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## **Supply chain management practices as a mediator of the relationship between operations capability and firm performance**

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The current study uses mediated regression analysis and structural equation modelling to test the proposition that supply chain management practices mediate the relationship between operations capability and firm performance. Operations capability is defined in terms of a firm's new product design and development, total quality management and just-in-time capabilities. Results support the research model and also suggest the existence of a direct relationship between operations capability and performance.

*Keywords:* Operations capability; Supply chain management; Firm performance

### **1. Introduction**

Supply chain management stresses the seamless integration of value-creating activities across organizational boundaries. It enables firms in a supply chain to eliminate waste, leverage synergies and compete more effectively in an intensely competitive global market. Accordingly, a strategic focus on managing the supply chain represents a top-level management initiative to integrate value-adding activities across both functional and organizational boundaries. The specific strategy adopted depends on, among other factors, industry, product type, and level of integration. However, in each case, the principle objective is to develop and implement intra and inter-organizational boundary-spanning relationships within the supply chain that enable members to integrate activities and leverage individual capabilities. Attempts by companies to implement supply chain management practices have not however been universally successful. In many cases, efforts have failed to yield positive results despite substantial resources being expended on them. This may be in part due to a lack of insight into the relationship between supply chain management practices and other elements of a firm's portfolio of operations capabilities.

The resource based view of the firm suggests that creating and preserving competitive advantage is a function of the core resources and capabilities that supply chain members provide in a given environment (Barney 1995). These represent the primary source of a firm's success (Grant 1991). Many research efforts stem from the

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theoretical assertion that the heterogeneity of organizational resources leads to differentiation in a firms' competitive advantage (Prahalad and Hamel 1990, Randall *et al.* 2003). In today's competitive market, for firms to simultaneously offer goods and services at low cost and high quality requires the integration of the operations capabilities of multiple supply chain members. To create competitive advantage, firms must develop and use their core resources to develop these capabilities in a manner that inhibits duplication by competitors (Dutta *et al.* 1999). Research shows that firms with similar levels of operations capability in the same market segment can have different levels of performance (Cool and Schendel 1988). Moreover, a firm's operations capability can create value both for the firm and its suppliers and customers (Porter 1980, 1985).

While operations capability at the firm level has been studied extensively (e.g., Nakane 1986, Ferdows and De Meyer 1990, Roth and Miller 1992), evidence of the impact of supply chain management practices on operations capability and firm performance is limited and inconclusive. The current research addresses this gap in the literature by analysing the roles of operations capability and supply chain management practice on firm performance. Drawing from the literature, we posit that operations capability is an enabler and antecedent of supply chain management practices, and that supply chain management practices mediate the relationship between operations capability and performance. In the following section, the conceptual model and research hypotheses are presented. In subsequent sections, the methodology, measurement, and statistical analyses, are addressed followed by discussion of the results. Finally, limitations of the study and directions for further research are provided.

## 2. Theoretical background and conceptual framework

Research in supply chain management has increasingly applied theories and conceptual contributions drawn from the strategy literature. The resource based view of the firm is a particularly appropriate theoretical framework for studying the performance implications of managing the supply chains (e.g., Olavarrieta and Ellinger 1997, Zsidisin *et al.* 2003, Sinkovics and Roath 2004). Grounded in evolutionary economics and the work of Penrose (1959), the resource based view complements traditional industrial organizational theory (performance is a function of industry structure and positioning) by recognizing the competitive value of resources/capabilities, and how they combine with and influence strategies pursued by a firm. Firms build competitive advantage by utilizing unique sets of resources and strategies (Wernerfelt 1984, Barney 1991). Resources are heterogeneous, and typically include all assets, capabilities, processes, and knowledge controlled by a firm. Resources enable firms to conceive and implement strategies, thereby improving their effectiveness (Barney 1991). In contrast, strategies are the means by which firms relate to their external environment (Porter 1985). They are the building blocks of managerial decisions and actions that determine long-run performance.

Within a supply chain, resources and strategies include those that reflect inter-firm activity. We therefore propose that operations capability and corresponding supply chain management practices play distinct roles in contributing to

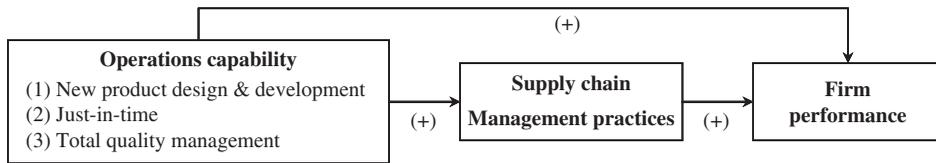


Figure 1. Conceptual framework.

firm performance. We further propose that operations capability is an antecedent of these supply chain management practices, and that insight into the relationship between capability and supply chain management practice can lead to a better understanding of the relationship between operations capability and firm performance. As several authors have suggested, the development of internal operations capabilities are the primary vehicle for operational excellence within a firm (e.g., Hammer and Champy 1990, Morash and Clinton 1998). A logical extension is that once a firm has developed its internal operations capabilities and infrastructure, it is in a position to leverage relationships within the supply chain. While the supply chain management literature debates extensively about collaborative, inter-firm development of supply chain capabilities, the reality is that firms typically develop an internal focus prior to involving external partners. The implication however, is that how a firm manages its supply chain should be considered simultaneously with consideration of the relationship between internal operations capability and firm performance. The conceptual framework underlying the study is presented in figure 1.

