Introduction

Over the last twenty years, different approaches have been proposed to help organizations respond to increasing competitive pressures that call for improved product quality, increased responsiveness, and shorter lead times, but at lower cost. Three in particular, just in time (JIT), quality management, and supply chain management (SCM) have been heralded in the operations literature as well as in the business press as the answer. The philosophy underlying JIT manufacturing is the elimination of waste by simplifying production processes. By reducing setup times, focusing on preventive maintenance, and controlling material flows using kanban system, excess inventories can be reduced or eliminated, and resources utilized more efficiently.

The quality management movement calls for organizations to embrace a corporate wide culture that emphasizes customer focus, continuous improvement, employee empowerment, and data driven decision-making. By aligning product design more closely with customer expectations and focusing on quality at all stages of the development and production process, product quality should in principle be improved and contribute to increase sales and profitability. More recently, SCM advocates have called for the integration of buyers’ and suppliers’ decision-making processes with the goal of improving material flows throughout the supply chain. By managing the supply chain more effectively, lead times and material costs should fall, while product quality and responsiveness should increase.

While differences exist in the focus and motivation of the three philosophies, the three are not mutually exclusive. For example, one of the goals of JIT methods is to elicit quality and resource...
utilization improvements accruing from process improvements and small lot production, while SCM aims to obtain improvements in quality and materials management by bringing together buyers and suppliers earlier in the product development process and improving coordination between supply chain members. Snell and Dean (1992) found it hard to distinguish between JIT and Total Quality Management (TQM) since the two share common elements. Support exists for the notion that achieving high levels of manufacturing performance requires the use of different but complementary manufacturing practices and strategies (Schonberger, 1986, 1990; Rehder, 1989). Dean and Snell (1996) stated that ‘important strategic potential’ exists from the use of integrated management, the adoption of advanced manufacturing technology in conjunction with JIT and quality management methods. Moreover, they stated that the creation of a ‘streamlined flow of automated value added activities, uninterrupted by moving, storage, or rework’ (Snell and Dean, 1992) allows an organization to simultaneously achieve goals of quality improvement and cost reduction. Sakakibara et al. (1997) suggested that JIT’s impact on performance is a function of the infrastructure required to support JIT operations, such as a focus on quality management and the integration of the JIT philosophy into a broader strategic framework. Nakamura et al., (1998) showed that JIT and quality management are necessary to improve manufacturing performance, while Tan et al., (1998a) suggested that quality management techniques needed to be used in conjunction with attempts to rationalize the supplier base to improve business performance. The overlap among the three approaches to achieving operations excellence raises a number of questions. Two in particular that have yet to be addressed are how do the three interact and how does this contribute to an organization’s business performance. Several studies have demonstrated empirically that in isolation, JIT (Fullerton and McWatters, 2001; Germain et al., 1996; Germain and Dröge, 1998; Huson and Nanda, 1995; Inman and Mehra, 1993; Sakakibara et al., 1997), quality management (Kannan et al., 1999; Wilson and Collier, 2000), and SCM (Tan et al., 1998b; Curkovic et al., 2000) positively impact an organization’s performance. Limited empirical evidence also exists of the impact on manufacturing performance of strategies that incorporate both JIT and quality management methods. Flynn et al., (1995a) demonstrated that quality management and JIT practices are mutually supportive, and that synergies they yield result in improvements in manufacturing performance beyond those yielded individually.

How do Quality Management, Supply Chain Management and JIT interact and how do they contribute to an organization’s business performance?

They also found that independently of JIT and quality management specific practices, common infrastructure factors positively impact performance. Nakamura et al., (1998) found that while both JIT and quality management methods positively impact manufacturing performance, quality methods have a stronger and more consistent effect. In contrast, Dean and Snell (1996) showed that while quality management methods impact performance, JIT practices do not. Sakakibara et al. (1997) suggested that while JIT specific practices alone do not correlate positively with manufacturing, they do when used in conjunction with elements of the infrastructure required to support JIT, for example quality management and product design. The implication of the latter two studies is that it is the infrastructure underlying JIT implementation rather than specific JIT practices that drives performance.

This study extends previous research by proposing and testing a structural equation model that outlines the relationships between just in time, quality management, and supply chain management, and their impact on a firm’s business performance. The remainder of this paper is organized as follows. The next section describes the pertinent literature on JIT, quality management, and SCM and their impact on performance. The structural model and corresponding hypotheses are then presented. This is followed by discussion of the methodology, results, and analysis of the model’s implications.

