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Supply chain management, knowledge management capability, and their linkages towards firm performance

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Abstract

Purpose – The purpose of this paper is to investigate how supply chain management (SCM) practices and knowledge management (KM) capabilities affect firm performance. This study was conducted in the Asia Pacific region, which had not been examined before.

Design/methodology/approach – A three-phase statistical analysis which comprised phase one (convergent validity, reliability, and discriminant validity), phase two (mediated regression analysis) and phase three (path analysis) was used to analyze the data.

Findings – The results from this paper have shown that the implementation of SCM practices will interact with KM capabilities to influence firm performance.

Research limitations/implications – The proposed model does not consider firm performance from multiple perspectives. In addition, the use of longitudinal data would be more useful to examine how changes in certain variables affect performance.

Practical implications – These findings provide important insights for managers to understand the disposition of the firm to better leverage internal capability (knowledge), by exploiting relationships with supply chain partners.

Social implications – This paper has extended knowledge in the mainstream management and provides valuable clues on how to improve organizational effectiveness, which is the crux of management.

Originality/value – The paper is among the first empirical works that specifically investigate the relationships between KM and SCM; thus this paper fills an important gap in the supply chain literature.

Keywords Malaysia, Supply chain management, Knowledge management, Organizational performance, Knowledge capability

Paper type Research paper

Introduction

Supply chain management (SCM) and knowledge management (KM) represent alternative approaches that have generated a lot of interests among organizations and researchers. While differences in their motivation and objectives have led to them being presented as distinct and separate, they are in fact intertwined and have some common groundings. For example, in both approaches, knowledge and the acquisition

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and sharing of information among the members in the system are addressed. Even though various studies have been carried out to analyze these approaches in a separate platform, there has not been any systematic study to the best of our knowledge that explores the relationship between the two approaches. There are some studies that have examined the linkage between SCM and other disciplines (such as quality management (Lin *et al.*; 2005; Kannan and Tan, 2005) and organizational structure (Kim, 2007)), but those that investigate the relationship between the former and KM are very scarce in the literature. Researchers are also inclined to look at the impact of these two approaches on organizational performance from a non-integrative perspective. For example, Li *et al.* (2006) examined the relationship between SCM and organizational performance without considering KM, while Kalling (2003) only studied how the latter approach was solely linked with performance. The same can be said for studies done by Brand (1998), Carneiro (2000), Vickery *et al.* (2003), Wisner (2003), Egbu *et al.* (2005), Kim (2007) and Fantazy *et al.* (2009). To date, evidence of the impact of SCM practices on KM capability and firm performance has been limited and inconclusive.

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). Many research efforts stem from the theoretical assertion that the heterogeneity of organizational resources leads to differentiation in a firm's competitive advantage (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 knowledge capabilities of multiple supply chain members (Kim and Im, 2002). Research shows that firms with similar levels of knowledge capability in the same market segment can have different levels of performance (Cool and Schendel, 1988). Moreover, a firm's knowledge capablity can create value both for the firm and its suppliers and customers (Porter, 1985).

As business practices today no longer evaluate the performance of a business enterprise at a unit level, but rather from a value chain (supply chain) perspective, it is therefore important to examine the management of knowledge in the supply chain context. The same philosophy of KM at the firm level cannot be applied directly to the supply chain level. This is because, probably, the roles that knowledge plays in both levels are different and therefore, the impact of KM will differ from a firm perspective to a supply chain perspective. This research gives two-fold contributions. First, it examines linkages between KM, SCM practices and firm performance; the results of which will help us to understand how to better manage knowledge in a supply chain context. Second, this research addresses the gap in the literature by analyzing the roles of KM capability and SCM practices on firm performance. This in turn will provide valuable clues on how to improve organizational effectiveness which is the crux of management.

In the following section, the conceptual model and research hypotheses are presented. In subsequent sections, the methodology, measurement and statistical analyses are described, followed by discussion of results. Finally, limitations of the study and directions for further research are provided.

Theoretical background and conceptual framework

We will now provide some theoretical grounds on the construction of the framework. We intend to answer the research question of:

RQ. How the combined effect of recognizing the competitive value of resources or capabilities, i.e. knowledge, with influence of SCM practices, implicates the performance of a firm?

A clear theoretical logic is that a firm performance depends on the proper management of both intangible and tangible resources. KM deals with the intangibles while SCM addresses the tangibles (e.g. raw materials, components, products, finished goods, etc.) throughout the whole value stream. From a related standpoint, KM capability is one of the tenets of the resource-based view. SCM practices represent the competence-based view, which constitutes the strategy used by firms to relate to their external environment (Porter, 1985). The combined effect of KM capability and SCM practices thus forms the building blocks of managerial decisions and actions that determine the long-run performance of an organization. Hence, it is reasonable to conceptualize the framework based on the resource- and competence-based views of the firm (Hsu *et al.*, 2009; Freiling, 2004). We therefore propose that KM capability and SCM practices play important roles in contributing to firm performance. We further propose that KM capability is an antecedent of these SCM practices, and that insights into the relationship between KM capability and SCM practices can lead to a better understanding of the relationship between KM capability and firm performance.