## 2.1 Content of operations capability

Operations capability refers to the tasks and activities at which firms must excel in support of corporate objectives (e.g., Dierickx and Cool 1989, Safizadeh *et al.* 2000). While the literature often fails to distinguish capability from competitive priorities or manufacturing competence, the underlying premise is that capabilities reflect how the operations function serves as a source of value to an organization. (Competitive priorities are dimensions of operations that firms believe to be important to success (e.g., Safizadeh *et al.* 2000, Boyer and Lewis 2002). Manufacturing competence is the extent to which manufacturing supports corporate objectives, (e.g., Cleveland *et al.* 1989, Vickery *et al.* 1993) The literature has focused primarily on the nature of capability, identifying the core dimensions of capability such as quality, price, flexibility and delivery, relevant to enhanced competitiveness (e.g., Leong, *et al.* 1990, Ward *et al.* 1998). Those studies that have addressed the content of capability however, the focus of this study, point to process improvement programs related to just-in-time, quality management, and new product development, in addition to information and process technology capabilities (e.g., De Meyer *et al.* 1989, Roth and Miller 1992, Hayes and Pisano 1996, Narasimhan and Jayaram 1998). We thus define operations capability in terms of a firm's new product design and development, just-in-time, and total quality management capabilities. While there may be other dimensions of capability, these three have the properties that they are rooted in the operations domain, documented in the literature (e.g. Tan *et al.* 2004),

unique to a firm, and have been demonstrated to be sources of sustainable competitive advantage.

### 3. Hypotheses development

#### 3.1 *Operations capability and supply chain management practices*

Several studies have demonstrated a relationship between new product design and development (NPDD) activities and management of the supply chain. For example, McGinnis and Vallopra (1999) proposed that purchasing and supplier involvement in NPDD is a source of competitive advantage. Ettlíe and Sethuraman (2002) showed that NPDD intensity and the resulting percentage of revenue generated are directly related to levels of global sourcing. Ragatz *et al.* (2002) demonstrated that early supplier involvement in NPDD leads to significant improvements in cost, quality, and cycle time across the supply chain when customers have clear goals and specifications. Cox *et al.* (2002) concluded that in the context of product innovation and supply chain management in the food processing and distribution industry, long-term relationships among firms, customers, and suppliers using information sharing networks would become more widespread in a demand-driven environment. Randall *et al.* (2003) examined the relationship between product demand characteristics and initial supply chain investments during market entry. Results showed that firms account for characteristics such as market growth, product variety, contribution margins and uncertainty when first considering supply chain investments. Tatikonda and Stock (2003) used organizational theory to develop a conceptual model of the determinants of successful product technology transfer. They proposed that product technology transfer is most effective when there is a good fit between the type of technology being transferred and the organizational interactions between the source and recipient of the technology.

A firm that actively involves key suppliers in design and development efforts must effectively manage its supply chain. Sharing information, technology and risk are contingent on having sound relationships with potential partners. Effectively incorporating supplier parts into new products requires careful evaluation of how they will interface. The potential for cost savings and quality improvements will be limited without a shared understanding of how partners plan to align their individual goals to meet shared objectives. We therefore hypothesize:

H<sub>1a</sub>: New product design and development capability positively affects supply chain management practices.

**3.1.1 Just-In-time and supply chain management practices.** Olhager (2002) argued that supply chain efficiency is contingent on the effectiveness and ability of individual supply chain members to connect. The author analysed supply chain management from a just-in-time perspective, focusing on linkages between supply chain members and the chain's collective efficiency. Results showed that lead-time conformity has a greater impact on supply chain lead-time performance than processing time equivalency. Yang and Pan (2004) proposed an integrated inventory management model for managing just-in-time inventory in environments where

supply chain members form strategic alliances for the purpose of profit sharing. Balsmeier and Voisin (1996) discussed the importance of rapid delivery of products, and how just-in-time manufacturing principles can be applied to supply chain management practices. They stressed that inter-organization competition for final consumers will soon be replaced by the concept of inter-supply chain competition for consumers, making it insufficient to solely focus on a firm's internal competencies.