Literature Review

Just in Time

Since its introduction in the English language literature in 1977 (Sugimori et al., 1977), the JIT philosophy has received considerable attention in both academic and practitioner circles. Early literature focused on the shop floor activities at the heart of JIT’s crusade to eliminate waste, for example setup time reduction, small lot production, the use of kanbans, level production scheduling, and preventive maintenance (Monden, 1983; Schonberger, 1982, 1986), and on the relationship of JIT to other manufacturing practices (Lee and Ebrahimpour, 1984; Ohno and Monden, 1983). Other supply chain practices related to JIT such as vendor and customer relations have also been addressed (Ansari and Modaress, 1990; Handfield, 1992; Inman, 1990; Sakakibara et al., 1993). While several articles have described actual JIT implementations (Celley et al., 1987; Crawford et al., 1988; Im and Lee, 1989; Voss and Robinson, 1987), few have attempted to identify those elements critical to the implementation of JIT and their
impact on business performance. Mehra and Inman (1992) observed that a JIT production strategy and vendor strategy were positively related to a successful JIT implementation. Germain and Dröge (1997) postulated that JIT systems have both a knowledge dimension and a process dimension. They showed that knowledge and understanding of the JIT system are precursors to designing processes, and that the extent to which participants understand the JIT system has implications for organizational design.

Several studies have examined the impact of a JIT strategy on performance. Most have focused on manufacturing performance, with improvement in inventory (Callen et al., 2000; Fullerton and McWaters, 2001; Germain and Dröge, 1998; Huson and Nanda, 1995; Nakamura et al., 1998), quality (Fullerton and McWaters, 2001; Im and Lee, 1989; Lawrence and Hottenstein, 1995; Nakamura et al., 1998), and throughput (Flynn et al., 1995; Fullerton and McWaters, 2001; Im and Lee, 1989; Lawrence and Hottenstein, 1995; Nakamura et al., 1998; White, 1993) performance consistently observed. A number of studies have also shown that a JIT strategy is associated with improved business performance. Relationships between a JIT strategy and various measures of both financial (Callen et al., 2000; Fullerton and McWatters, 2001, 1998; Germain and Dröge, 1998; Germain et al., 1996; Huson and Nanda, 1995) and market performance (Germain and Dröge, 1998; Germain et al., 1996) have been demonstrated.

Quality Management

During the nineties, TQM was considered by manufacturing executives to be one of their top strategic issues (Malhotra et al., 1994). Organizations experimented with an array of initiatives aimed at improving product and process quality. While some efforts were successful (Hendricks and Singhal 1996, 1997; Easton and J arrell 1998), they were not uniformly so (Hiam 1993; Grant et al., 1994). This was in large part due to the uncertainty over what works and how quality programs should be implemented (Greene 1993). Despite the wealth of knowledge on quality management, much has been descriptive or anecdotal in nature (Flynn et al., 1995b) and thus of little help in guiding the deployment of quality management programs. Not until the late eighties were attempts made to identify the underlying constructs of quality management (Saraph et al., 1989). In recent years however, several studies have attempted to identify the underlying dimensions of quality management and to relate them to organizational success. Anderson et al. (1994, 1995) developed and tested a theory of quality deployment based on the Deming philosophy of quality. They demonstrated that visionary leadership, internal and external cooperation, process management, and employee fulfillment are drivers of customer satisfaction. Others have also tested and found support for the proposition that quality management, as embodied in constructs similar to those identified by Anderson et al. (1994, 1995) affects performance, either in terms of product quality (Ahire et al., 1996; Dow et al., 1999), broader measures of manufacturing performance (Flynn et al., 1995b; Samson and Terziowski, 1999) and business performance (Kannan et al., 1999; Powell, 1995). In addition to the evidence that strategic quality management affects performance, studies also suggest that the effective deployment of quality tools can affect business performance (Handfield et al., 1999; Kannan et al., 1999).

