stages [11,16]. Supply chains often face a situation in which they have to satisfy the different, sometimes conflicting demands of their stakeholders; many of whom, such as NGOs and local communities may not interested in the economic performance, but rather are focused on the chain's impact on society or the environment [18]. We, however, focus on the synergistic view on sustainable SC capabilities based on the relevant literature, offering numerous cases of companies and supply chains who achieve both economic and noneconomic performance [9]. Cumulative capabilities build upon each other and are mutually reinforcing [41]. Improvement in certain capabilities enables improvements to be made more easily in other capabilities, which in turn, result in cumulative capabilities [42]. By synthesizing the cumulative theory, the natural RBV [43] and other studies regarding sustainable SCM, we can conjecture that sustainable SC capabilities are also mutually reinforcing, and therefore, can be cumulative capabilities rather than being traded off.

First, the natural RBV [43] indicates that capabilities in continuous improvement or cross-functional management (*i.e.*, capabilities in the economic dimension) enable a firm to more quickly accumulate the resources necessary for pollution prevention and product stewardship (*i.e.*, capabilities in the environmental dimension). In addition, synergistic effects between operational and environmental capabilities, referred to as "lean and green" [44–46] have been often reported. These logics can apply to the supply chain, and then predict that the economic and environmental SC capabilities influence each other in a positive way. Vachon and Klassen [8] provided supporting evidence that technological integration between the customers and suppliers, a part of the economic

SC capability, to be a significant driver of environmental collaboration, a part of the environmental SC capability.

Second, a few of sustainable SCM studies have hinted that the conventional SCM and social/environmental SCM expertise might covary. Parmigiani *et al.* [47] addressed the relational capabilities, reflecting the ability to align incentives, share information, increase commitment, as well as facilitate collaboration and knowledge transfer, and can be deployed to develop social and environmental capabilities of the supply chain in several ways. For example, highly evolved forms of supplier evaluation enable the firms to create new metrics for social/environmental assessments of its supply chain. Furthermore, collaboration toward long-term goals also reduces incentives for short term opportunistic behavior, such as the covert use of underage labor, short-changing workplace safeguards, using banned substances or improperly disposing of materials, which in turn create social and environmental capabilities of the supply chain.

Collectively, it is believed that one sustainable SC capability can play a foundation for other capabilities to build, and therefore, the sustainable SC capabilities are cumulative ones. This argument leads to the following proposition.

*Proposition 1.* Economic, environmental, and social supply chain capabilities are cumulative. In other words, there are only significant positive correlations and no negative correlations among economic, environmental, and social SC capabilities.

### *2.3. Relationship with Supply Chain Performance*

There is little empirical support that the pursuit of cumulative SC capabilities leads to supply chain performance. To conjecture about the impact of such capabilities on performance, we firstly reviewed the previous studies that have examined the impacts of each economic, environmental, social SC capabilities on the performance, separately, and then synthesize them for providing a proposition.

First, it is widely believed that the (conventional) SCM capability, which is referred as the economic SC capability of the present study, provides firms with competitive benefits. Enhancing the SCM capability can have significant impact on firm performance in several ways. For example, information sharing among the supply chain partners may reduce demand uncertainty, the levels of inventories, and costs in the process of matching supply with demand in the supply chain [48]. In addition, a seamless supply chain system simplifies the organizational process and then reduces the lead times with suppliers. Social capital theory also supports these positive effects. Structural and relational capitals, usually accumulated through information sharing, collaboration, effective communication, mutual trust, and commitment between the supply chain partners, have been reported to result in improvements in supplier performance, as well as buyer performance along operational dimensions of product design, process design, reduced lead time and improved quality [49].

Second, integrating environmental issues into SCM is also believed to be associated with the manufacturing and firm performance of buyers, as well as suppliers. Improvements in environmental management, such as waste reductions, efficient and effective input use, and control of internal processes, can facilitate total quality management and lean manufacturing practices, because environmental management and lean production are fundamentally parallel to one another [50,51]. A number of studies have provided for this notion by presenting empirical evidence that environmental improvements can enhance delivery performance and reduce the cost of goods, overall costs, as well as improve the net income [52,53]. This synergistic effect applies to the supply chains, and provides explanations about the positive impacts of green SCM on buyers' and suppliers' performance. In particular, environmental collaboration representing advanced proactive environmental orientation can facilitate the formation of idiosyncratic interaction routines between the supply chain partners [8], and thus, render innovations and enhance the accumulation of valuable assets that are tacit, relationship-specific, socially embedded and are not easily replicated by competitors [54]. It should be noted that the social side of sustainable SCM has been relatively little addressed in the literature [17].

Human right issues relating to supplier labor practices, such as child labor, forced labor and illegal work environment, were initially explored, and then other social issues, including diversity and philanthropy to local communities were addressed. Carter and Jennings [55] proposed a comprehensive measure to simultaneously capture diverse social issues in the supply chain, namely purchasing social responsibility (PSR).

Regarding to the relationship between cumulative sustainable SC capabilities and performance, the evidence is quite limited. However, based on the previous studies, which addresses each capability contributing to higher performance, we can expect that the more sustainable SC capabilities a firm owns, the higher performance it can achieve.

*Proposition 2.* There are direct relationships between cumulative sustainable SC capabilities and supply chain performance.

## 3. Research Methodology

### *3.1. Sample*

Our unity of analysis is one side of a dyadic relationship between the buyer and the supplier. The sustainable SC capabilities of a supply chain were measured and analyzed from the perspective of suppliers. In particular, this study focused on medium-sized suppliers for two reasons. First, environmental and social SC capabilities in the supply chain are usually more critical in the relationships between the large buying firms and their small- and medium-sized suppliers than those between the large firms. Second, the development of sustainable SC capabilities is initiated mainly by the large firms' effort to their supply chain. In fact, sustainable SC capabilities between a relatively powerful large customer and a smaller supplier typically translate into buyer monitoring and support for the supplier [34]. In addition, we believe that suppliers' perception can better reflect the reality of sustainable SC capabilities than those of the buyers.

The sample consisted of 850 SMEs (defined as firms whose number of employees ranged from 50 to 500) that were listed in the Small and Medium Sized Enterprise Support Program Directory of the Korea Small and Medium Business Administration. First, we contacted each firm by telephone to request its participation in the survey, and for those willing firms, we asked for the appropriate respondents. We targeted a single, well-informed respondent. While the position of respondents varied depending on firm characteristics, such as the CEO or the senior manager in charge of sales, quality assurance, production, planning, or environmental management, these managers were well acquainted with the buyers' requirements and collaborative activities in economic, environmental, and social areas because they dealt with their customers' environmental/social requirements as well as conventional quality, cost, and delivery demands. We collected a total of 248 responses (29.2% response rate). Fifty responses were excluded from further analysis because they were not suppliers (27) or had missing data (23). The final usable sample contained 198 responses (23.3% response rate). Table 1 provides a summary of the respondents.

We assessed non-respondent bias by comparing the responses that were returned before the reminder call with those were returned after the call. For this, 20 items from the survey were randomly selected and conducted a *t*-test to examine any differences in responses between early and late respondents ($n_1$ = 143, $n_2$ = 105). The result indicated that there was not difference between the sample and the population at the 95 percent confident interval. We also examined the common method variance by using Harmon's single-factor approach. A single factor will emerge from a factor analysis of all survey items, or one general factor will account for most of the common variance in the data if common method variance exists [56]. A factor analysis (with a sample of 248 respondents) using the eigenvalue-greater-than-one criterion revealed four distinct factors that accounted for 65% of the variance while the first factor captured only 21% of the variance, suggesting that the potential problem of the common method variance was not significant.