From another perspective, the genealogy of KM in supply chain can be traced back from the knowledge-based view of the firm. According to this theory which was built on tenets of the resource-based view, unique abilities to create and exploit valuable knowledge enhance outcomes (Grant, 1996; Hult *et al.*, 2004). If these abilities are embedded into SCM, they will create values for the chain and subsequently contribute to better performance. Hence, the knowledge-based view provides a foundation for supporting the hypothesis that KM influences SCM and firm performance. Besides relying on the resource-, competence- and knowledge-based views of the firm, the information system literature has also highlighted that KM, SCM and operational performance are related (Bayraktar *et al.*, 2009). In addition, it is widely acknowledged that knowledge-sharing shapes SCM practices (Thonemann, 2002; Zhou and Benton Jr, 2007; Pedroso and Nakano, 2009) which in turn will affect the performance of an organization. These findings help to substantiate the propositions made earlier.

As several authors have suggested, the development of KM capabilities is the primary vehicle for performance excellence within a firm (Drucker, 1995; Stewart, 1997; Chong *et al.*, 2006). A logical extension is that once a firm has developed its internal KM capabilities and infrastructure, it is in a position to leverage relationships within the supply chain. While the SCM literature discussed 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 is that, how a firm manages its supply chain should be considered simultaneously with the relationship between internal KM capabilities and firm performance. The conceptual framework underlying this study is shown in Figure 1.

KM capability

KM capability is a kind of absorptive capacity, which is an ability to use prior knowledge to recognize the value of new information, assimilate it and apply it to create new knowledge and capabilities (Grant, 1996). Knowledge is created through two generic processes, namely combination and exchange. The meaning of KM capability relates

to the concept of social capital, whereby social capital refers to "the sum of actual and potential resources embedded within, available through and derived from the network of relationships possessed by a social unit" (Nahapiet and Ghoshal, 1998). The maximization of social capital is enabled through infrastructure capabilities, which comprise technological, structural and cultural. Technological infrastructure refers to the technology-enabled ties that exist within the firm (Grant, 1996); structural infrastructure refers to the presence of norms and procedural mechanisms (Nonaka and Takeuchi, 1995); while shared contexts comprise the cultural dimension (DeLong, 1997).

In order to leverage infrastructure, KM processes must be present to store, transform and transport knowledge throughout the organization, and these activities are related to the aspect of knowledge development (Earl, 2001). In a fast-changing business environment, the competitive advantage of many organizations is based on the decision to exploit and develop the power of knowledge development. The development process starts with creation and adoption at the individual level, and then it moves to distribution, review and revision at the organizational level, which actually converts individual knowledge to organizational knowledge (Bhatt, 2000). KM capability which is molded from infrastructure and process will eventually lead to knowledge integration. The more times the company carries out KM processes, the more efficient will be the integration and vice versa. By viewing from the perspectives of infrastructure and process, it will therefore provide a useful theoretical foundation for defining important aspects of KM capability (Gold *et al.*, 2001).

From another perspective, Tsoukas (1996) viewed knowledge as a "de-centered system" and "not self-contained". Orlikowski (2002) perceived knowledge as an on-going element that is reinforced through sustained practices. In other words, both of them focused on what people do and how they do it. Both referred to KM capability as knowledge sharing among human agents.

In this paper, we view KM capability from a balanced socio-technical perspective (Pan and Scarbrough, 1998) by focusing on technology (Grant, 1996), structure (Nonaka and Konno, 1998), culture (DeLong, 1997) and process (Earl, 2001). The human agent element and its dynamic effect (Tsoukas, 1996; Orlikowski, 2002) are therefore included in this study because the constructs or components above involve humans although they are not mentioned explicitly. Readers are advised to take this socio-technical viewpoint as complementing rather than substituting for the perspective on KM capability.

In summary, effective initiation and maintainence programs of KM can be framed along broad dimensions of infrastructure and process. Infrastructure capability can be further subdivided into technological, structural and cultural. Process capability consists of acquisition, conversion, application and protection of knowledge. Note that these constructs are not direct dimensions, rather, they are classified according to their respective factors, consistent with the notion of "capability" or "resource" in the organizational behavior perspective (Law *et al.*, 1998).