Supply Chain Management

As far back as 1994, it was claimed that SCM was one of the three most important practices for determining world-class performance (White, 1994). Today, that claim is likely even more appropriate. While several definitions of SCM have been proposed (Larson and Rogers, 1998), common themes are the integration of processes throughout the supply chain, and the goal of adding value to the customer. In this respect, SCM represents the coordination of the manufacturing, logistics, and materials management functions (Lee and Billington, 1992) within, and increasingly between, organizations that form a value chain. Three distinct perspectives on SCM emerge from the literature (Tan et al., 1998b). The transportation and logistics perspective reflects the historical view of SCM as synonymous with logistics. According to this perspective, SCM is the coordination of the logistics operations of independent firms in the value chain to form a unified logistics entity. This facilitates the effective, timely pulling of materials through the supply chain in response to demand patterns, as opposed to the anticipatory pushing of materials. Logistics coordination allows organizations to respond to demand uncertainty more effectively, improve flows within the supply chain, manage inventory more effectively, and improve service levels (Davis, 1993; Houlihan, 1987, 1988; Scott and Westbrook, 1991). The coordination of logistics processes is similar to the concept of integrated logistics systems about which much has been written (Lambert et al., 1998; Bowersox and Closs, 1996; Coyle et al., 1996). The purchasing and supply perspective reflects the emphasis on supplier base integration that has evolved from traditional purchasing and supply management functions. It is synonymous with attempts to rationalize and streamline the supply base, and to integrate suppliers into traditionally company specific product development and manufacturing activities. The need to manage the supply base is a result of the increasing recognition that firms need to outsource non-core activities so that they may focus on core competencies (Prahalad and Hamel, 1990). Doing so allows firms to not only better utilize their own resources and remain more flexible and responsive to changing needs, it allows them to exploit the capabilities, expertise, technologies, and efficiencies of their suppliers.
To this extent, SCM reflects an increased reliance on suppliers and thus a need to better manage the supply process. Managing the supply chain implies reducing and streamlining the supplier base to facilitate managing supplier relationships (Krause, 1997), developing strategic alliances with suppliers (Copacino, 1996; Mason, 1996), working closely with suppliers to ensure that expectations are met (Watts and Hahn, 1993), and involving suppliers earlier in the product development process to take advantage of their capabilities and expertise (Monczka et al., 1994; Ragatz et al., 1997).

A third, emerging perspective, reflects the need to seamlessly integrate the transportation and logistics, and purchasing and supply perspectives with manufacturing processes, to create competitive advantage (Anderson and Katz 1998; Birou et al., 1998; Lee and Billington, 1995; Lummus et al. 1998). Not only does this require the coordination of material and information flows between suppliers, manufacturers, distributors, and customers (Narasimhan and Carter, 1998; Trent and Moncza, 1998; White et al., 1999), it requires the effective implementation of product postponement and mass customization strategies throughout the supply chain (Lee and Tang 1998; Pagh and Cooper 1998; Van Hoek et al., 1998). The expectation is that increased integration and strategic alignment of supply chain participants will create a competitive advantage that is hard to duplicate (Hines et al., 1998; Johnson 1999; Lummus et al., 1998; Narasimhan and Jayaram, 1998).

While empirical evidence of the impact of integrated SCM on performance does not exist, evidence from the transportation and logistics and purchasing and supply perspectives yields insights into the impact of SCM on performance. Inter-firm coordination, characterized by effective communication, information exchange, partnering, and performance monitoring (Stank and Lackey, 1997; Stank et al., 1999; Fawcett and Clinton, 1996), functional integration of logistics or purchasing functions (Stank and Lackey, 1997), a customer focused logistics strategy (Fawcett and Clinton, 1996; Stank and Lackey, 1997), and the management of logistics as an integrated activity (Fawcett and Clinton, 1996) have all been shown to be positively associated with operational performance. From the supply perspective, evidence exists that supplier development (Scannell et al., 2000), supplier partnerships (Scannell et al., 2000; Groves and Valsamakis, 1998), supplier involvement (Vonderembse and Tracey, 1999), and strategic sourcing (Narasimhan and Jayaram, 1998) all positively impact the buying firm’s operational performance. In addition, supplier partnerships (Tan et al., 1998a), supplier development (Curtkovic et al., 2000) and supply chain flexibility (Vickery et al., 1999) are all positively associated with the buying firm’s business performance.

**Research Hypotheses**

While SCM, JIT, and TQM have each been shown to be elements of strategies to improve operations performance and competitiveness, the question addressed here is how do the three philosophies interact to yield superior performance. This is an important issue to managers, who, faced with constrained resources, are trying to successfully leverage not only their capabilities and resources, but those of their partners. A complementary relationship between quality management and JIT has already been demonstrated (e.g., Flynn et al., 1995; Nakamura et al., 1998; Sakakibara et al., 1997). The elimination of excess inventory characteristic of JIT systems can only occur if a quality focus exists. Likewise, the adoption of JIT practices such as reduced lot sizes and preventive maintenance is consistent with improvements in quality. The relationship between quality management and JIT thus suggests the hypothesis:

**H1:** Quality management practices and JIT practices are correlated.

Evidence from prior studies has also established that quality management and JIT practices are drivers of business performance, suggesting the hypotheses:

**H2:** Business performance is directly influenced by quality management practices.

**H3:** Business performance is directly influenced by JIT practices.

To date, the relationship between SCM practices and quality management practices has not been explicitly examined. However, the implication of studies of SCM and its role in product development is that by careful selection of suppliers, leveraging supplier expertise, and strategic partnering with suppliers, quality can be enhanced (e.g., Monczka et al., 1994; Ragatz et al., 1997). Furthermore, sound supplier relations and effective communication between supply chain members have been identified as key elements of quality management (e.g., Ahire et al., 1996; Black and Porter, 1996; Flynn et al., 1995b) and drivers of performance. This suggests that quality and SCM practices are inter-twined, leading to the hypotheses:

**H4:** Quality management practices and SCM practices are correlated.

**H5:** Business performance is directly influenced by SCM practices.

At the heart of any JIT implementation is the need to coordinate supplier deliveries with the buyer’s production schedules, and to share schedule details with suppliers and customers so that they are apprised of future material flows (Germain and Drögé, 1997). This requires a commitment on the part of both buyer and supplier to share information and work towards common goals. The adoption of JIT practices is also consistent with reducing pipeline inventory, and distributing inventory more effectively in order to increase the responsiveness of the supply chain to prevailing demand patterns. This suggests that a buyer’s commitment to JIT must be aligned with its SCM efforts, giving rise to the hypothesis:

**H6:** SCM practices and JIT practices are correlated.
Suppliers are a common link in SCM, quality management, and JIT strategies. Regardless of whether a SCM focus is adopted, producing high quality products in a timely, efficient, and cost effective manner requires the careful selection of suppliers, and timely evaluation of supplier performance. Moreover, coordinating internal manufacturing needs with supplier needs and capabilities requires manufacturers to work closely with their suppliers. This implies that due attention be paid to selecting suppliers whose capabilities and practices are aligned with the buying firm's quality, supply chain, and JIT practices, and to working with these suppliers to ensure that expectations are met. This gives rise to the hypotheses:

H7: SCM practices directly affect supplier management tactics.
H8: Quality management practices directly affect supplier management tactics.
H9: JIT practices directly affect supplier management tactics.
H10: Supplier management tactics directly affect business performance.

To test the above hypotheses, the following structural equation model is proposed (Figure 1):

Three sources of information were used to identify constructs pertinent to the study; a review of the literature, company documentation, and discussions with practitioners. Ten indicators of a firm's commitment to SCM, operationalized by efforts to coordinate supply chain activity, nine criteria used to select and evaluate suppliers, eight indicators of the importance of JIT principles, and eleven indicators of quality management associated with improving products and processes were identified (Appendix 1). A five point Likert scale was developed for each item that sought information on the importance of the item to the responding firm. No consensus exists on how to assess business performance in cross industry studies (Tan et al., 1998b). The approach used was thus to identify five commonly used measures of performance that reflect financial, market, and product performance, and to develop five point Likert scales for each that sought information on the performance of the responding firm relative to that of its major competitors (Tan et al., 1998b; Appendix 1).

Survey Methodology

A survey instrument was developed based on the constructs described above. Questions were worded and ordered with the goal of minimizing the risk of common method bias in mind. This was particularly important since cost precluded soliciting more than one response from the same firm. To further enhance the validity and clarity of the survey instrument, it was pre-tested by thirty senior purchasing and materials managers, and where necessary, questions re-worded. Pre-test questionnaires were not used for subsequent analyses. The revised instrument was mailed to senior purchasing and materials managers in North America and Europe identified from the Institute of Supply Management (ISM) and American Production and Inventory Control Society (APICS) membership lists. Efforts were made to target respondents familiar with their organizations' SCM, operations, and quality efforts, and who could make meaningful
judgments regarding relative firm performance. The original mailing consisted of the survey and a postage-paid self-addressed return envelope. Two weeks later, a follow-up in the form of a postcard was mailed, and a second follow-up consisting of a duplicate survey and postage-paid self-addressed envelope was mailed two weeks thereafter.

Of the forty-five hundred surveys mailed out, five hundred and fifty-six usable surveys were returned. Firms varied in size from ten to two hundred thousand employees (median = 250), and had annual sales of between $20,000 and $30 billion (median = $30 million). To ensure that survey items measured the corresponding constructs consistently and were reasonably free of measurement error, Cronbach’s α (Cronbach, 1951) was used to assess the reliability of the survey instrument. The minimum generally acceptable value for Cronbach’s α is 0.70 (Nunnally, 1988). The analysis suggested that the resulting scales were reliable (Table 1).