**Table 1.** Summary of responses.

| Industry | Machinery and Materials | Electrical and Electronics | Telecommunications | Chemical | Total (Mean) |
|---|---|---|---|---|---|
| Sample Size | 335 | 281 | 134 | 100 | 850 |
| Respondents | 73 | 65 | 22 | 38 | 198 |
| Sales (in million USD) | 18.6 | 10.5 | 19.3 | 15.8 | 15.5 |
| No. of Employees | 95 | 64 | 98 | 55 | 77 |

### 3.2. Survey

Following previous research, we employed previously validated scales whenever possible. All items, except for the firm size, were measured using a seven-point Likert scale (1 = strongly disagree and 7 = strongly agree). The firm size was measured in terms of the number of employees.

Economic SC capability: We defined the economic SC capability as a supply chain's ability to address the quality, cost, delivery and flexibility issues in the supply chain in an efficient and effective way. This capability is characterized as a set of inter-organizational activities between the supply chain partners, including information sharing and collaborative practices, and consequential mutual trust and commitment. As noted before, this paper focuses on the perspective of suppliers, and thus, measures the perception of suppliers about the activities conducted between them and their major buyer. We developed five items for the economic SC capability based on the literature of SCM [28,35,57]. These items include information sharing, technical assistance, collaborative problem solving, mutual trust, and long-term partnership development.

Environmental SC capability: The definition and measurement of this capability is analogous to those of the social capability. The scale for the environmental dimension was adopted from previous research on green SCM [9,36,50]. This five-item scale also reflected the monitoring and collaboration practices conducted between the supply chain partners (environmental criteria for supplier evaluations, environmental management system implementation, auditing, environmental information sharing, educational and technical assistance, and collaborative product development).

Social SC capability: This capability is defined as a supply chain's ability to manage the social issues in the supply chain and then characterized as the extents of inter-organizational activities between a buyer and its supplier in responding to social issues. Five-item scale reflected the monitoring and collaboration practices conducted between a buyer and its supplier, including social criteria for supplier evaluations, management system certification, auditing, educational and technical assistance for social issue management, and collaborative and precautionary response [2,10,37].

Supplier performance: We measured the supplier's performance by its environmental, social and manufacturing performance. For environmental performance, a perceptual scale consisting of three items was designed. The scale included environmental performance improvements in environmental-friendly products, waste and emissions. For social performance, this study developed a three-item scale, including improvements in the realms of health, safety and human rights of employees and local communities. Previous studies of operations and SCM have reached a general consensus on a list of competitive priorities that can serve primary performance goals for suppliers, including their quality, cost, delivery, and flexibility [35]. We measured manufacturing performance using perceptual measures [20].

### 3.3. Validity and Reliability

The measurement was tested for its reliability, validity, and unidimensionality. We validated the content validity of the constructs though an extensive literature review before collecting data. We conducted a confirmatory factor analysis (CFA). Table 2 shows the factor loading, composite reliability, average variance extract, and Cronbach's alpha, which provided support for the unidimensionality, convergent validity, and reliability for all constructs. Table 3 shows the correlations between the latent variables. We assessed discriminant validity by examining whether

the average variance extracted for items exceeded the average shared variance (square of off-diagonal correlations) between the two constructs [58]. All constructs satisfied this criterion, indicating sufficient discriminant validity.

**Table 2.** Constructs' reliability and validity.

| Construct | Items | Standardized Loading | AVE | Composite Reliability | Cronbach-Alpha |
|---|---|---|---|---|---|
| Sustainable SC capabilities | | | | | |
| Economic SC capability | ESC01 | 0.72 | 0.64 | 0.89 | 0.92 |
| | ESC02 | 0.72 | | | |
| | ESC03 | 0.79 | | | |
| | ESC04 | 0.89 | | | |
| | ESC05 | 0.82 | | | |
| Social SC capability | SSC01 | 0.87 | 0.75 | 0.94 | 0.94 |
| | SSC02 | 0.88 | | | |
| | SSC03 | 0.91 | | | |
| | SSC04 | 0.78 | | | |
| | SSC05 | 0.87 | | | |
| Environmental SC capability | GSC01 | 0.66 | 0.6 | 0.87 | 0.88 |
| | GSC02 | 0.78 | | | |
| | GSC03 | 0.74 | | | |
| | GSC04 | 0.78 | | | |
| | GSC05 | 0.78 | | | |
| Supplier performance | | | | | |
| Environmental performance | GPER01 | 0.86 | 0.71 | 0.84 | 0.88 |
| | GPER02 | 0.85 | | | |
| | GPER03 | 0.81 | | | |
| Social performance | SPER01 | 0.91 | 0.76 | 0.91 | 0.94 |
| | SPER02 | 0.85 | | | |
| | SPER03 | 0.81 | | | |
| Manufacturing performance | MPER01 | 0.8 | 0.63 | 0.82 | 0.87 |
| | MPER02 | 0.61 | | | |
| | MPER03 | 0.81 | | | |
| | MPER04 | 0.81 | | | |

**Table 3.** Correlation Matrix.

| Construct | Mean | S.D. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| 1. Economic SC capability | 5.03 | 1.16 | (0.62) | | | | | |
| 2. Environmental SC capability | 4.68 | 1.37 | 0.58 ** | (0.85) | | | | |
| 3. Social SC capability | 4.32 | 1.59 | 0.62 ** | 0.66 ** | (0.58) | | | |
| 4. Environmental performance | 4.71 | 1.05 | 0.55 ** | 0.51 ** | 0.54 ** | (0.67) | | |
| 5. Social performance | 4.91 | 1.11 | 0.56 ** | 0.50 ** | 0.51 ** | 0.77 ** | (0.65) | |
| 6. Manufacturing performance | 5.40 | 0.95 | 0.56 ** | 0.45 ** | 0.43 ** | 0.60 ** | 0.66 ** | (0.63) |

(1) **: $p < 0.01$; (2) The lower half of the matrix shows estimated correlations between latent variables, and figures along the diagonal in brackets indicate the AVE.

### *3.4. Data Analysis*

We used hierarchical regression and cluster analyses to test our propositions. The propositions regarding to cumulativeness and sequences were tested with correlation and multiple regressions by following the approach of Noble [59] and Flynn and Flynn [20]. For example, positive significant coefficients indicate cumulative capabilities, while negative significant correlations represent trade-offs. In addition, stepwise regression and the standardized coefficients were used to determine the order of significant predictor capabilities for each dependent capability. The analysis also provides the variance inflation factors (VIF), indicating the absence of multi-collinearity.

Second, a cluster analysis was carried out to identify the patterns of supply chains to how to accumulate sustainable SC capabilities, and test the relationship between cumulative capabilities and supply chain performance. A hierarchical clustering procedure was applied to draw an adequate

number of clusters (Ward's method). The explanatory power and pseudo F value of this cluster analysis verified that the four clusters were a valid classification. Then, a non-hierarchical clustering method (K-mean method) was implemented to assign the sample to the clusters. In addition, an ANOVA was performed to investigate the differences between the cumulative types in terms of supplier firm size and supplier manufacturing performance.

## 4. Results

### *4.1. Cumulative Sustainable SC Capabilities*

The results in Table 4 provide support for the first proposition, which predicted cumulative sustainable SC capabilities. All positive and significant pairs of correlations support each capability, enhancing the accumulation of the other capabilities, with no apparent trade-offs. These revealed that the supply chain firms were not trading off an emphasis in the development in social or environmental capabilities for economic capabilities. The results of regression analysis provided an additional support for the development of an emphasis on cumulative sustainable SC capabilities. The results show that there is not a single negative relationship between the three capabilities, economic, social, and environmental capabilities.