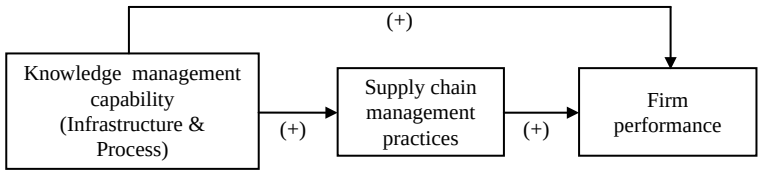

Figure 1.
Conceptual framework

SCM practices

SCM practices are defined as a set of activities undertaken in an organization to promote the effective management of its supply chain, e.g. supplier partnership and information technology (IT) sharing (Donlon, 1996); supply chain integration, delivery and response time improvement, and quality (Tan *et al.*, 1998); communication, vision, goals, and long-term relationship with suppliers and customers (Chen and Paulraj, 2004; Min and Mentzer, 2004). In addition, lean capabilities, logistics, and leadership also promote the effective management of the supply chain (Tan, 2002; Min and Mentzer, 2004). For the parsimony of the measurement instrument, we consolidate the items into five distinctive dimensions, i.e. information sharing, integration, on-time delivery, response time and communication of strategic needs.

Firm performance

Firm performance refers to how well an organization achieves its market-oriented goals as well as its financial goals (Li *et al.*, 2006). A number of prior studies have measured firm performance using both financial and market criteria, including return on investment (ROI), market share, profit margin on sales, growth of ROI, growth of sales, and growth of market share (Tan *et al.*, 1998). In line with the above literature, the same items will be adopted to measure firm performance in this study. In the following section, we will explain the development of the hypotheses.

Hypotheses development

KM capability and firm performance

A central tenet underlying the existence of KM capabilities is their association with firm performance (Cohen and Levinthal, 1990; Nonaka and Takeuchi, 1995). KM capabilities were found to improve firm performance (Kalling, 2003). Firm performance is more than just financial ratios and actually encompasses a wider dimension and terms of description, e.g. it also includes dimensions such as overall product quality and overall competitive position (Venkatraman, 1990). Recent literature has identified the contributions of knowledge on firm performance in terms of abilities to improve productivity and competitiveness, decision making, responsiveness, innovation, product or service quality, learning curve, flexibility and cost efficiency (Chong *et al.*, 2006; Sharmillah *et al.*, 2007; Bixler, 2000; Stewart, 1997; Skyrme and Amidon, 1997). Case studies conducted in different industrial sectors also showed that noticeable improvements in terms of firm performance were attained by companies which had implemented KM (Wong and Aspinwall, 2005). In essence, various benefits and values can be gained from a proactive KM effort and capability.

Zooming into each element of KM capabilities, starting from technological capability, several past researchers had supported that technological capability of KM enhances firm performance. For instances, Kogut and Zander (1992) highlighted that technology enables firms to improve their performance by learning new skills and enhancing current capabilities. Sambamurthy *et al.* (2003) further highlighted that KM technological capability influences contemporary firm performance through dynamic organizational learning. Recent evidences show that the technological "link" between KM and firm performance has become even more critical as we move into the era of k-economy. The role of technology is becoming more important to enable knowledge transfer and develop

intangible benefits which can be a source of competitive advantage especially for leading-edge firms (Chong, 2006; Egbu *et al.*, 2005; Chourides *et al.*, 2003).

For structural capability, it can be viewed from the product and process perspectives. For instances, through flexibility and modularity (Nonaka and Konno, 1998), a firm can easily adapt to an ever-changing environment. Modularity and flexibility in product and process can reduce the cost of coordination and adaptation (Sanchez and Mahoney, 1996). Flexible product and process designs are associated with increased customer satisfaction (Chase *et al.*, 1998). Likewise, a more knowledge friendly structure that encompasses the elements of low formalization, high decentralization, wide spans of control, free flow of information, and cross-functional teams will improve the innovativeness and responsiveness of an organization (Robbins and Coulter, 2007). Anecdotal evidence in the industry also suggested that structural capability positively affects firm performance (Chong, 2006; Egbu *et al.*, 2005).

A firm with high cultural capability, e.g. when the top management is more supportive of knowledge-related activities, will foster better relationship and greater knowledge sharing among its employees, which can lead to innovation, responsiveness, better decision making, higher productivity and competitiveness, and better product or service quality (Carneiro, 2000; Kalling, 2003). A fertile culture which highly values knowledge and supports the adoption of KM will help a company to thrive and prosper (Martensson, 2000; Wong, 2005; Wong and Aspinwall, 2006).

The process capability of KM brings the organizational knowledge assets together and enables the achievement of better organizational and market performance (Day, 1994). Grant (1996) also highlighted that KM process capability contributes to firm performance through innovation and value-adding activities. For instance, better quality and lower cost products or production systems are enabled through process improvement and innovation. Recent researchers supported that the output from KM process capability, that is knowledge asset is a source of competitive advantage which benefits firms and improves their overall performance (Lei *et al.*, 1999; Linda and Paul, 2000). It was further highlighted that a systematic KM process capability to collect, review, classify, store and manage knowledge (Wong and Aspinwall, 2006) is one of the key ingredients for better performance.