### Structural Equation Modeling

#### Model Development

Structural equation modeling allows both measurable and latent variables to be incorporated into a hypothesized model of causality (Byrne, 1998). The methodology takes a confirmatory approach to data analysis, requiring inter-variable relations to be specified a priori, and testing whether hypothesized relationships implied by a structural model are statistically consistent with sample data. Several authors have suggested the use of a two-step approach to modeling (Anderson and Gerbing, 1988; James et al., 1982; Jöreskog and Sörbom, 1993; Mulaik et al., 1989). Measurement models are first developed to test the construct validity of latent variables. Construct validity reflects the degree to which measures of the same trait correlate higher with each other than with measures of other traits (Schoenfeldt, 1984). It is assessed in terms of convergent validity, the degree to which pre-specified measures correlate with the underlying construct(s) predicted by theory, and discriminant validity, the degree of exclusiveness that can be attained by reflective measures, and the absence of incorrect relationships between measured variables and non-hypothesized constructs. Once the construct validity of latent variables has been established, the structural model defining hypothesized direct and indirect relations among latent variables can be specified. This allows predictive validity to be determined.

A structural equation model is only reliable if its parameter values can be estimated (Raykov and Marcoulides, 2000). For this to occur, the model must be identified (Byrne, 1998; Maruyama, 1998; Raykov and Marcoulides, 2000). A necessary condition for identification is that the model must have a positive number of degrees of freedom. If the measurement and structural models are separated and the measurement models identified independently, the structural model will be identified (Maruyama, 1998). Sample size also affects the ability to correctly estimate parameter values and determine model fit (Schumacker and Lomax, 1996). Adequacy of sample size can be determined either in terms of the total sample size or in terms of the number of cases per variable. Using the former approach, Anderson and Gerbing (1988) suggested a minimum sample size of one hundred and fifty, though others have suggested the need for larger sample sizes (Hu et al., 1992). Using the latter approach, five cases per variable are sufficient for normal and elliptical distributions, and ten cases per variable for other distributions (Bentler and Chou, 1987). Since the model to be tested in this study contains forty-three indicators and five latent variables, the sample size of 379 is adequate. Measurement and structural models were developed using LISREL-SIMPLIS 8.30 (Byrne, 1998; Jöreskog and Sörbom, 1993; Schumacker and Lomax, 1996). Maximum likelihood estimation, which assumes multivariate normality of the observed variables, was used. Although this method requires observations be independently and identically distributed (Schumacker and Lomax, 1996), it is robust to minor deviations from normality (Raykov and Marcoulides, 2000). To establish the scale for each latent variable, the value of the first regression path in each measurement model was fixed at one.

#### Measurement Models

Analysis of the SCM measurement model indicated that all ten parameter estimates exhibited the correct sign and size and were consistent with underlying theory (Byrne, 1998). Modification indices however suggested adding a number of error covariance terms.

Error covariance was added between new ways to integrate SCM activities (Q1B), and improving supply chain integration (Q1A) and establishing more frequent

<table>
<thead>
<tr>
<th>Scale</th>
<th>Items</th>
<th>α</th>
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<tr>
<td>Supply Chain Management (SCM)</td>
<td>10</td>
<td>0.8609</td>
</tr>
<tr>
<td>Supplier Management (SM)</td>
<td>9</td>
<td>0.7526</td>
</tr>
<tr>
<td>Just-In-Time (JIT)</td>
<td>8</td>
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</tr>
<tr>
<td>Quality (QLT)</td>
<td>11</td>
<td>0.8661</td>
</tr>
<tr>
<td>Performance (PERF)</td>
<td>5</td>
<td>0.7194</td>
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communication with supply chain members (Q1C), and between extending the supply chain past immediate suppliers and customers (Q1I), creating SCM teams with external members (Q1F), and involving all members of supply chain in product plans (Q1H), and creating a compatible information system with suppliers and customers (Q1J). Integration of supply chain activities requires frequent and effective communication amongst supply chain members to achieve a shared understanding of goals, actions, and outcomes, and so that problems can be identified and addressed (Lambert and Cooper, 2000). Extending the supply chain also requires involving supply chain partners beyond immediate suppliers and customers in internal product development and planning activities, and sharing information in a timely, effective manner. The measurement model was modified accordingly (Figure 2). Parameter estimates shown are standardized solutions.

Although a number of goodness-of-fit criteria/tests have been proposed, no single test or index can absolutely identify a correct model (Schumacker and Lomax, 1996). The comparative fit index (CFI) and normed fit index (NFI) are the preferred measures (Bentler, 1992), though the non-normed fit index (NNFI, Bentler 1990) and X²/degrees of freedom (X²/df) are also commonly used. Values for several commonly used measures of goodness of fit are shown in Table 2 with corresponding values indicative of good model fit. Most fit index values are consistent with good model fit. Large error terms for two of the ten observed measures in the supplier management measurement model, price (Q2B), and certification...
(Q2C), indicated that they were unimportant to the model and should be dropped (Byrne, 1998). Modification indices suggested adding error covariance terms between service level (Q2A), and flexibility (Q2D) and quick response (Q2E), and between flexibility and quick response. This complementary relationship between flexibility, responsiveness, and service is not new (e.g., Gerwin, 1993), thus error covariance terms were added and the measurement model modified (Figure 2). Fit indices suggest the revised model fits the data well (Table 2).