**Table 4.** Relationships between capabilities.

| Dependent | Adj-$R^2$ | $F$ | Independent | Coefficient β | $T$ | VIF |
|---|---|---|---|---|---|---|
| Economic SC capability | 0.42 | 66.99 ** | Social capability | 0.45 | 6.17 ** | 1.66 |
| | | | Environmental capability | 0.27 | 3.78 ** | 1.66 |
| Social SC capability | 0.50 | 91.21 ** | Environmental capability | 0.42 | 6.66 ** | 1.44 |
| | | | Economic capability | 0.39 | 6.17 ** | 1.44 |
| Environmental SC capability | 0.44 | 71.08 ** | Social capability | 0.47 | 6.61 ** | 1.62 |
| | | | Economic capability | 0.26 | 3.71 ** | 1.62 |

**: $p < 0.01$.

As evident from the results of multiple regression analyses (Table 4), the economic and environmental SC capabilities include social SC capability as the most significant predictor, while the social and environmental capabilities include economic capability as the second significant predictor. This implies that the economic capability is a higher level (the lastly accumulated and/or a capability that is more difficult to accumulate), building upon the foundations of the social and environmental capabilities (relatively easily accumulated capabilities), indicating the possible sequences of cumulative capabilities.

### *4.2. Cumulative Capabilities and Supplier Performance*

To assess the impact of cumulative sustainable SC capabilities on supply chain performance, we firstly classified groups of cumulative capabilities and then compared the performance between the groups. The cluster analysis yielded four types of cumulative capabilities. Table 5 summarizes the results of the analysis, including the mean scores for each capability and the number of cased belonging to each group.

**Table 5.** Cluster analysis and cumulative capabilities.

| Sustainable SC Capability | Cluster | | | |
|---|---|---|---|---|
| | Laggard | Environmental-Focused | Social-Cautious | All-Round |
| Economic | 3.01 | 4.31 | 4.64 | 5.84 |
| Environmental | 2.01 | 5.34 | 4.18 | 5.78 |
| Social | 1.63 | 2.88 | 4.01 | 5.82 |
| Number of cases | 19 (9%) | 34 (16%) | 71 (36%) | 75 (39%) |

The first cluster scored relatively low on all three sustainable capabilities, lagging behind any other clusters in sustainable supply chain capabilities. This was labeled the "laggard". The second cluster shows relatively high and moderate levels in the environmental and economic SC capabilities, respectively. This group's cumulative capabilities primarily involved the environmental and economic SC capabilities. We labeled this cluster the "environmental-focused". The third cluster scored relatively high and moderate on the economic, environmental and social SC capabilities, respectively. This cluster is likely to be more cautious about the social issues in the supply chain than the other two groups of the "laggard" and "environmental-focused". This cluster was labeled the "social-cautious". The last group shows the highest scores in all three capabilities. This cluster represents highly cumulative sustainable SC capabilities, labeled as the "all-round".

Table 6 shows the results of the ANOVA, indicating the differences between the types of cumulative sustainable SC capabilities. First, the firm size of a supplier was found to be associated with cumulative sustainable SC capabilities, even though the extent of the relationship was not quite strong. The suppliers of the "all-round" group were likely to be larger than those of the other groups, but statistical support was not significant. Second, significant differences of supplier environmental, social and manufacturing performance among the clusters were found, providing support for the second proposition. According to the Duncan's test, the average performance of suppliers was not the same across the four clusters. Supplier environmental, social and manufacturing performance of the "all-round" group was significantly higher than that of the other clusters. The "environmental-focused" and the "social-cautious" clusters also showed significantly higher performance than the "laggard" cluster. These results indicate that cumulative sustainable SC capabilities are significantly and positively related to the supply chain performance.

**Table 6.** ANOVA: Cumulative capabilities and firm performance.

| Variables | Laggard (A) | Environmental-Focused (B) | Social-Focused (C) | All-Round (D) | Duncan's Test (*F* Value) |
|---|---|---|---|---|---|
| Firm size | 136 | 206 | 285 | 367 | D = C = B = A (0.54) |
| Environmental performance | 3.28 | 4.46 | 4.56 | 5.28 | D > C = B > A (25.07 **) |
| Social performance | 3.71 | 4.61 | 4.66 | 5.54 | D > C = B > A (21.45 **) |
| Manufacturing performance | 4.25 | 5.23 | 5.24 | 5.87 | D > B = C > A (19.05 **) |
| Number of cases | 16 (9%) | 29 (16%) | 68 (36%) | 72 (39%) | |

**: $p < 0.01$.

## 5. Discussion and Implications

This study provides a more comprehensive definition of the sustainable SC capabilities and identifies a set of three interconnected dimensions of sustainable capabilities: economic, social and environmental capabilities. In addition, the study proposes valid and reliable instruments that are simplified for measuring the sustainable SC capabilities. These constructs, with better definitions and measures, are expected to facilitate future empirical research.

In this research, we explored the cumulative sustainable SC capabilities, indicating the positive and significant relationships between the economic, social, and environmental capabilities. Results provide strong evidence regarding the cumulative capabilities, illustrating that economic, social, and environmental SC capabilities mutually reinforce each other, rather than traded off when they are developed. This is quite consistent with the original cumulative manufacturing capabilities theory [19,59]. This result implies the natural RBV [43], explaining the possibilities of mutual reinforcement between the economic and environmental capabilities, can be extended to the triple bottom line, as well as supply chain contexts. The results of this are also in line with several observations that sustainable supply chain management has been diffused into some of Korean industries. For instance, a national green supply chain initiative was started in 2003, which was originally programed and supported by the Korean government to encourage small- and medium-sized supplier to improve their environmental capabilities by utilizing relationships between the key-players

of large buying firms and their suppliers. Hyundai Motor Company, Samsung SDI, and other large-sized Korean firms have implemented their own green supply chain management practices by actively participating in this national project. Hyundai Motor Company and Samsung SDI introduced their green procurement policy in 2003 and 2004, respectively, by demanding their suppliers to put an environmental management system into place and assure that their products were free of hazardous substances. Along with such an environmental performance monitoring, they also have implemented a supplier-support program by providing their selected major suppliers with environmental education, technical assistance, and environmental information sharing systems. Through these practices, suppliers in the Korean automobile and electronics industries, have improved their environmental capability without compromising economic capability [60], which in turn support the possibility of cumulative capabilities rather than trade-offs.

This study also provides a strong evidence of a relationship between cumulative sustainable SC capabilities and supply chain performance. The cumulative capabilities of the three capabilities (the "all-round" cluster) showed the highest supply chain performance, followed by two other cumulative capabilities, namely the economic/environmental cumulative (the "environmental-focused" cluster) and the middle levels of economic/social/environmental cumulative (the "social-cautious" cluster). This result is very consistent with the previous studies in operations management about the positive relationship between the cumulative capabilities and plant performance [19] and that between the SC capability and firm performance [28], as well as that between the sustainable SCM practices and firm performance [9]. Collectively, this study answers the call for a more comprehensive analysis of sustainable business operations based on all dimensions of the triple bottom line, simultaneously [16], and fills the gap in empirical research on outcomes of sustainable SCM [17,47].

This study provides a better understanding about the sustainable SC capabilities and important guidelines for managers of suppliers and buyers who wish to build a more sustainable supply chain. First, supply chain managers should recognize that cumulative sustainable SC capabilities can increase the supply chain performance. Buyers should integrate sustainability issues into the conventional SCM practices in a steady manner by expecting a balance between the financial performance and nonmonetary performance outcomes, such as quality, buyer–supplier relationship, and social capital. Suppliers should explicitly recognize that enhancing their efforts to comply with social and environmental requirements of their buyers, and make proactive use of support and/or collaboration programs may facilitate the development of sustainable SC capabilities, which in turn, lead to higher manufacturing performance [9,61].