The above literature had provided empirical evidences of the connection between KM capabilities and firm performance. To further advocate the linkage, we conceptualize the relationship using grounded theory, i.e. resource-based view. According to this theory, when the firms have unique abilities to exploit and create resources, they will be able to improve their performance. Knowledge can be viewed as a resource and the competitive advantage of many organizations relies on the power of knowledge development. As the development of this capability (i.e. KM capability) permeates through the organization, it will lead to innovation and value-adding activities. For instance, when employees share knowledge in their work, they can produce better quality and lower cost products; and this will lead to improvements in the production systems through process improvement and innovation. In line with the consistency of the extant empirical results from past research, as well as the support from the structuralists' theory (Sutton and Staw, 1995), i.e. when two variables are connected, changing one variable will affect the other, we therefore hypothesize the main hypothesis and its sub-hypotheses as follows:

H1. KM capability positively affects firm performance.

H1a. Technological capability positively affects firm performance.

H1b. Structural capability positively affects firm performance.

H1c. Cultural capability positively affects firm performance.

H1d. Process capability positively affects firm performance.

SCM, KM capabilities and firm performance

Though it was mentioned in the preceding section that KM capability is associated with firm performance, firm performance is also vastly affected by many other factors. One of the prominent factors is SCM practices. Several researchers had examined the relationship between SCM practices and firm performance. For example, Tan *et al.* (1998) found that SCM practices improve financial and business performance; Vickery *et al.* (2003) found that positive direct and indirect relationships exist between supply chain integration and financial performance. Some recent studies have also demonstrated the significant relationship between SCM and firm performance, e.g. through partnership relationships, outsourcing activities, and other relevant components of SCM practices in organizations (Wisner, 2003; Tan, 2002; Ragatz *et al.*, 2002).

On the other hand, several past studies have also demonstrated a relationship between knowledge capabilities and management of the supply chain. For example, Kant and Singh (2008) proposed an integrated framework that shows the relationship between knowledge development and SCM. Other significant findings are also as follows. Simon (2005) showed that KM capabilities (e.g. through technology such as web browser and internet) have a profound impact on SCM. Ofek and Sarvary (2001) demonstrated that early implementation or involvement in KM leads to significant improvements in cost, quality and cycle time across the supply chain when knowledge is used and applied in work. Hult *et al.* (2007) concluded that inter-organizational relationships can be enhanced through SCM practices by utilizing knowledge for innovation and competitiveness. Maqsood *et al.* (2007) highlighted the extension of KM into learning chains, and concluded that long-term relationships among firms, customers and suppliers using knowledge-sharing networks would become more widespread in the supply chain environment.

Particularly for each element of KM capability, its association with SCM practices are as follows. For example, for technology capability, Kim and Im (2002) argued that supply chain efficiency is contingent on the effectiveness and ability of individual supply chain member to connect. Lee *et al.* (1997) and Gurbaxani and Whang (1991) also posited that technological infrastructure, such as IT can facilitate the necessary knowledge coordination between business partners by nurturing cooperative relationship. For the structural element of KM capability, structural flexibility through modularity in product and process design enhances collaboration among supply chain members (Sanchez and Mahoney, 1996; Nonaka and Takeuchi, 1995). For instance, if a firm practices product and process modularity, it may eliminate certain processes, reduce material movements, and adopt relationships with key suppliers to share confidential information and exchange knowledge. On the other hand, the effect on cultural capability can be viewed from the value and vision of the company, e.g. the total quality management (Kanji and Wong, 1999) and the Toyota production system (Morgan and Jeffrey, 2007) promote a knowledge-sharing network to increase its suppliers' involvement and shares valuable knowledge in its supply chain. In addition, several other past researchers had also highlighted that a culture

which promotes dynamic learning could improve a supply chain's competitive capabilities and management practices (Gonzalez-Benito *et al.*, 2003; Gunasekaran and McGaughey, 2003; Hult *et al.*, 2004). Effective process capability of KM leads to improved ability to innovate (Brand, 1998; Carneiro, 2000; McAdam, 2000), improved quality of product and cost reduction (Ofek and Sarvary, 2001; Skyrme and Amidon, 1997), and increased productivity (Fritsch and Meschede, 2001; Mohr, 2001). These positive effects on the firm are likely to cascade down to the supply chain level (Darroch and McNaughton, 2002; Forcadell and Cuadamillas, 2002), e.g. firms will be motivated to collaborate with suppliers to further develop new product design, adopt relationships with suppliers, and share knowledge, information and technology.