Numerous examples exist of a firm's just-in-time capability influencing its supply chain management practices. Just-in-time manufacturers are expected to deliver raw materials and/or component parts in small lot sizes, frequently, and directly to the point of use, eliminating the need for incoming inspection and warehousing, and reducing material movements. However, the reductions in inventory also mean that manufacturers must ensure that incoming materials and component parts are of the quality and quantity expected, and that deliveries are on-time. To achieve this, many organizations adopt relationships with key suppliers to share confidential information and technology. Instead of relying on inspection of incoming materials and component parts, they certify strategic suppliers' processes and/or products. A firm with advanced just-in-time capability is likely to place significant emphasis on such practices. Based on these observations we hypothesize:

H<sub>1b</sub>: Just-in-time capability positively affects supply chain management practices.

**3.1.2 Total quality management and supply chain management practices.** Romano (2002) stressed that quality certification is a necessity for firms to compete, and that quality is a strategic variable that should be considered and managed across the entire supply chain. González-Benito *et al.* (2003) explored connections between buyer and supplier quality assurance practices among automotive component suppliers. Their results highlighted the importance of a commitment to quality assurance from all firms within the supply chain. Gunasekaran and McGaughey (2003) examined relationships between total quality management and supply chain management such as operational flexibility and performance measurement. Several research areas involving total quality management and supply chain management were suggested to be worthy of further research. Kanji and Wong (1999) investigated relationships between total quality management and supply chain management and concluded that failure to consider the impact of total quality management programs helps to explain the inadequacies of existing models of supply chain management. Kannan and Tan (2005) also highlighted the inherent relationships between quality management and supply chain management practices.

The rationale for the relationship between a firm's total quality management capability and its supply chain management practices is apparent. For example, a firm with advanced quality management capability is likely to select suppliers that are similarly competent. They will be motivated to form alliances with such suppliers and allow them to participate in new product design and development initiatives. Conversely, a firm that is less advanced in its capability is unlikely to be invited to do so due to its lack of capability, motivation to improve, and credibility in the eyes of suppliers. We therefore hypothesize:

H<sub>1c</sub>: Total quality management capability positively affects supply chain management practices.

### 3.2 Operations' capability and firm performance

**3.2.1 New product design and development capability and firm performance.** New product design and development capability has been shown to yield multiple advantages such as operations synergies (Palepu 1985), economies of scope (Ghoshal 1987), the creation of inimitable resources (Barney 1991), the effective transfer of core competencies (Prahalad and Hamel 1990), and financial synergies (Majid and Myers 1987). Zirger and Hartley (1996) and Griffin (1997) showed that companies benefit from product development practices such as part standardization that can simultaneously lead to improvements in inventory, cost, and quality performance. New product design and development activities are also associated with increased customer satisfaction (Chase *et al.* 1998). Recent evidence shows that leading-edge firms have shifted their quality emphasis from relying on quality inspection to designing quality into the product (Tan 2001). Designing quality into the product recognizes that quality efforts in the design phase yield benefits in manufacturability, thereby reducing total quality costs and enhancing firm performance. Doing so, particularly when implemented concurrently with other strategic operations practices, can be a source of competitive advantage. While there is a lack of empirical evidence to support the relationship between new product development capability and firm performance, the literature and anecdotal evidence from industry suggest that new product design and development capability will positively firm performance. We therefore, hypothesize:

H<sub>2a</sub>: New product design and development capability positively affects firm performance.

**3.2.2 Just-in-time capability and firm performance.** The role of just-in-time capability as a contributor to firm performance is well documented. It is based on the notion that simplifying manufacturing processes and reducing variation eliminates waste, thereby reducing cost and lead times and increasing quality. This in turn leads to improvements in measures of firm performance (e.g., Nakamura *et al.* 1998, Callen *et al.* 2000, Fullerton and McWatters 2001). Kim and Ha (2003) showed that optimal just-in-time delivery policies, when adopted by both buyers and suppliers in a cooperative manner, were economically beneficial to both parties.

Various just-in-time practices, including setup time reduction, process standardization, preventive maintenance, frequent deliveries of small lot sizes, continuous improvement efforts, and top management involvement have been observed in the manufacturing sector (e.g., Flynn *et al.* 1995, Germain and Dröge 1997). While the capability and extent of just-in-time implementation differs by firm, industry and manufacturing environment (Lee and Ebrahimpour 1984), firms that are more advanced in their capabilities can be expected to use resources more efficiently and effectively, thereby yielding greater benefits. Consistent with the literature, we therefore hypothesize:

H<sub>2b</sub>: Just-in-time capability positively affects firm performance.

**3.2.3 Total quality management and firm performance.** The relationship between total quality management and firm performance is also well established (e.g., Anderson *et al.* 1994, Anderson *et al.* 1995, Flynn *et al.* 1995, Ahire *et al.* 1996, Dow *et al.* 1999). Recent studies have however investigated the relationship from different perspectives. For example, the resource-based view of the firm (Escrig Tena *et al.* 2001) suggests that the relationship is the result of the unique resources and competencies generated by the implementation of total quality management. These competencies are viewed as sources of sustainable competitive advantage and therefore contribute to improved performance. Das *et al.* (2000) utilized the neoclassical perspective of the influence of competitive environment to develop an integrative framework of total quality management. Their results showed that significant investments in quality are necessary to achieve high levels of customer satisfaction when firms face moderate to high competition. Samson and Terziovski (1999) took a behavioral science perspective, concluding that leadership, management and customer focus are significant predictors of operational performance. Chang *et al.* (2003) showed that the congruence of business strategy, quality dimensions, and capability is vital to firm performance on the dimensions of new product introduction, net profit and sales. Consistent with prior findings, we therefore hypothesize:

H<sub>2c</sub>: Total quality management capability positively affects firm performance.