Second, supply chain managers can utilize the measures of this study as powerful tools to build environmental and social SC capabilities. They should design and undertake effective and integrated sustainable SC practices by fully visualizing that the three dimensions of the triple bottom line in the supply chain are closely interrelated. For instance, supply chain partners should introduce environmental and social procurement systems, including the formal monitoring and auditing process with ISO 14001 and/or SA 8000 certificates [10,36]. In addition, information sharing and collaborative activities in response to environmental and social issues need to be facilitated [62]. Such environmental/social monitoring and collaboration practices are not much different from conventional supply chain practices, indicating that supply chain practices to improve sustainable SC capabilities are closely interrelated.

Finally, the results imply that the economic SC capability is the most difficult to build among the three sustainable capabilities because it can build upon the foundation of social and environmental capabilities. Firms, both buyers and suppliers, need to proactively address the social and environmental issues in the supply chain even though the economic capability is the ultimate goal to achieve. Doing so can foster frequent communication, mutual understanding, goal congruence, shared philosophies, and benefit sharing [63,64], which in turn enables the supply chain partners to develop much easily of the economic SC capability.

## 6. Conclusions and Future Research

This paper proposed an integrated concept of sustainable SC capabilities by combining diverse concepts of capabilities, supply chain management, and the triple bottom line (sustainability). Our findings present a range of issues for managers of buying firms, as well as suppliers attempting to foster social and environmental management capabilities, in addition to the traditional SC capability throughout the supply chain. Evidence of cumulative sustainable SC capabilities and their positive effects on supply chain performance suggests strong possibilities of win-win-win situations and requires firms to develop supply chain strategies toward sustainable development [3]. Overall, the results of this study provide guidance for managers and academics considering how to identify, design and manage the dimensions of sustainability into supply chain management.

By clarifying the limitations of this paper, we suggest directions for future research. First, this study examined sustainable SC capabilities from a supplier perspective. Future research should explore this topic from a dyadic perspective by using data from both sides of the buyer and supplier. In addition, this study relied exclusively on self-reported and subjective measures. The positive effects of cumulative sustainable SC capabilities need to be investigated with objective measures such as financial performance data. Third, this study did not fully consider the radical innovation aspect of sustainable SC capabilities. Sustainability is a fundamentally new way of thinking about SCM requiring radical innovations in terms of practices [12]. Future research should focuses on how to create truly sustainable supply chains being to maintain economic viability, while doing no harm to social or environmental systems. Fourth, this study presented the degree to which the three dimensions of sustainable SC capabilities are correlated varies significantly across firms (e.g., four types of cumulative sustainable SC capabilities). However, the question why firms differ in building sustainable SC capabilities remains unanswered. Intra-organizational factors such as internal process integration, purchasing and supply function capability and organizational learning and inter-organizational factors including the buyer–supplier relationship and dependency as well as contextual factors such as stakeholders' sustainability pressure should be explored in future research. Fifth, the extent and strength of particular relationships may vary across countries, and contextual differences may matter. In particular, future research should address emerging economies that have emerged as one of the factories of the world that are offering a large workforce, in which regulators and consumers do not likely to impose the same extent of environmental and social pressure onto supply chains.

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**Author Contributions:** Jung Seung Lee and Soo Kyung Kim designed the study and conducted literature review. Su-Yol Lee collected data and conducted statistical data analysis. Su-Yol Lee wrote the manuscript and the other authors read and approved the final manuscript.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A. Questionnaire Items Used for This Study

| Construct | Item Code | Items |
|---|---|---|
| Sustainable Supply Chain Capabilities | | |
| Economic SC capability | | |
| | | To what extent do you agree or disagree with each of the following statements (*1 = not at all, 4 = moderately, and 7 = very much*)? *During the last two years, our major customer . . .* |
| | ESC01 | shared relevant and timely information with us. |
| | ESC02 | provided us with technical and managerial assistance. |
| | ESC03 | and our firm solved problems jointly. |
| | ESC04 | and our firm trust each other. |
| | ESC05 | and our firm consider us as a long-term partner. |

| Construct | Item Code | Items |
|---|---|---|
| Social SC capability | | |
| | SSC01 | assessed our social performance (e.g., good relationships with local community and employees, no occupational accidents, and legal compliance) a formal procurement process. |
| | SSC02 | conducted audits regarding social issues (e.g., those related to labor, ethics, and community relations) on a regular basis. |
| | SSC03 | provided us with relevant and helpful information on how to comply with its social requirements. |
| | SSC04 | provided us with technical, managerial, and financial assistance to address social issues. |
| | SSC05 | and our firm jointly identified possible social issues to prepare for and respond to them. |
| Environmental SC capability | | |
| | GSC01 | assessed our environmental performance through a formal and green procurement process. |
| | GSC02 | demanded us to implement an environmental management system |
| | GSC03 | conducted environmental audits on a regular basis. |
| | GSC04 | provided us with technical, managerial, and financial assistance to address environmental issues. |
| | GSC05 | and our firm jointly developed environmental-conscious products. |
| Supplier Performance | | |
| | | For each of the items listed below, how does your firm compare with primary competitors? (*1 = far worse than competitors, 4 = about the same as competitors, and 7 = far better than competitors*) |
| Manufacturing performance | | |
| | MPER01 | Product quality |
| | MPER02 | On-time delivery |
| | MPER03 | Production costs |
| | MPER04 | Ability to change output volume |
| Environmental performance | | |
| | GPER01 | Reduced air emissions (e.g., $SO_x$, $NO_x$ and $CO_2$) |
| | GPER02 | Reduced waste water and/or solid waste |
| | GPER03 | Decreased consumption of hazardous/toxic materials |
| Social performance | | |
| | SPER01 | Increased employees' health and safety |
| | SPER02 | Improved local community's overall health and safety |
| | SPER03 | Improved awareness and protection of the claims and rights of local community |

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# SWOT ANALYSIS OF PAKISTAN TEXTILE SUPPLY CHAIN

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**ABSTRACT**

This study is part of a research project, Contributions for Improving Textile Supply Chain Management in Pakistan, which is focused on reduction of lead times and costs. SCM is an interdisciplinary field that emphasizes cross-functional links and seeks to manage those links to enhance a company´s competitive advantage. Textile supply chains are driven by big brands and retailers. These are segmented into high and low profit steps with retailers and brands keeping high profit steps and mid-chain suppliers and low-cost producers keeping the low profit steps. Pakistan textile industry which has its roots in cotton products has focused on the lower end of this value chain. It has retained an important share of world textile and clothing exports although weaknesses exist at different tiers of the supply chain. The SWOT analysis is conducted to study the status of existing potential and find future directions of the study followed by a statistical study of Pakistan´s exports of textile and clothing. Important markets are highlighted and an initial survey of freight travelling time being part of lead times is conducted.

**Key words**: Supply chain management, textile and clothing industry, transports, lead times;

## 1. INTRODUCTION

The textiles and clothing sector generated, in 2007, flows of about 583.4 Billion $US, amounting to almost 4.2% of total world exports [6]. The clothing sector, accounting for about 345.3 Billion $US, is particularly important to many developing countries where textiles are the main source of export revenue and manufacturing employment.

Over the past 25 years, trade liberalisation and communication innovations have increased the opportunities for retailers and brands to buy their products from producers worldwide. According to recent studies, these retailers and brands have become "global sourcing companies", outsourcing the production of goods they sell to tiers of competing suppliers and producers through complex international networks, or global supply chains.