Stemming from all the above findings between SCM practices, KM capabilities and firm performance, we can advocate the argument (with the support of resource-based theory) on the effect of SCM practices on the relationship between KM capabilities and firm performance as follows. KM capability is one of the tenets of resource-based view. SCM practices represent the competence-based view, which constitutes the strategy used by a firm to relate to its external environment (Porter, 1985). Together, they are the building blocks of managerial decisions and actions that determine long-run performance. As mentioned earlier, if unique abilities are able to exploit and create valuable knowledge, performance outcomes will be enhanced (Grant, 1996; Hult *et al.*, 2004). This means that, if KM capability is embedded into SCM practices, it will create values in the chain, and ultimately enhance firm performance. Existing studies that have hinted at these relationships are such as Thonemann (2002) and Pedroso and Nakano (2009). Both studies substantiated the claim that the two practices are associated in relation to firm performance. At such, we hypothesize the second, its sub-hypotheses and the final hypothesis as follows:

H2. The relationship between KM capability and firm performance is mediated by SCM practices.

H2a. The relationship between technological capability and firm performance is mediated by SCM practices.

H2b. The relationship between structural capability and firm performance is mediated by SCM practices.

H2c. The relationship between cultural capability and firm performance is mediated by SCM practices.

H2d. The relationship between process capability and firm performance is mediated by SCM practices.

H3. SCM practices positively affect firm performance.

Figure A1 in Appendix 1 shows the summarized proposed hypothesized model.

Methodology

Survey instrument and data collection

A set of questionnaires was developed to measure the relevant constructs of the framework. The contents of the developed questionnaires were based on the review of literature (Gold *et al.*, 2001; Tan, 2002). The questionnaires were not exactly imitations

or replications from past work; modifications were added to suit the objective of this study. The modifications were done in stages as follows: the questionnaires were initially reviewed by a sample of academicians with relevant expertise, to obtain feedback on the comprehensiveness, clarity, validity and readability of the scales and instructions. Based on the feedback, a modified survey instrument was developed and tested by 20 senior managers. In response to their feedback, further minor changes were made. With this approach, the content validity of the survey instrument was checked and evaluated. The questionnaires comprised three main sections. The first part examined the infrastructure and process capabilities of KM, the second section investigated the SCM practices and the third section addressed the firm performance.

The resulting questionnaires were sent to 800 respondents consisting of senior managers from various functional areas working in companies identified from the Federation of Malaysian Manufacturers Directory (FMM, 2009). There are altogether more than 2,000 manufacturing and industrial service companies of various sizes in FMM. As a result, the sample of the present study could be considered as an appropriate representation of the companies in Malaysia. We selected manufacturers as the respondents because they actively use and apply knowledge for the accomplishment of their tasks. They are also the key echelon in a supply chain and are primarily involved in SCM activities. Generally, Malaysian organizations have influences on the technological, structural, cultural and process aspects because they were found to perceive these elements as important in KM (Wong, 2008). Moreover, they were reported to have developed a culture of trust to encourage the application and development of knowledge (Chong *et al.*, 2007, 2009).

Senior managers from various organizations are considered as ideal respondents for this study because they have access to and use of their organization's knowledge and should be able to describe the structural elements of their organization in addition to the knowledge-oriented processes. In order to improve the accuracy of reports gathered from key respondents, we adhered to the guidelines proposed by Huber and Power (1985); potential organizational respondents were profiled and the instrument was pretested among this constituency to ensure that these respondents understood the questions and provided informed responses. From the 800 questionnaires distributed, 233 completed questionnaires were returned to the researchers, yielding a response rate of 29.1 percent. In order to make sure that non-response bias was not problematic, it is customary to use late respondents as surrogates for non-respondents (Nwachukwv *et al.*, 1997). We compared the answers and found that none of them was significantly different at the 0.05 level. Thus, non-response bias was not problematic.

The measures

For each construct, respondents were asked to indicate their level of agreement using a five-point Likert scale ranging from 1 – strongly disagree to 5 – strongly agree. For firm performance, respondents were asked to indicate their company's performance as compared to that of major competitors. Appendix 2 shows the items measured for each construct. Note that these items represent a priori measurement model of the theoretical construct space. Given the theory driven approach to construct development, the analytical framework of confirmatory factor analysis provides an appropriate means of assessing the efficacy of measurement among scaled items (Anderson and Gerbing, 1988). In essence, we expect that each of the scaled items will

uniquely measure its associated construct. Correlation analysis was used to compare responses from a sample of firms with published financial data. The results indicated that correlation was statistically significant ($\alpha = 5$ percent).

Statistical analysis

First, we checked for normality assumptions using the normal probability plot of the regression standardized residuals. The results indicated that the variables of the study were normally distributed. In addition, the skewness and kurtosis of the variables were scrutinized to assess the normality of the distribution of the variables. These statistics also suggested no serious departure from multivariate normality or excessive kurtosis.