### 3.3 Supply chain management practices and firm performance

Tan *et al.* (1998) examined the relationship between operational quality practices, supply chain management practices, and firm performance. They concluded that quality management and supply chain management techniques and tools must be implemented concurrently to achieve superior financial and business performance. Vickery *et al.* (2003) investigated the performance implications of an integrated supply chain management strategy. They concluded that positive direct and indirect relationships exist between supply chain integration and financial performance. Tan (2002) studied the concerns of supply chain managers, concluding that certain supply chain management practices positively impact firm performance. In a related study, Wisner (2003) developed a theoretical framework for supplier and customer management, and demonstrated a positive relationship between supply chain management and firm performance.

The literature is replete with examples of firms that have downsized to focus on core competencies, and attempted to achieve superior competitive advantage by capitalizing on exceptional supplier capability and technology (Prahalad and Hamel 1990). These organizations have reduced their supply bases to more effectively manage relationships with strategic suppliers and develop mutually beneficial partnership relationships (Tully 1995). Superior supplier capability can lead to reduced product development lead time, exceptional quality and rapid integration of new technologies (Tan 2001, Ragatz *et al.* 2002). By increasing outsourcing activities, these organizations rely to a greater extent on their partners and must therefore effectively manage their supply chains to remain competitive. We thus hypothesize:

H<sub>3</sub>: Supply chain management practices positively affect firm performance.

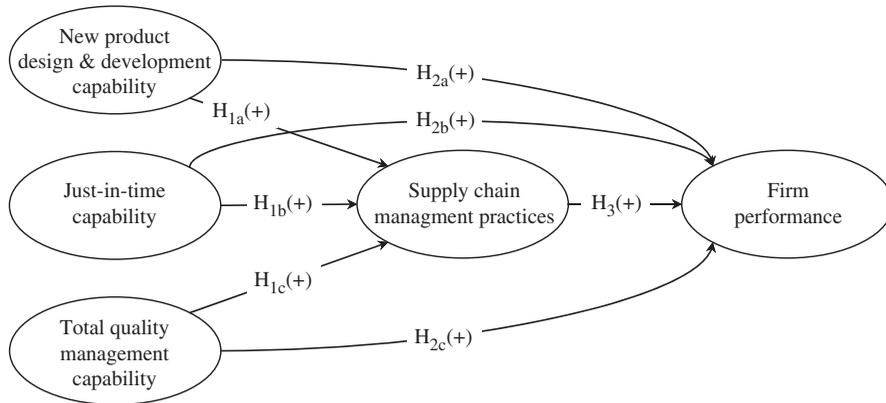


Figure 2. Proposed research model.

Figure 2 and table 1 summarize the proposed hypothesized model and the key literature as it relates to the hypotheses of interest.

## 4. Methodology

### 4.1 Survey instrument and data collection

In addition to the literature review, in-depth interviews with operations and purchasing managers were used to identify pertinent dimensions of the constructs of interest. Interviews help to ensure that the constructs of interest and the associated relationships, as reported in the literature, are consistent with industry practice. A draft survey instrument was reviewed by a sample of academics with relevant expertise, to obtain feedback on the comprehensiveness, clarity, face validity, and readability of the scales and survey instructions. Based on the feedback, a modified instrument was developed and tested by thirty senior managers. In response to their feedback, further minor changes were made.

The resulting instrument was sent to 4500 senior purchasing and operations managers identified from the Institute for Supply Management (ISM) and the Association for Operations Management (APICS) membership lists. Lists were pre-screened to identify only respondents likely to be familiar with their firm's supply chain and operations strategy practices. The original mailing followed by a reminder postcard and a second mailing of the survey (Dillman 1999) yielded 455 usable observations (10.11% response rate). To test for non-response bias, *t* tests of random samples of early and late returned surveys were tested for statistically significant differences in the sales and size of the firms. Late returned surveys can be considered to be representative of non-respondents (Lambert and Harrington 1990). No statistically significant differences ( $\alpha = 0.05$ ) between the two samples suggests the absence of non-response bias.

Table 1. Summary of literature and hypotheses.