These supply chains are driven by the big brands and retailers that have tremendous power in determining price, quality, delivery, and labour conditions for suppliers and producers down the chain. They are segmented into high and low profit steps. Retailers and brands keep high profit steps such as innovation, marketing and retailing. Low profit steps, such as sourcing raw materials, production and assembly, finishing and packing, are outsourced to mid-chain suppliers and low-cost producers worldwide. Thus global supply chains have created labour-intensive exports from low-cost locations. The result is an enormous growth in the number of producers, increasing competition among the world's factories at the bottom of the chain.

SCM is an interdisciplinary field that emphasizes cross-functional links and seeks to manage those links to enhance a company's competitive advantage. It involves forecasting, resource allocation, production planning, flow and process management, inventory management, customer delivery, after-sales support and service, and a multitude of other activities and processes familiar and essential to business. Nowadays an ever-increasing number of companies rely on supply chain management as a key competitive weapon. Large and small businesses alike have reported remarkable results, including dramatic reductions in cycle time.

## 2. OBJECTIVES

Pakistan textile industry has focused on the lower end of the world textile market in the past, and supplied low cost products with good quality, that is why it has attracted the buyers around the world in that market segment. SCM should be the key focus to enhance competitiveness of Pakistani textile industry. In saturated markets, like textiles, the issue of lead times is of great importance and one of the main driving factors for business sustainability and profitability. There are many textile fashion brands which are manufactured in countries like Pakistan. The fashion cycles of these brands are mainly once or twice per year, making it possible, to some extent, for Pakistani suppliers to respond to their lead times. However, world trends in textile and fashion business indicate clearly that lead times are continuously reducing. This created a new and an advanced demand and supply market where each key player collaborates with its suppliers and shares market information and risks. It seems that Pakistani textile industry may not be prepared for this scenario and may have difficulties in meeting lead times and prices of key markets. The current context of these markets frequently creates changing short run orders causing a strong impact on planning. Despite having latest computerised manufacturing machines, Pakistani companies put less emphasis on demand forecasting, production and inventory planning systems. This results on high costs of operation and late deliveries.

Thus, even with state of the art machinery and access to capital, Pakistani textile industry is compelled to manufacture and export non-seasonal and low value textile products where high capital is required to manufacture at extremely low margins. This reduces the overall competitiveness. Textile Supply Chain Management in Pakistan should have two main objectives: reduction of lead times and costs. Obstacles in achieving these objectives include geographical location, imperfect Logistics systems, scarce Production Planning and Inventory Management systems. The long lead times are the result of all this.

## 3. SWOT ANALYSIS

Textile industry in Pakistan is one of the oldest manufacturing sectors of the country. People are linked with textile manufacturing for more than 5000 thousand years, evident from the findings at Moen-jo-Daro, an archeological site near Larkana, Pakistan. The statue found from this site bear the proof of dyed/printed fabrics worn by the man and this fabric is produced till today and called as ``Ajrak``. It has its roots in cotton fiber production which is the second most important crop of the country and man-made fibers like polyester, acrylic and viscose are produced domestically. The value chain of textile in Pakistan is expanded from cotton, man-made fiber production, ginning, yarn manufacturing by Ring/Rotor Spinning, fabric manufacturing by Weaving/Knitting, coloring of fabric by Dyeing/Printing, finishing of the fabric by various mechanical and chemical finishes and their conversion into apparel and made-ups.

In this section we present a SWOT[1] analysis of Pakistan textile value chain and associated sectors.

### 3.1 STRENGTHS

Average yearly production of cotton between 1990 and 2005 is 10 309 000 bales [1]. It is ranked fourth in cotton producing countries and third in cotton consuming countries of the world [2]. There is domestic production of man-made fibers as polyester, acrylic and viscose.

It is an important industry in Pakistan which captures 46 percent of entire manufacturing sector and 38 percent of industrial employment [4]. Wages are in the lowest side in the world textile industry ($0.39/hour), although Bangladesh and Vietnam have smaller wages (of $0.27/hour and $0.29/hour respectively [3]).

The textile manufacturing side is comparatively strong one and enjoys new technology from Germany, Switzerland, Belgium, UK, Japan, USA and China. The capital intensive side of the textile supply chain is therefore in a strong state.

Clothing remained unattended in past but it is improving since late 1990s. Trainings are being launched by government jointly with foreign consultants to improve the skills of local operators and productivity of the processes.

There is a strong support from government concerning textile and clothing sector which involves technology upgrading, skill development and research.

[1] SWOT Analysis is a strategic planning method used to evaluate the **S**trengths, **W**eaknesses, **O**pportunities, and **T**hreats involved in a project.

### 3.2 WEAKNESSES

The per acre yield of cotton production is low due to improper crop management, attacks of viruses and pests on the crops. Picking of seed cotton, storage and transportation conditions add impurities as the standard practices are not followed, deteriorating product quality. Cotton farmers are not familiar with recent developments in cotton farming and forward marketing. Ginning industry is using outdated technology and untrained labor. Lint cleaners are rarely used which can improve the yield at later stages of yarn manufacturing. Manual methods of open sky drying for seed cotton increase contamination and introduce variations of moisture content.

Limited types of man-made fibers are being produced which are less competitive for quality and cost.

The yarn sector is producing coarser counts and traditional yarns although it has the potential to produce medium, fine counts and fancy yarns. The versatility in yarns can give weaving industry a stronger basis.

The storage conditions of cotton lint in the factories are not very good so quality deterioration takes place.

In general, power loom sector is organized as cottage industry in the country which is facing problems of yarn and power supplies, finance and many others. Efficient fabric manufacturing technology can be incorporated to upgrade these sectors as organized industry.

In coloring and finishing the use of sophisticated color matching techniques and software are nonexistent which could enhance the responsiveness to customers. Strong relationship between quality suppliers and processing industries is very important for consistency of product quality, yield and costs.

The clothing sector is scattered across the country due to nature, size and investment required to set up such a unit. There is a recent move to establish specific hubs of garment manufacturing by providing special zones for the industry. Fashion clothing attracts maximum profits in the international market. The fashion designers lack familiarity with the international fashion styles and market trends. The industry needs to be linked with the international fashion market.

The industry has not fully understood the importance of social responsibility and workers welfare.

Transportation infrastructure in the country is in the process of development; the only effective means of freight movement is trucking on the roads. These trucks are low capacity and under-power, manufactured within the country. Domestic industries enjoy the lowest freight rates in the world but at par lower services. The average travelling speed in the country is 28-40 km/hr compared to 80-90 km/hr in Europe [5]. The overloading is usual which adds to decrease the commercial running speeds of truck and increase the road deterioration pace. The rail transport accounts for less than 5 percent of freight traffic in the country [5]. Domestic customers do not find it appropriate for transportation of their goods on time and safely. The situation of handling ship-to-shore conditions have improved on the domestic ports but the entry and handling charges are 5-9 times higher than other neighboring ports in the region [5]. The updating of ports is in process and it will take some time to observe the improvements.

The departments of marketing, planning, storage, production, quality control, packaging, purchasing, finance, and others are not linked through computer networking for fast and less expensive communication; the advantages of using ICT are not fully understood yet.

Reworks exist in the system. An effective and well understood inspection and quality control policy is needed at all stages of preparation, production and final inspection.

Inventory management needs more attention in respect of planning, use of sophisticated technology and training of personnel. No periodic monitoring of all stocks and their effective categorization exists. Material stores are substandard, record keeping is manual and time consuming, material handling and identification and traceability needs more care. Suppliers are not fixed and practice of supplier`s evaluation needs improvement.