We conducted a three-phase statistical analysis. First, we used LISREL 8.30 (Jöreskog and Sörbom, 1993) to perform confirmatory factor analysis for each construct. Cronbach's α (Cronbach, 1951) was used to estimate internal consistency, and convergent validity was established by ensuring item loadings were significant. The mediation effects of SCM practices were examined using a three-step mediated regression analysis (Baron and Kenny, 1986). The adoption of SCM practices was first regressed on the independent variables (KM 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. Lastly, for the third phase, we used structural equation modeling to assess the psychometric properties of the scaled items for each construct and to establish the relationships between the exogenous and endogenous variables.

Results

In order to address common method bias, we used the Harman's one factor test (Podsakoff *et al.*, 2003) to check whether a single factor emerged from the factor analysis of all the constructs' items. We found no single factor emerged from all the items, and there was no one general factor that accounted for most of the variances for all the constructs. As such, we concluded that common method bias was not an issue.

The results on the zero-order correlation matrix of the six latent constructs showed that the correlations are statistically significant ($\alpha = 5$ percent) and there exist positive relationships (Table AI in Appendix 1). This provides preliminary support for the relationships shown in Figure A1. All correlation coefficients are significant and less than 0.50, suggesting that multi-collinearity is not present and discriminant validity can be assumed (Mason and Perreault, 1991). Note that LISREL 8.30 was used to analyze the hypothesized model because it supports exploratory research and theory development (Komiak and Benbasat, 2006). Specifically, raw data rather than a covariance matrix were input directly into LISREL for data analysis. A two-step model-building approach

was used, in which the measurement models (or confirmatory factor models) were tested prior to testing the structural model.

Phase one analysis

Confirmatory factor analysis was conducted on the six dimensions. The results indicated a significant strength of measurement between the items and the associated constructs. The results showed that the χ^2 p-value is statistically significant, indicating that the data fit the hypothesized model. The ratio of χ^2 to degrees of freedom is also less than 3 (i.e. equals to 2.55); this further supports the measurement model. Note that this ratio is often used as the preferred fit index in recent structural equation modeling studies. The reliabilities of KM capabilities, SCM practices and firm performance were assessed with Cronbach's α.

It has been suggested that composite reliability and average variance extracted be used in addition to the Cronbach's α. The reason for this is that, as Cronbach's α is based on internal consistency, it may not adequately estimate the errors caused by external factors such as differences in test situations and respondents over time (Netemeyer *et al.*, 1990; Bollen, 1989). The values for composite reliability, average variance extracted and Cronbach's α for each construct are reported in Table AII (Appendix 1). The values of Cronbach's α for all constructs are greater than 0.70; the composite reliabilities for all constructs exceed the required value of 0.60; and the average variances extracted for all constructs with exception of the SCM practices construct, exceed the threshold level of 0.50. Together, these statistics suggest that all constructs are sufficiently reliable (Bollen, 1989).

To test for convergent, discriminant and nomological validities of the measurement models, the followings results were analyzed. Note that five of the six models yielded values for average variance extracted in excess of 0.50 (Table AII), thus suggesting excellent convergent validity (Shock *et al.*, 2004). Correlations between pairs of latent variables should be unidimensional and significantly less than one for the variables to be distinct (Anderson and Gerbing, 1988). All the correlation coefficients are significant and less than 0.5, thus discriminant validity can be assumed. In addition, there is also evidence that the constructs exhibit discriminant validity based on the average variances extracted for each of the six constructs which are greater than the squared correlation values (Table AII in Appendix 1).

The RMSEA value is only 0.035, which represents a very good fit of the model. A rule of thumb is that RMSEA $\leq$ 0.05 indicates a close approximate fit, values between 0.05 and 0.08 suggest a reasonable error of approximation and RMSEA $>$ 0.10 suggests a poor fit (Brown and Cudeck, 1993). Other additional goodness-of-fit indices: NFI $= 0.98$, GFI $= 0.99$, AGFI $= 0.95$, and CFI $= 0.98$ also suggest that overall the model has a good fit (Table AIII in Appendix 1).

Phase two analysis

In model 1, we regressed the adoption of SCM practices on the predicted antecedents, i.e. KM capabilities. The model was statistically significant in which KM capabilities accounted for 15.8 percent of the variance in SCM practices (Table AIV in Appendix 1). Regression coefficients for technological capability ($\beta = 0.185$) and process capability ($\beta = 0.230$) were statistically significant ($\alpha = 0.05$). The coefficients for structural capability and cultural capability were statistically insignificant, suggesting a lack

of mediation effect between these two variables and SCM practices. The preliminary conclusion to be drawn is that technological and process capabilities have similar effects on SCM practices. The relationship is also positive, as such, the first requirement to infer that mediation effects occur, is met. The results implied that firms should critically review their technological and process (or operational) capabilities when adopting and implementing SCM practices.

In model 2, firm performance was regressed on KM capabilities. The four independent variables accounted for 18.3 percent of the variance in firm performance. The regression coefficients for technological capability ($\beta = 0.130$; $p < 0.05$), structural capability ($\beta = 0.151$; $p < 0.05$), cultural capability ($\beta = 0.165$; $p < 0.05$) and process capability ($\beta = 0.192$; $p < 0.05$) were statistically significant and in the positive direction. The results implied that a firm's performance is positively related to KM capabilities (i.e. infrastructure and process).