Hypotheses	Past literature	Findings/descriptions
H <sub>1a</sub>	Ettlie and Sethuraman (2002)	Research and development intensity and product development benefits are directly related to increased level of global sourcing
New product design and development capability positively affects supply chain management practices	McGinnis and Vallopra (1999)	Early supplier involvement in new product design and development is a source of competitive advantage
	Ragatz <i>et al.</i> (2002)	Early supplier involvement in new product design and development leads to improvements in cost, quality, and cycle time objectives
	Cox <i>et al.</i> (2002)	Identified two distinct, complementary inter-firm networks (networks of control and innovation)
	Randall <i>et al.</i> (2003)	Examined the relationship between product demand characteristics and the initial supply chain investment
	Tatikonda and Stock (2003)	Proposed an organizational theory with a conceptual model of determinants of product technology transfer success
H <sub>1b</sub>	Olhager (2002)	Investigated supply chain management from just-in-time perspective, focusing on the 'linkages' of the supply chain
Just-in-time capability positively affects supply chain management practices	Yang and Pan (2004)	Argued that manufacturing firms are using just-in-time production to gain competitive advantage in supply chain management
	Balsmeier and Voisin (1996)	Discussed how just-in-time manufacturing can be applied to supply chain management
	Romano (2002)	Stressed that quality should be managed across the supply chain
H <sub>1c</sub>	González-Benito <i>et al.</i> (2003)	Highlighted the importance of a company-wide commitment to the application of quality assurance principles of the supply chain

(continued)

Table 1. Continued.

Hypotheses	Past literature	Findings/descriptions
H <sub>2a</sub>	Gunasekaran and McGaughey (2003) Kanji and Wong (1999)  Palepu (1985), Ghoshal (1987), Majid and Myers (1987), Prahalad and Hamel (1990), Barney (1991)	Identified the relationship between total quality management and supply chain management Concluded that total quality management enriches the inadequacy of the existing supply chain management model New product design and development capability yield multiple advantages, including operations and financial synergy, economy of scope, and core competency transfer
New product design and development capability positively affects firm performance	Zirger and Hartley (1996), Griffin (1997)  Chase <i>et al.</i> (1998)	Part reduction and standardization are beneficial product development practices  New product design and development is a value-added activity that reduces cost and increases customer satisfaction
H <sub>2b</sub>	Nakamura <i>et al.</i> (1998), Callen <i>et al.</i> (2000), Fullerton and McWaters (2001) Kim and Ha (2003)	Benefits of just-in-time capability include superior inventory performance, improved quality level, and firm performance Just-in-time delivery is economically beneficial to both the buyer and supplier
Just-in-time capability positively affects firm performance		

H <sub>2c</sub>	Escrig Tena <i>et al.</i> (2001)	Total quality management affects firm performance through the resources they control (resource-based view)
Total quality management capability positively affects firm performance	Das <i>et al.</i> (2000)	Tested an integrative framework of total quality management
	Chang <i>et al.</i> (2003)	Stressed that congruency between quality capability and business strategy is critical to firm performance
H <sub>3</sub>	Angel and Chandra (2001)	Proposed a multi-level model linking quality program to firm performance
Supply chain management practices positively affect firm performance	Tan <i>et al.</i> (1998)	Examined various operations approaches and their relationships with firm performance
	Vickery <i>et al.</i> (2003)	Examined the performance implications of an integrated supply chain strategy
	Wisner (2003)	Developed and analysed a theoretical framework of supply chain management and firm performance
	Tan (2002)	Showed that supply chain management affects firm performance

## 4.2 The measures

To achieve a high degree of validity, multiple indicators were used to represent each construct (table 3, column 1). For each construct, respondents were asked to indicate on a five-point Likert scale (1 = low, 5 = high), the importance of each practice in their firm. For firm performance, respondents were asked to indicate their firm's performance compared to that of major competitors. Correlation analysis was used to compare responses of a sample of firms to published financial data. Results indicated that correlation was statistically significant ( $\alpha = 5\%$ ).

## 4.3 Statistical analysis

A three-phase statistical analysis was adopted. LISREL 8.30 (Jöreskog and Sörbom 1993) was first used to perform confirmatory factor analysis of each construct. Internal consistencies were estimated using Cronbach's  $\alpha$  (Cronbach 1951), and convergent validity was established by ensuring item loadings were significant. Three-step mediated regression analysis (Baron and Kenny 1986) was used to examine the mediation effects of supply chain management practices. The mediator (supply chain management practice) was first regressed on the independent variables (operations capabilities). The dependent variable (firm performance) was then regressed on the independent variables. Finally, the dependent variable was regressed simultaneously on the independent variables and the mediator. Mediation effects exist if the independent variables are related to the mediator and dependent variable, and the mediator affects the dependent variable (Baron and Kenny 1986). The relationship between the independent variables and the dependent variable must be weaker when the mediating variable is considered than when it is not. Complete mediation is said to exist if the independent variables have no statistically significant effect on the dependent variable when the mediator is controlled for. Partial mediation exists if the statistically significant effects of the independent variables on the dependent variable are smaller when the mediator is controlled for. In the third phase, structural equation modelling was used to simultaneously assess the psychometric properties of the scaled items for each construct, and to establish the relationships between the exogenous and endogenous variables.