Parameter estimates for seven of the eight observed measures in the JIT measurement model exhibited the correct size and sign and were consistent with underlying theory. Preventive maintenance (Q3D) exhibited large error variance, and was thus removed from the model. Modification indices suggested adding error covariance terms between setup time (Q3B), and reducing lot size (Q3A) and reducing inventory to expose problems (Q3H), and between reducing the supplier base (Q3C), and buying from JIT suppliers (Q3E). Setup time reductions are an important precursor of reductions in lot size in JIT systems, and facilitate reductions in inventory levels (Monden, 1983). It has also been observed that firms implementing JIT practices are reducing their supplier base as well as focusing on suppliers with JIT capabilities (Billesbach et al., 1991). Error covariance terms were added accordingly and the measurement model modified (Figure 2). Fit indices suggest the revised model fits the data well (Table 2).

Large error terms for two of the eleven observed measures in the quality measurement model, inspection (Q4A), and use of benchmark data (Q4B), indicated that the measures were not important and should be dropped. Modification indices suggested adding error covariance terms between product simplification (Q4C), and designing quality into the product (Q4E), process improvement (Q4F), and design for manufacturability (Q4K), between designing quality into the product (Q4E) and design for manufacturability (Q4K), and between employee training in quality (Q4G) and top management communication of quality goals (Q4I). Product simplification, design for manufacturability, and process improvement are all elements of a product development strategy focused on designing quality into the product (Flynn et al., 1995b). Similarly, evidence suggests that quality training is a component of a quality strategy designed to facilitate employees discharging their responsibilities in line with goals articulated by top management (Flynn et al., 1995b). Error covariance terms were added, and the model modified accordingly (Figure 2). Fit indices again indicated good model fit (Table 2).

All five parameter estimates for the performance measurement model exhibited the correct sign and size. Modification indices suggested adding error covariance terms between market share (Q5A), and return on assets (Q5B) and overall competitive position (Q5D), and between overall product quality (Q5C) and overall customer service levels (Q5E). It is generally accepted that competitiveness is a driver of market share. It is similarly understood that

<table>
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<th>Table 2</th>
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<tr>
<td><strong>Model Fit Indices</strong></td>
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<tr>
<td>GOODNESS-OF-FIT INDEX</td>
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<tr>
<td>$\chi^2$/degrees of freedom</td>
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<td>Normed Fit Index (NFI)</td>
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<td>Non-Normed Fit Index (NNFI)</td>
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<td>Adjusted GFI (AGFI)</td>
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<tr>
<td>Root Mean Square Error of Approximation (RMSEA)</td>
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<td>Standardized Root Mean Square Residual (RMSR)</td>
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* Source: Raykov and Marcoulides (2000).
increasing market share, and thus sales, leads to an increase in return on assets. A customer-focused strategy is consistent with improvements in not only product quality, but in meeting broader measures of customer satisfaction. Error covariance terms were added and the model modified accordingly (Figure 2). Fit indices again indicated that the modified model demonstrated good fit (Table 2).

Structural Model

Having established the validity of the measurement models, the proposed structural model was tested. Analysis of the model revealed that paths from SCM, supplier management, and JIT to performance were insignificant.
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Discussion

The results support six of the ten hypotheses. A firm's SCM, quality management, and JIT practices are correlated (H1, H4, H6). Support for hypothesis H1 regarding the relationship between quality and JIT management practices is consistent with previous studies that have suggested that quality management and JIT strategies support each other (Flynn et al., 1995; Nakamura et al., 1998). However, unlike in previous studies, the results here explicitly demonstrate that the two affect each other rather than the relationship being unidirectional (i.e., quality management drives JIT but is not driven by it). The implication is that while JIT practices may be a means to operationalize a quality focus by paying attention to continuous process improvement, quality practices must reflect the firm's ability to exploit its JIT capabilities. For example, if a firm intends to reduce lot sizes through process improvement, its policies regarding inspection may need to be modified. A JIT focus, with its emphasis on inventory reduction, imposes on the production system the need to operate at a high level consistently and reliably, and to respond rapidly when performance fails to meet expectations. Appropriate quality practices are needed to support this. Support for hypothesis H4 suggests that quality and SCM practices are correlated. While this relationship has not previously been empirically validated, it is consistent with the notion that realizing high quality levels while relying on supply chain partners requires close coordination with suppliers. This requires amongst other issues, supplier involvement from early in the product development process, frequent communication and information sharing with suppliers, and the integration of buyer and supplier production activities. It may also necessitate the modification of one's own processes and quality practices to leverage a supplier's capabilities and expertise. For example, quality checks by the supplier may obviate the need for incoming inspection and may permit delivery directly to the point of use. Coordination of buyer and supplier schedules may also reduce or eliminate quality problems attributable to system failures such as machine breakdowns that result in the buyer acting in crisis mode.