In model 3, we added the SCM practices construct to the regression model. The results showed that the variance explained increased to 19.1 percent. The revised model and the SCM practices coefficient ($\beta = 0.090$) were both statistically significant ($\alpha = 0.05$) (note: $\Delta R^2 = 0.008$ (significant at $\alpha = 0.05$) and $\Delta F = 2.274$, significant ($\alpha = 0.05$) indicated that the additional variable, i.e. SCM practices can explain 0.8 percent of the variance of firm performance, and there is a significant contribution of the construct to the model). Owing to the adoption of SCM practices, the coefficients for technological capability decreased (from 0.130 to 0.121), structural capability decreased (from 0.151 to 0.128), cultural capability decreased (from 0.165 to 0.133), and process capability decreased (from 0.192 to 0.165), respectively.

This implies that SCM practices partially mediate the relationship between technological and process capabilities and firm performance, supporting *H1a*, *H1d*, *H2a*, *H2d* and *H3*. The results also show that the adoption of SCM practices does not affect the relationship between structural and cultural capabilities and firm performance (*H2b* and *H2c*). The direct impact of structural and cultural capabilities on firm performance is, however, evident from models 2 and 3 (*H1b* and *H1c*). This is consistent with the literature that suggests that optimization of knowledge sharing within a functional area can many times suboptimize the sharing of knowledge across the firm (O'Dell and Grayson, 1998). Taken to a larger level, the optimization of knowledge sharing within the firm can suboptimize sharing across the supply chain. In essence, it is important that organizational structure be designed for flexibility and organizational culture be supportive of KM practices so that they encourage sharing and collaboration within the organization and across the supply chain.

Phase three analysis

To provide further support for the hypotheses tested in the second phase, we conducted path analysis to predict the parameter estimates of the hypothesized model. Path analysis is a special case of structural equation modeling. It provides the structural model, but not the measurement model. In this paper, the primary interest was to find out the causal relationship between the theoretical variables, rather than the mapping of measures onto the theoretical constructs. Hence, the path model was used.

Standardized parameter estimates for the paths from technological capability ($\beta = 0.18$) and process capability ($\beta = 0.23$) to SCM practices were statistically significant ($\alpha = 5$ percent), providing further support for hypotheses *H2a* and *H2d* (Figure A2 in Appendix 1).

There was insufficient evidence to support *H2b* and *H2c* due to insignificant path coefficients between structural and cultural capabilities with SCM practices. The standardized parameter estimates for the paths between technological and process capabilities with firm performance ($\beta = 0.16$ and $\beta = 0.19$, respectively) were statistically significant, providing further support for *H1a* and *H1d*. Similarly, the standardized parameter estimates for the path from structural capability to firm performance ($\beta = 0.27$) and from cultural capability to firm performance ($\beta = 0.35$) were statistically significant, providing additional support for *H1b* and *H1c*. Support for *H3* exists by virtue of the significant path coefficient from SCM practices to firm performance ($\beta = 0.13$).

Discussion

The significant path relationships for technological and process capabilities show that these dimensions of KM capabilities have both direct and indirect effects on firm performance. A primary reason is that technologies (i.e. IT or other forms of electronic linkages) provide a mechanism for transferring knowledge and information, and eliminating physical distance barriers. These "electronic communication effects" are closely related to the process capability of KM; Nonaka (1994) has coined this as the "knowledge creation cycle". The operational perspective of the knowledge creation cycle is positively related to firm performance, e.g. through the externalization process, tacit knowledge is transformed into explicit knowledge by individuals; through the socialization process, knowledge is transmitted to others and, after a successful conversion process, knowledge of the individuals will be exchanged, shared, combined and eventually developed into value-added elements for the firm (Nonaka, 1994). Organizations attempting to nurture effective technological and process (operational) KM capabilities should not overlook the important role of effectively managing the supply chain.

Internally executed practices of knowledge sharing, application, mapping, etc. that are reflected in programs such as concurrent engineering and value analysis, can positively impact development efforts and thereby performance. However, new technologies are emerging which may require specialized knowledge and expertise, as well as significant capital investment and willingness to assume risk. In addition, increased customer expectations and shorter lead time requirements for any product or service have made it difficult for firms acting on their own to remain competitive. They are therefore reliant on the active participation of members in the supply chain and this implies a need to develop relationships with chain members with the requisite knowledge. Alignment of knowledge and expectations in the supply chain affects firm performance to a certain extent as organizations cannot rely solely on their internal capabilities.