## 5. Results

The zero-order correlation matrix for the five constructs (table 2) shows that correlations are statistically significant ( $\alpha = 5\%$ ) and show the expected positive relationships. This provides preliminary support for the relationships depicted in figure 2. All correlation coefficients are less than 0.50, suggesting that multicollinearity is not present (Mason and Perreault 1991).

### 5.1 Phase one analysis

Results of confirmatory factor analysis provide support for the measurement models. Although the  $\chi^2$   $p$ -value is statistically significant ( $\chi^2_{d.f.} = 220 = 565.42, p < 0.01$ ), the ratio of  $\chi^2$  to the degrees of freedom of 2.57 is less than 3, indicating that the data fit

Table 2. Correlation matrix of latent constructs.

Latent constructs	Just-in-time capability	Total quality management capability	Supply chain management practices	Firm performance
New product design and development capability	0.497	0.451	0.301	0.312
Just-in-time capability	–	0.495	0.304	0.282
Total quality management capability		–	0.259	0.363
Supply chain management practices			–	0.217

All coefficients significant at  $\alpha = 5\%$ .

the hypothesized model well. Many researchers emphasize the need to relax the interpretation of  $\chi^2$  statistics, especially when sample size is large. Indeed, most recent structural equation modelling studies use the ratio of  $\chi^2$  to degrees of freedom as the preferred fit index (e.g., Byrne 1988, Hu and Bentler 1995).

Values of Cronbach's  $\alpha$  (table 3) for the constructs range from 0.7064 for firm performance to 0.8630 for new product design and development capability, suggesting that the scales are reliable (Bollen 1989). Some critics argue that Cronbach's  $\alpha$ , which is used to test the reliability of a measure based on internal consistency, does not adequately estimate errors caused by factors external to an instrument such as differences in testing situations and respondents over time. In the context of structural equation modelling, it has been suggested that composite reliability and average variance extracted be used since they are more parsimonious than Cronbach's  $\alpha$  (Netemeyer *et al.* 1990). Statistics for composite reliability (table 3) for the five constructs exceed the required value of 0.60. With the exception of the supply chain management practices construct, all average variances extracted exceed the threshold level of 0.50. Taken together, these three statistics suggest that all constructs are sufficiently reliable.

Measurement models were tested for convergent, discriminant, and nomological validity. Four of the five models yielded values for average variance extracted in excess of 0.50 (table 3), suggesting excellent convergent validity (Shock *et al.* 2004). The test for discriminant validity involves examining correlations between pairs of latent variables (Anderson and Gerbing 1988). If variables are distinct, correlations should be unidimensional and significantly less than one. All correlation coefficients are significant and less than 0.5 (table 2), thus discriminant validity can be assumed. Nomological validity is suggested by the values of the RMSEA, GFI, AGFI, NNFI, CFI, and IFI fit indices. The analysis thus suggests that the measurement models are acceptable for reproducing the population covariance matrices (Steiger 1990).

## 5.2 Phase two analysis

Results of the mediated regression analysis are shown in table 4. In model 1, the dependent variable, supply chain management practices, was regressed as the mediator on the three predicted antecedents (i.e., operations capabilities). The model was statistically significant, operations capabilities accounting for 12.9% of the

Table 3. Constructs, reliabilities and average variance extracted.

Latent constructs and measured variables	Cronbach's $\alpha$	Composite reliability	Average variance extracted
New product design and development capability 1. Early supplier involvement 2. Concurrent engineering 3. Simplification of parts 4. Value analysis/value engineering	0.8630	0.8767	0.6404
Just-in-time capability 1. Reducing supplier base 2. Increasing delivery frequencies 3. Reducing inventory to expose problems	0.7873	0.8089	0.5855
Total quality management capability 1. Employee training in quality 2. Employee empowerment 3. Communication of quality goals 4. Emphasis on quality instead of price	0.8556	0.8810	0.6510
Supply chain management practices 1. Increase suppliers' just-in-time capabilities 2. Participating in sourcing decisions 3. Geographical proximity of suppliers 4. Formal information-sharing agreements 5. Improving the integration of activities 6. Searching for new ways for integration 7. Communicating future strategic needs 8. On-time delivery 9. Reducing response time	0.7518	0.7622	0.3846
Firm performance 1. Average selling price 2. Overall product quality 3. Overall competitive position	0.7064	0.7599	0.5173
Acceptable level	$\geq 0.70$	$\geq 0.60$	$\geq 0.50$

variance in supply chain management practices. Coefficients for new product design and development capability ( $\beta = 0.173$ ) and just-in-time ( $\beta = 0.170$ ) were statistically significant ( $\alpha = 0.05$ ) and in the predicted positive directions, thus meeting the first requirement to infer mediation effects. The coefficient for total quality management capability was statistically insignificant, suggesting a lack of mediation effect between total quality management and supply chain management practices. The preliminary conclusion to be drawn is that new product design and development capability and just-in-time capability have a similar effect on supply chain management practices. The implication is that firms should critically review their new product design and development and just-in-time capabilities when adopting and implementing supply chain management practices.