The electricity and gas shut downs cause production losses, quality deterioration and cost increase. The usage of energy is inefficient in majority of sectors.

### 3.3 THREATS TO INDUSTRY

The industry is facing problems because of non competitive behavior of entrepreneurs, short term & inconsistent government policies, rising regional and international competition, increasing costs of energy and low pace of human resource development.

Machine manufacturing is not properly groomed till now and it requires a lot of resources to upgrade the processes with new technology and fulfill their recurring needs. It is producing low technology machinery and certain parts; workshops are associated with manufacturing and repair of the equipment and tools. Without a proper engineering base it will be very difficult to match the future upgrading of the industry.

Various types of chemicals are needed along the textile value chain. Companies of multinational origin and domestic as well are engaged with the manufacture and trade of these chemicals. Most of the

chemicals are imported in finished forms or sometimes as basic raw material which causes an increase in import bills.
Local industries are working without quality management systems and standards; these are required to be formalized.

### 3.4 OPPORTUNITIES

There are many related areas to existing manufacturing set up which can be explored and added as arteries, such as non woven, clothing and made-ups for health service industry and technical textiles.
Production and usage of petroleum based fibers can extend the scope of textile industry into new areas of versatile and high value applications.
Denim area is strong and products meet the quality standards of many international brands for their retail chains of lower end market. There is need to upgrade these products as high valued. There is although tough competition ahead from leading suppliers of denim which are considered as high quality producers.
The culture is rich and has a long history of textiles manufacturing. The cultural trends can be mixed with international fashion to give the world new flavors. There is a need of exploring the creativity of designers and familiarizing them with the world fashions. One of the important directions can be collaborations between domestic and international fashion institutes, fashion houses, designers, research institutes and others. A variety of cultural items are produced for domestic use through hand printing, appliqué work, rug making, hand embroidery, handloom weaving, hand knitting and others techniques. The quality and access of these products can be improved for important export markets.
Information and communication technology skills have been upgraded in the country in recent years. These skilled individuals can be attracted towards the textile industry by providing them opportunities in the textile industrial zones. There is a lot of room in this industry for upgrading the computer and information technology skills of the persons. Many applications of ICT lie with the planning of activities and their integration at different levels, sharing and communication of process and product information among different tiers of the process and customers.
There is need of focusing towards research and development in the areas of new products and improved processes. The need for studying the international business trends and role of trade agreements on these are important. This can be achieved by studies of consultants, researchers, government agencies and all available sources.

### 3.5 SWOT ANALYSIS SUMMARY

We summarize the SWOT analysis in table 1.

Table 1: SWOT Analysis of Pakistan Textile Value Chain and Associated Industries

| **Textile Value Chain** | **Strengths** (1,2=Poor, 3,4=Medium & 5-8=Strong) |
|---|---|
| Fiber Production | |
| Cotton Farming | 5 (Strong) |
| Ginning | 2 (Poor) |
| MMF Production | 3 (Medium) |
| Yarn Manufacturing | |
| Ring Spinning | 7 (Strong) |
| Rotor Spinning | 5 (Strong) |
| Fabric Manufacturing | |
| Weaving | 5 (Strong) |
| Knitting | 6 (Strong) |
| Narrow | 4 (Medium) |
| Fabric Coloration | |
| Dyeing | 4/5 (Medium to Strong) |
| Printing | 6 (Strong) |
| Fabric Finishing | 4/5 (Medium to Strong) |
| Clothing | 4 (Medium) |
| **Associated Industries** | |
| ICT and its Application | 3 (Medium) |
| Machine Manufacturing | 2 (Poor) |
| Dyes & Chemical Manufacturing | 4 (Medium) |

## 4. ANALYSIS OF PAKISTAN TEXTILE AND CLOTHING EXPORT DESTINATIONS AND RESPECTIVE LEAD TIMES

The statistics of world textile and clothing show that main textile importers are USA, China, EU, Canada, Japan and Mexico. Their combined share in world textile imports is around 60 %, in 2007. For clothing the main importers are EU, USA, Japan and Canada representing around 81 % of world clothing imports in 2007[6].

The statistics of textile and clothing exports of Pakistan, between 2000 and 2007, is summarized in Table 2. The most important market destinations are shown in Figures 1 and 2. These markets have attracted around two third of Pakistan´s textile and clothing exports [6] in that period. Based on this statistics an initial survey of travelling times from Pakistan to these destinations and some other important countries has been carried out through shipping lines from Pakistan. The details of this survey are compiled in Table 3 and presented in Figure 3.

Table 2: Textile & Clothing Exports Statistics of Pakistan 2000-2007

| | | Textile | | | | | | | | Clothing | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Destinations** | | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
| World | Value* | 4532 | 4525 | 4790 | 5811 | 6125 | 7087 | 7469 | 7371 | 2144 | 2136 | 2228 | 2710 | 3026 | 3604 | 3907 | 3806 |
| | Share** | 2,9 | 3,1 | 3,1 | 3,4 | 3,1 | 3,5 | 3,4 | 3,1 | _ | _ | _ | 1,2 | 1,2 | 1,3 | 1,3 | 1,1 |
| | Rank*** | 12th | 9th | 9th | 9th | 10th | 8th | 9th | 9th | >15 | >15 | > 15 | 15th | 15th | 13th | 13th | 12th |
| Canada | Value | 100 | 84 | 89 | 97 | 88 | 101 | 104 | 97 | 60 | 70 | 70 | 71 | 70 | 69 | 81 | 82 |
| | Share | 2,4 | 2,2 | 2,3 | 2,5 | 2,1 | 2,3 | 2,4 | 2,1 | 1,6 | 1,8 | 1,7 | 1,6 | 1,3 | 1,2 | 1,2 | 1,1 |
| | Rank | 7th | 7th | 7th | 7th | 7th | 6th | 6th | 6th | 14th | 13th | 13th | 14th | 15th | 14th | 12th | 12th |
| USA | Value | 945 | 1057 | 1161 | 1251 | 1478 | 1704 | 1902 | 1700 | 1049 | 1102 | 1060 | 1200 | 1322 | 1447 | 1628 | 1696 |
| | Share | 6 | 6,9 | 6,8 | 6,8 | 7,2 | 7,6 | 8,1 | 7,1 | 1,6 | 1,7 | 1,6 | 1,7 | 1,7 | 1,8 | 2 | 2 |
| | Rank | 7th | 6th | 6th | 6th | 6th | 6th | 5th | 6th | 21st | 21st | 22nd | 23rd | 21st | 18th | 15th | 14th |
| Mexico | Value | N/A | N/A | 38 | 42 | 42 | 51 | 37 | 37 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | Share | _ | _ | 0,7 | 0,8 | 0,8 | 0,8 | 0,6 | 0,6 | _ | _ | _ | _ | _ | _ | _ | _ |
| | Rank | _ | _ | 8th | 8th | 8th | 7th | 12th | 12th | _ | _ | _ | _ | _ | _ | _ | _ |
| EU | Value | 1006 | 995 | 1115 | 1363 | 1739 | 1527 | 1728 | 2099 | 867 | 834 | 904 | 1130 | 1389 | 1228 | 1395 | 1547 |
| | Share | 2 | 2,2 | 2,4 | 2,6 | 2,6 | 2,3 | 2,5 | 2,5 | 1 | 1,1 | 1,1 | 1,1 | 1,1 | 1 | 1 | 1 |
| | Rank | 7th | 7th | 5th | 5th | 5th | 5th | 5th | 5th | 15th | 15th | 14th | 12th | 11th | 12th | 12th | 11th |
| China | Value | N/A | N/A | 474 | 460 | 450 | 574 | 702 | 731 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | Share | _ | _ | 3,6 | 3,2 | 2,9 | 3,7 | 4,3 | 4,4 | _ | _ | _ | _ | _ | _ | _ | _ |
| | Rank | _ | _ | 6th | 6th | 7th | 7th | 7th | 7th | _ | _ | _ | _ | _ | _ | _ | _ |
| Japan | Value | 152 | 109 | 81 | 76 | 87 | 75 | 71 | 66 | 15 | 16 | 9 | 8 | 8 | 8 | 8 | 9 |
| | Share | 3,1 | 2,3 | 1,8 | 1,5 | 1,6 | 1,3 | 1,1 | 1 | 0,1 | 0,1 | 0,1 | | | | | |
| | Rank | 8th | 8th | 10th | 10th | 10th | 10th | 10th | 11th | 20th | 20th | 26th | 29th | 29th | 27th | 28th | 26th |