Acceptance of hypothesis H6 suggests that SCM and JIT practices are correlated. JIT, with its focus on frequent small lot deliveries, short setup times, and low inventory levels is consistent with and a facilitator of attempts to reduce supply chain inventory. However, this will only be effective if there is a shared commitment to inventory reduction on the part of supply chain partners. Without this commitment, inventory is merely redistributed rather than reduced. The implication is that while JIT practices are utilized internally, SCM efforts establish the support and cooperation of external partners. A JIT focus is also consistent with reductions in the supplier base. Alliances with a small number of suppliers facilitate the sharing of information and production technology, and increase the likelihood of buyer/supplier collaboration in product development and production. A buyer's JIT practices may also be a driver of supplier JIT initiatives. Companies purchasing in large quantities may be in a position to impose delivery expectations as a condition of the purchase contract. They may also be more likely to support the suppliers' JIT initiatives. Moreover, companies implementing a JIT strategy may favor suppliers who do likewise since this will enable them to function without the need to carry large inventories of purchased parts. Support for hypothesis H7 demonstrates that firms dedicated to managing the supply chain understand that a concerted effort to manage suppliers is a key to achieving competitive advantage. They recognize the importance of working with suppliers who understand the importance of improving material flows, and are committed to working with their customers to reduce development lead times, improve quality and reduce costs. Moreover, they understand that managing the supply chain means sharing information, risks and rewards. With this in mind, these firms realize they cannot build relationships with suppliers in an arbitrary manner. Attempts to enhance supply chain performance involves identifying suppliers who are competitive not only with respect to price, quality, and delivery, but who have the capability and willingness to be supportive partners. It also requires identifying suppliers they feel comfortable involving at an earlier stage of the product development process, deferring to when the supplier's expertise warrants, and in general, viewing as an equal partner in the product development and production process. Conversely, it requires suppliers who are equally comfortable working in a partnership mode as in a more hands off mode. Similar arguments can be made for firm's having a quality focus, thus hypothesis H8 is supported. A firm with a commitment to quality understands the need to involve suppliers early in the product development process. They will also place a premium on identifying suppliers who can meet their quality expectations in a consistent manner, and who demonstrate a commitment to rapid resolution of quality deficiencies.

Support does not exist for hypothesis H9 that JIT practices impact supplier management. While a supplier's capability and in particular ability to support a buyer's JIT strategy would appear to be relevant to supplier selection and assessment, the results do not support this proposition. One possible explanation for this is that JIT is one means by which quality
and SCM can be operationalized. Suppliers that can meet quality and delivery expectations imposed by quality and SCM strategies will likely be able to meet JIT expectations. JIT practices thus impacts supplier management indirectly rather than directly.

Support for hypothesis H2 that quality management practices are a driver of business performance is consistent with results of previous studies (Kannan et al., 1999; Powell, 1995; Wilson and Collier, 2000). Producing high quality products not only gives the producer the potential to charge a price premium for its products, it makes the product more attractive in a competitive market, which can lead to improvements in market share and profits. However, the results do not provide support for hypotheses H3, H5, and H10, that JIT practices, SCM practices, and supplier management respectively, directly impact performance. Failure to support hypothesis H3 is consistent with past research claiming that JIT does not impact performance directly but does so indirectly due to elements of infrastructure that are shared by a quality management strategy (Sakakibara et al., 1997; Snell and Dean, 1996). To the extent that JIT strategy involves the deployment of practices that contribute to quality improvement, its impact on performance is subsumed by that of quality management practices. It is also possible that the focus of this study on business performance rather than manufacturing performance helps to explain the lack of relationship between JIT and performance. Studies that have demonstrated a link between JIT and performance in the presence of a quality focused strategy have focused on manufacturing performance (Flynn et al., 1995; Nakamura et al., 1998). Moreover, while evidence of JIT’s impact on operational performance is widespread and unequivocal, the same cannot be said for its impact on business performance. One can surmise that the inclusion of performance measures such as inventory turnover, cycle time, and scrap rates may have demonstrated a link between JIT and performance. Similar arguments can be made to explain the lack of support for hypothesis H5 regarding the relationship between SCM practices and performance. Efforts to coordinate material flows and improve product quality by involving suppliers, is but one means of operationalizing a quality focused strategy. Moreover, the impact on business performance of efforts a firm makes to integrate and coordinate its supply chain may be small in comparison to internal, quality driven initiatives, over which it has greater control. Again, the use of operational measures of performance may have yielded a different result. The lack of support for hypothesis H10 regarding the impact of supplier management on performance is again somewhat surprising at first glance, but less so in light of the performance measures used. Supplier performance can certainly impact performance measures such as cost, lead time, and defect rates, but compared to the buyer’s internally driven initiatives, its impact on the buyer’s business performance is likely marginal at best unless purchased items represent a large proportion of product value.