In model 2, firm performance was regressed on the three predicted antecedents. The three independent variables accounted for 16.3% of the variance in firm performance. Regression coefficients for new product design and

Table 4. Mediated regression analysis.

	Model 1	Model 2	Model 3
	Supply chain management practices	Firm performance	Firm performance
<i>Predicted antecedents (operations capability)</i>			
New product design and development capability	0.173*	0.160*	0.144*
Just-in-time capability	0.170*	0.077	0.062
Total quality management capability	0.097	0.253*	0.244*
<i>Mediator</i>			
Supply chain management practices			0.092*
<i>F</i>	22.21*	29.38*	23.19*
<i>R</i> <sup>2</sup>	12.9%	16.3%	17.1%
Adjusted <i>R</i> <sup>2</sup>	12.3%	15.8%	16.4%

\* Parameters/coefficients statistically significant at  $\alpha = 5\%$ .

development ( $\beta = 0.16$ ) and total quality management capability ( $\beta = 0.253$ ) were statistically significant and in the expected positive direction, but the coefficient for just-in-time capability was insignificant. These results suggest that total quality management capability has a larger direct impact on performance than new product design and development capability. This is consistent with the literature that suggests that the benefits of new product development on performance are usually gained through effective supply chain management practices such as early supplier involvement, information sharing, and leveraging supplier technologies and capabilities.

When the supply chain management practices construct was added to the regression model (model 3), the variance explained by the data increased to 17.1%. The revised model and the supply chain management practices coefficient ( $\beta = 0.092$ ) were both statistically significant ( $\alpha = 0.05$ ). As expected, the coefficient for new product design and development capability decreased (from 0.160 to 0.144) because of the mediation effect of supply chain management practices. This implies that supply chain management practices not only partially mediate the relationship between new product design and development capability and performance, supporting hypotheses  $H_{1a}$ ,  $H_{2a}$  and  $H_3$ , they completely mediate the relationship between just-in-time capability and firm performance, supporting hypotheses  $H_{1b}$  and  $H_3$ . However hypothesis  $H_{2b}$  was not supported. The results also show that supply chain management practices are not a mediator of the relationship between total quality management capability and firm performance ( $H_{1c}$ ). The direct impact of total quality management capability on firm performance is however evident from models 2 and 3 ( $H_{2c}$ ).

### 5.3 Phase three analysis

Structural equation modelling was used to predict parameter estimates of the hypothesized model and to provide further support for the hypotheses tested in the

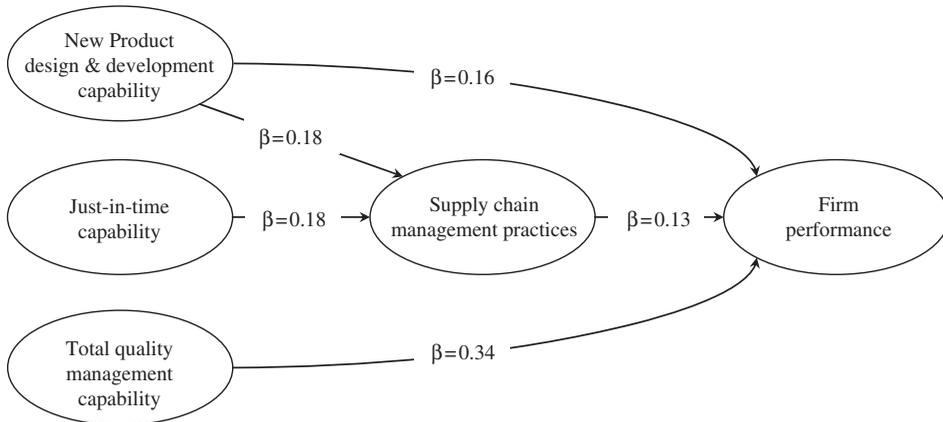


Figure 3. Path model parameter estimates.

second phase analysis (figure 3). Standardized parameter estimates for the paths from new product design and development ( $\beta = 0.18$ ) and just-in-time ( $\beta = 0.18$ ) capability to supply chain management practices were statistically significant ( $\alpha = 5\%$ ), providing further support for hypotheses  $H_{1a}$  and  $H_{1b}$ . There was insufficient evidence to support hypothesis  $H_{1c}$  due to the insignificant path coefficient between total quality management capability and supply chain management practices. The standardized parameter estimate for the path between new product design and development capability and firm performance ( $\beta = 0.16$ ) was statistically significant, providing further support for hypothesis  $H_{2a}$ . Similarly, the standardized parameter estimate for the path from total quality management capability to firm performance ( $\beta = 0.34$ ) was statistically significant, providing additional support hypothesis  $H_{2c}$ . The insignificant estimate for the path from just-in-time capability to firm performance again suggests an absence of evidence to support hypothesis  $H_{2b}$ . Support for hypothesis  $H_3$  exists by virtue of the significant path coefficient from supply chain management practices to firm performance ( $\beta = 0.13$ ). Squared multiple correlations for firm performance (0.28) and the significance or otherwise of parameter estimates, closely match results obtained from the mediated regression analyses.