* Million of $US

** Pakistani share in region imports

*** Rank in regions import suppliers

Table 3: Travelling Times from Karachi Port, Pakistan to Different Destinations in World

| Destination | Travelling Time | Destination | Travelling Time | Destination | Travelling Time |
|---|---|---|---|---|---|
| United Kingdom | 20-22 | Norway | 32-35 | Mexico | 40-45 |
| Germany | 22-24 | Portugal | 30-32 | Brazil | 40-45 |
| France | 28-30 | America (NY) | 22-24 | Argentina | 30-35 |
| Italy | 21-22 | Canada | 28-30 | Vietnam | 20-22 |
| South Africa | 24-25 | Tunisia | 29-30 | Malaysia | 16-17 |
| Algeria | 24-25 | Saudi Arabia | 10-11 | Japan | 22-25 |
| Egypt | 18-20 | Australia | 30-35 | Bangladesh | 18-20 |

## 5. CONCLUSION AND FUTURE WORK

The SWOT analysis of the textile value chain and associated subsectors rates cotton ginning and machine manufacturing as weakest areas (rated 2-Poor); clothing, man-made fibre production, ICT, dyes and chemical manufacturing as medium (rated 3 or 4); cotton farming, weaving, dyeing, finishing as strong (5); spinning, knitting and printing as strongest areas (6 or 7).
The textile and clothing export statistics show that important markets for Pakistan textile products are EU, USA, China, Canada, Japan and Mexico. Initial surveys reveal that the freight travelling times to South America, Australia, Northern Europe and African countries are higher than other destinations. Although the freight travelling time is only a part of product lead times but this is important for countries like Pakistan which due to their geographical location are distant from the main markets.
An intermodal link between Pakistan and Europe through Iran and Turkey can decrease travelling times and therefore to improve the market response time through lead times reduction.

The project will develop through the following studies:

- Production times;
- Travelling times to more destinations;
- Travelling times to main ports in Pakistan;
- Lead times as a combined effect of travelling times with planning and production times
- Production costs;
- Statistical analysis of lead times and costs;
- Textile and clothing lead times in Portugal;
- Benchmarking of results;
- Development of strategies and recommendations for decreasing lead times and costs in Pakistan;

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Figure 1: Pakistan Textile Exports (Million $US) 2000-2007

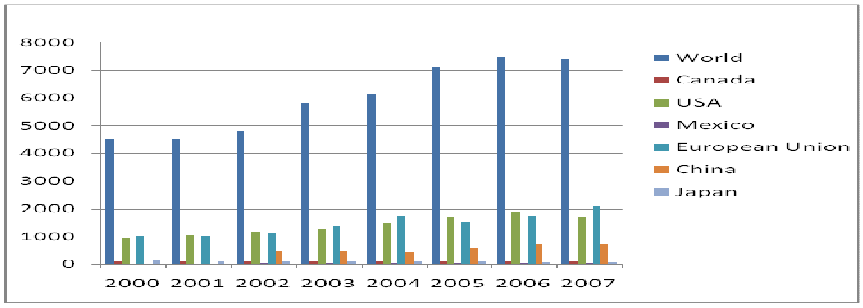



Figure 2: Pakistan Clothing Exports (Million $US) 2000-2007

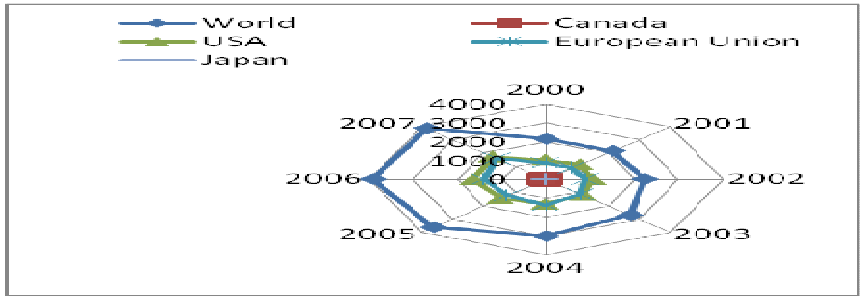
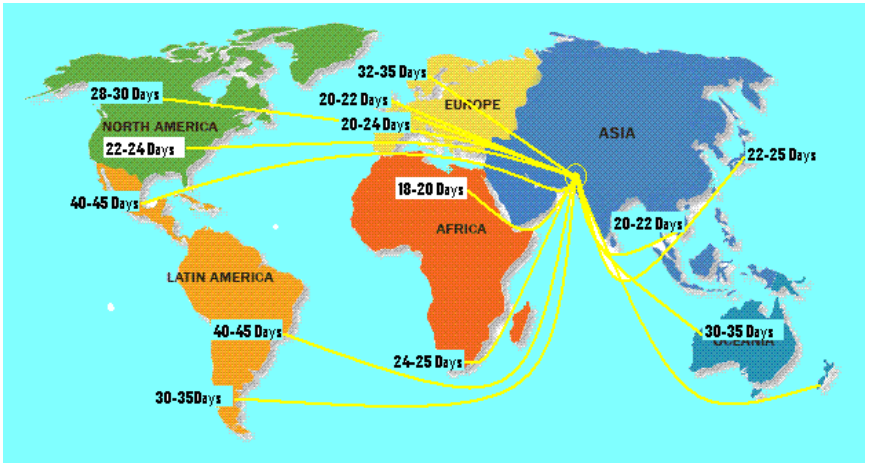



Figure 3: Freight Travelling Times from Karachi Pakistan



Logistics Bureau

# A 70-Point Supply Chain Basics Checklist From Logistics Bureau

Running today's complex supply chains is no easy task. This 70-point checklist should help you to get your supply chain on track and keep it there. Use it to look for basic improvement opportunities, which can easily be overlooked in any busy company, especially when the main focus is on product development, marketing, and sales.

Simply check the boxes which you believe apply to each point in the checklist.

"Yes" means your company is meeting basic supply chain requirements.

"No" means an opportunity for improvement.