Conclusion

Managers are faced with numerous options as they seek to improve the competitiveness of their organizations. This study demonstrates that not only are practices based on the principles of quality management, SCM, and JIT mutually supportive, but that quality management practices are the single most important driver of business performance. While the use of JIT or SCM practices can be used to operationalize an emphasis on quality, whether they can in isolation drive business performance is not clear. Reducing lot sizes or involving suppliers in one’s own product development or manufacturing activities, may not impact performance in the market place unless these activities occur within the context of a customer focus or commitment to continuous improvement. Conversely, a strategy based on the principles of quality management may be able to drive business performance without the need to deploy specific elements of JIT and SCM. The results support the contention that operations excellence depends on the integration of different but complementary approaches to operations management. This study is not without its limitations. As complex as they are, the multiple dimensions of SCM, quality management, and JIT cannot be fully captured in forty-one survey items. However, the reality of empirical research is that compromises must be made to realize an adequate data set. Moreover, focusing solely on business performance not only limits the ability to draw conclusions regarding how specific practices impact operations performance, it precludes examination of how operations performance drives business performance and which measures of operations performance are indicators of a firm’s business success. This however represents an opportunity for future research. As is the case with many empirical studies, the study is also limited by the use of single responses from firm’s participating in the study, and, as a result, is vulnerable to inaccuracies or biases in respondents’ answers. Limitations notwithstanding, the study extends the literature by applying structural modeling to identify how alternative operations practices interact, and by highlighting the importance of quality as the cornerstone of operations strategy. Moreover it provides direction to managers as they contend with the smorgasbord of performance improvement options available to them.
References


APPENDIX I: SURVEY ITEMS

(1 = very low, 5 = very high)

1. How important are the following issues in your firm’s supply chain management efforts?
   a. Improving the integration of activities across your supply chain
   b. Searching for new ways to integrate supply chain management activities
   c. Establishing more frequent contact with members of your supply chain
   d. Communicating your firm’s future strategic needs to your suppliers
   e. Creating a greater level of trust among your firm’s supply chain members
   f. Creating SCM teams that include members from different companies
   g. Reducing response time across the supply chain
   h. Involving all members of your firm’s SC in your product/service/marketing plans
   i. Extending your SC to include members beyond immediate suppliers and customers
   j. Creating a compatible information system with your suppliers and customers

2. How important are the following issues when selecting and evaluating your key suppliers?
   a. Service level
   b. Price/cost of product
   c. Presence of certification or other documentation
   d. The flexibility to respond to unexpected demand changes
   e. Quick response time in case of emergency, problem, or special request
   f. Technical expertise
   g. Commitment to quality
   h. Ability to meet delivery due dates
   i. Commitment to continuous improvement in product and process

3. How important are the following JIT principles in your operations?
   a. Reducing lot size
   b. Reducing setup time
   c. Reducing supplier base
   d. Preventive Maintenance
   e. Buying from JIT suppliers
   f. Increasing delivery frequencies
   g. Reducing inventory, which in turn frees up capital investment
   h. Reducing inventory to expose manufacturing and scheduling problems

4. How important are each of the following quality practices in your firm?
   a. Inspection
   b. Using benchmark data
   c. Simplifying the product
   d. Statistical process control
   e. Designing quality into the product
   f. Process improvement (modification of process)
   g. Employee training in quality management and control
   h. Empowerment of shop operators to correct quality problems
   i. Top management communication of quality goals to the organization
   j. Emphasis on quality instead of price in the supplier selection process
   k. Considering manufacturability and assembly in the product design stage

5. What is the level of your firm’s performance compared to your major industrial competitors in terms of?
   a. Market share
   b. Return on assets
   c. Overall product quality
   d. Overall competitive position
   e. Overall customer service levels