## 6. Discussion

Significant path relationships for new product design and development capability show that this capability has both direct and indirect effects on firm performance. A primary reason for manufacturing firms to continuously engage in new product design and development is that the life cycle of most consumer products is becoming ever shorter in today's competitive environment. After years of discovery, development, testing, and commercialization, generic alternative products often appear soon after patent protections have expired. To remain competitive, bringing high-quality new products to market before competitors do is crucial.

Firms attempting to nurture effective new product design and development capabilities should not overlook the important role that effectively managing the supply chain can have. Internally executed practices such as concurrent engineering, part simplification, and value analysis/engineering, can, in and of themselves, positively impact development efforts and thereby performance. However, new technologies are emerging which may require specialized knowledge and expertise, as well as significant capital and a willingness to assume risk. In addition, increased product offerings and customer expectations make it difficult for firms acting on their own to bring potentially successful products to market in a timely, competitive manner. They are therefore reliant on the active participation, from the early stages of the development process, of key suppliers. This in turn implies a need to identify and develop relationships with suppliers with the requisite knowledge. Firms are unlikely to make the commitment to doing so unless goals, strategies, and expectations are aligned.

The direct impact of just-in-time capability on firm performance was not confirmed. This result is not altogether surprising. Past research has suggested that the positive impact of just-in-time practices on performance is attributable to infrastructural decisions made as part of broader quality management initiatives (Sakakibara *et al.* 1997). However, the analysis does demonstrate that just-in-time capability impacts firm performance indirectly through supply chain management practices. This may help to explain why some just-in-time implementations fail to enhance performance. Typical just-in-time practices such as reducing the supplier base, increasing delivery frequency, and lowering inventory levels, cannot be successfully implemented without the assistance of suppliers. For example, reducing inventory levels by increasing delivery frequency requires suppliers to be located close to the buyer and/or to be willing to deliver in small quantities. It also requires the sharing of information on production schedules. The viability of small lot delivery also relies heavily on the buyer having confidence in the supplier's ability to achieve high quality levels. This will not typically occur unless there is a prior relationship between the buyer and supplier and a commitment to working together to resolve quality and delivery problems. Additionally, early supplier involvement is critical to ensure that quality, technical, and cost issues are addressed during product development.

The results do not indicate a significant relationship between total quality management capability and supply chain management practices, but suggest that quality capability affects firm performance directly. A possible explanation for this surprising finding is that the measures used to assess total quality management capability relate to internally focused quality initiatives and do not explicitly address boundary spanning quality issues such as supplier quality. As such, the results should not be interpreted as suggesting that firms should focus only on internally quality. Prior research has suggested that supplier driven quality and a focus on customer needs can have a positive impact on performance (e.g., Anderson *et al.* 1994, 1995, Flynn *et al.* 1995, Ahire *et al.* 1996). For example, certifying suppliers' products and processes, participating in continuous improvement efforts with suppliers, involving customers in product development efforts, and implementing systems that measure and manage customer satisfaction, are all important elements of a quality management program.

## 7. Conclusions

This study provides empirical support for the central thesis that supply chain management practices mediate the impact of operations capability on performance. This is consistent with resource-based and competence-based views of the firm, and for resource-advantage theory as it relates to manufacturing success. Supply chain management practices allow firms to take advantage of their manufacturing capabilities by leveraging the expertise and cooperation of key members of their supply chains. This allows them to achieve performance levels in excess of those they might achieve by relying solely on their internal capabilities. This finding is important since it not only helps managers to recognize how to better leverage internal capabilities by exploiting relationships with supply chain partners, it highlights the need to hone these capabilities prior to focusing on the extended enterprise. The coordination of internal capabilities with support from key partners provides the basis for creating the inimitable resource base that is critical to sustainability. As such the results demonstrate that supply chain management is a key to sustainable competitive advantage. The study also provides further evidence of the direct influence of operations capability and supply chain management practices on firm performance and on the need to examine operations capability in a broader, supply chain context.

The research is not without its limitations. The proposed model does not consider performance from multiple perspectives. For instance, it does not consider variables such as market structure from the industrial organization literature, ownership structure from the finance literature, or corporate governance from the organizational behaviour literature. The use of longitudinal data would also have been useful to determine whether the effects of variables in the model are short-term or endure over time. Such data would also be useful for examining how changes in certain variables affect performance. A model that uses changes in antecedents (operations capabilities) and changes in consequence (performance) may yield more interesting results, since dynamic formulation eliminates the influence of variables whose levels are stable over time. Moreover, a lagged relationship between variables over time would help to pinpoint causation in the model. Future research also needs to explore additional facets of operations capability, such as logistics and purchasing capability.

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