"Don't know" should be a prompt to investigate and find out the answer.

| 70- Point Supply Chain Basics Checklist | | | | |
|---|---|---|---|---|
| **A. Supply Chain Strategy** | | **Yes** | **No** | **Don't Know** |
| 1 | Does your company have a documented supply chain strategy? | | | |
| 2 | Does your supply chain strategy clearly support overall business strategy? | | | |
| 3 | Is your supply chain strategy supported by clear and understandable functional, team, and individual performance objectives? | | | |
| 4 | Do you have a set of key performance indicators (KPIs) to measure performance against strategic supply chain objectives? | | | |
| 5 | Are your supply chain KPIs aligned across all functions touched by supply chain? | | | |
| 6 | Are employees' incentives and compensation linked to your strategic supply chain objectives? | | | |
| **B. Customer Service** | | **Yes** | **No** | **Don't Know** |
| 7 | Does your supply chain strategy include objectives for customer service improvement? | | | |
| 8 | Does your company use customer-focused KPIs such as "Perfect Order" or DIFOT? | | | |
| 9 | Is each customer-focused KPI cascaded down to each supply chain function and tailored to measure functional customer service performance? | | | |
| 10 | Are supply chain employees trained to understand the concept of internal and external customers? | | | |
| 11 | Do employees in all supply chain functions receive customer service-related training? | | | |
| 12 | Does your company regularly gather feedback from customers to assess their current and future needs? | | | |

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| 13 | Does your company seek feedback from customers who stop placing orders or defect to other suppliers? | | | |
| **C. The Supply Chain Network** | | **Yes** | **No** | **Don't Know** |
| 14 | Has your company ever performed a review of its distribution network design with a view to optimisation? | | | |
| 15 | Has a distribution network design optimisation project ever been completed? | | | |
| 16 | Has a network design review taken place within the last 5 years? | | | |
| 17 | If you supply chain has been impacted by a merger or acquisition, has a distribution network review since been conducted? | | | |
| 18 | Are your company's customers satisfied with product availability and service lead times? | | | |
| **D. Inbound Logistics Process** | | **Yes** | **No** | **Don't Know** |
| 19 | Are items checked for quality, quantity and condition upon arrival of each inbound shipment? | | | |
| 20 | Do you have a booking-in process for suppliers, with a time-slot allocated to each inbound delivery? | | | |
| 21 | Does your company insist on the use of advanced shipping notifications by all suppliers (as far as practicable)? | | | |
| **E. Inventory Management** | | **Yes** | **No** | **Don't Know** |
| 22 | Has your company implemented a cycle-counting program in all its DCs/warehouses? | | | |
| 23 | Is all inventory included during counts, even those items set aside for repackaging or other reasons? | | | |
| 24 | When counting, is every discrepancy between "counted stock" and "stock on record" double checked and investigated? | | | |
| 25 | Is your inventory categorised and segmented by ABC inventory system or similar? | | | |
| 26 | Does your company actively collaborate with customers and suppliers to develop inventory strategies? | | | |
| 27 | When stock becomes obsolete or is discontinued, does your company move quickly to write it down or sell it off at a discount? | | | |
| 28 | Has your company implemented a Sales and Operations Planning (S&OP) process? | | | |
| **F. Warehouse Layout** | | **Yes** | **No** | **Don't Know** |
| 29 | Has your company modeled and optimised the layout of its warehouse space/s? | | | |
| 30 | Are warehouse layouts reviewed on a regular basis? | | | |
| 31 | Are your fastest moving SKUs stored close to the shipping areas/loading doors in your warehouses? | | | |
| 32 | Are warehouse spaces clearly segregated into areas for receiving, storage, picking, dispatch and where applicable, cross-docking? | | | |
| **G. General Warehouse Management** | | **Yes** | **No** | **Don't Know** |
| 33 | Do your warehouse operations include a structured system for pick-face replenishment? | | | |
| 34 | Is warehouse health and safety managed using a proactive system (near-miss and hazard reporting)? | | | |

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| 35 | Do warehouse managers practice a fully documented handover during shift changes? | | | |
| 36 | Is a rigorous housekeeping policy and process in place in each warehouse? | | | |
| 37 | Has your company implemented a warehouse management system (WMS) in each of its warehouses? | | | |
| 38 | Do warehouse management systems include hands-free transaction recording (bar-code scanning or RFID)? | | | |
| 39 | Has your company eliminated paper-based warehouse processes? | | | |
| 40 | Does your warehouse management team operate a continuous improvement program (Lean, Six Sigma, PDCA, or similar)? | | | |
| 41 | Are your warehouses managed in a way that directly supports your company's supply chain strategy? | | | |
| **H. Warehouse Material Handling Equipment (MHE)** | | **Yes** | **No** | **Don't Know** |
| 42 | Is MHE utilized to the maximum? | | | |
| 43 | Is MHE adequate for a balanced operation? | | | |
| 44 | Do you have MHE of the right types and sizes for each activity and environment within your company's warehouses? | | | |
| 45 | Is all MHE maintained according to manufacturers' recommended programs, including preventative maintenance schedules? | | | |
| 46 | Does your company enforce a strict policy regarding authorised use of MHE by qualified operatives? | | | |
| **J. Transportation/Distribution** | | **Yes** | **No** | **Don't Know** |
| 47 | Has your company's decisions regarding insourcing/outsourcing of (road) transportation been based on a balancing of the costs and benefits? | | | |
| 48 | If insourced: is your fleet effectively utilised? | | | |
| 49 | If insourced: does your company have people appointed to ensure all applicable legislation is adhered to regarding vehicle roadworthiness, driver-hours and other operational responsibilities? | | | |
| 50 | If insourced: does your company have vehicles of the right type and capacity for the transportation activities performed? | | | |
| 51 | If outsourced: Does your company insist on service level agreements with high-volume carriers? | | | |
| 52 | If outsourced: do you monitor and measure the performance of 3PL partners using agreed KPIs? | | | |
| 53 | If outsourced: do you have a dedicated person (or team) employed with responsibility for managing the outsourcing relationship? | | | |
| 54 | If outsourced: do you and your outsourcing partners have a clear and aligned understanding of how risks and liabilities are apportioned? | | | |
| 55 | Is your transport/distribution operation managed in a way that directly supports your company's supply chain strategy? | | | |
| **K. Supplier Performance/Relationship Management** | | **Yes** | **No** | **Don't Know** |
| 56 | Has your company implemented a supplier performance management program? | | | |

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| 57 | Are supplier performance KPIs used as part of supplier performance management? | | | |
| 58 | Are supplier performance KPIs focused on value for your end-customers? | | | |
| 59 | Does your company capture the reasons behind suppliers' missed KPI targets? | | | |
| 60 | Does your company's use the performance management process to drive forward-looking, added-value opportunities? | | | |
| 61 | Does the process include regular face-to-face meetings between suppliers and key stakeholders from your company? | | | |
| 62 | When there is a need for performance improvement, is there a clear action plan identified, with specific dates for delivery? | | | |
| 63 | Are action plans followed up regularly until objectives have been achieved? | | | |
| 64 | Are suppliers chosen on the basis of value offered, rather than lowest price? | | | |
| **L. Supply Chain Performance** | | **Yes** | **No** | **Don't Know** |
| 65 | Has your company benchmarked supply chain performance against other supply chains with similar characteristics? | | | |
| 66 | Does every supply chain-related function manage employee performance according to an objective structure of measurement? | | | |
| 67 | Is employee performance-measurement aligned to functional goals that support the supply chain strategy? | | | |
| 68 | Are your company's supply chain KPIs straightforward and easy to understand for employees at all levels? | | | |
| 69 | Is the range of KPIs balanced across a range of criteria, including financial, operational, and customer service? | | | |
| 70 | Do your company's functional managers brief their teams face-to-face on a daily basis, informing employees of key performance achievements and issues, and capturing qualitative feedback? | | | |

***Did you find some areas in your company's supply chain that need improvement?***

***Although the points in this checklist really cover some of the supply chain fundamentals, solutions for improvement are not always so basic. In fact some issues may require fairly complex solutions.***

***If you need help bringing any aspects of your supply chain up to scratch, Logistics Bureau exists purely to lead, assist, or support your supply chain leaders in affecting positive change.***

***Contact us today at one of our branches in Australia or Southeast Asia.***