The results do not indicate a significant relationship between structural and cultural capabilities and SCM practices, but suggest that these two dimensions affect firm performance directly. A possible explanation for this surprising finding is that the measures used to assess structural and cultural capabilities relate to internally focused initiatives and do not explicitly address boundary spanning relationship building such as strategic supplier partnership and customer relationship. As such, the results should not be interpreted as suggesting that firms should focus only on internal structural and cultural capabilities. Prior research has suggested that strategic alliances among supply chain partners can have positive impact on performance (Dyer and Nobeoka, 2000; Dyer, 1997). These strategic relationships are the succedents of a supportive culture and flexible structure of organizations that encourage sharing of knowledge

from different perspectives. For example, Toyota's knowledge-sharing network represents a good example of a supportive culture and structure; through this network, the suppliers were able to involve highly in interaction and learning, thus it developed a dynamic learning capability that embodied trust, collaboration, openness and problem solving.

Implications of research and limitations

This study provides empirical support for the central thesis that there exist linkages between KM, SCM and firm performance. The relationship is that SCM practices mediate the impact of KM capabilities on performance. This is consistent with the resource- and competence-based views of the firm as they relate to firm success. SCM practices allow organizations to take advantage of their internal capabilities (e.g. knowledge) by leveraging the expertise and cooperation of key members in 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 because it helps managers to recognize how to better leverage internal capabilities by exploiting relationships with supply chain partners, and it highlights the need to hone these capabilities prior to focusing on the extended enterprise.

To understand how to better manage knowledge in the supply chain context, one has to understand how knowledge impacts the SCM practices. From the results, technological and process capabilities are the two major dimensions of KM capabilities that affect the SCM practices. The impact of these dimensions can be viewed in this way. With high technological and process capabilities, KM enables the sharing of knowledge among the employees of the organization and between the organizations for creating more values to the customers. These capabilities help in building close long-term relationships among the supply chain partners by integrating them in the knowledge development cycle which in turn will be helpful in increasing the efficiency and effectiveness of the chain. They may also enhance SCM effectiveness through inter-organizational relationships which are crucial for innovation and competitiveness (Hult *et al.*, 2004). By leveraging these knowledge capabilities in the supply chain, they help in coordination efforts to synchronize and orchestrate (align) the flow of knowledge to reduce the bullwhip effect and to create value-added products or services to customers.

Another interesting point gleaned from the results is that the measures developed in this research exhibit good qualities of reliability and validity and provide a useful tool for further inquiry into the capability perspective of KM. The results also suggest that managers must first understand the underlying knowledge capability of their firm before setting milestones or expectations for their KM effort. The findings also provide some insights for determining the disposition of a firm to leverage existing knowledge. As implied in the results, rather than focusing the effort entirely on one particular dimension, e.g. process – creating an environment for knowledge sharing, a more successful approach may be to invest in change efforts along both dimensions (i.e. infrastructure and process or operation). As demonstrated in the study, both infrastructure and process capabilities predict performance. Therefore, managers should be careful not to optimize one aspect of KM because this may suboptimize the entire effort (Wong and Aspinwall, 2004). Davenport *et al.* (1998) highlighted that the tendency to optimize one aspect of KM projects can cause them to produce detrimental effects in customer service and innovation.

This study has also provided important insights into how KM and SCM complement each other in the context of strategic management (i.e. firm performance).

Strategic management is a discipline that concentrates on identifying, explaining and predicting the determinants of organizational performance. Its central thrust is to determine "why do some companies outperform others?" (Ketchen Jr and Giunipero, 2004; Meyer, 1991). While psychological research emphasizes the role of individuals and organizational theory focuses on firm-level factors in shaping success, this study has adopted a more encompassing approach that incorporates both intra- and inter-organizational issues to answer the question above. Some scholars also often argue that KM and SCM have "bottom-line" impact, but the justification for such a relationship is predominantly based on assertions rather than empirical studies. This research has statistically and empirically shown that the effective management of knowledge and supply chain is linked with improved firm performance (the ultimate quest of strategic management), if not inseparable. As such, KM and SCM would be best treated as a strategic rather than operational issue. Arguably, increased interaction between these two areas will enhance knowledge development in mainstream management, and this will lead to improved convergence among them over time.

Some of the limitations of this study are as follows. The proposed model does not consider firm performance from multiple perspectives, e.g. it does not consider market structure from industrial organization literature, ownership structure from finance literature, or corporate governance from organizational behavior literature. The use of longitudinal data would be more useful compared to a snapshot of data to examine how the changes in certain variables affect performance. A lagged relationship between variables over time may help to pinpoint causation in the model.

In addition, future research can investigate how SCM practices in different countries and settings (e.g. supply chain structure, supply chain length, etc.) affect the relationship. Specifically, organizations in a supply chain could be separated geographically in different locations or countries, and each of them could have disparate institutional and cultural values, which in turn may influence their collaborative KM capabilities. For example, Li and Scullion (2006) postulated that geographical, institutional and cultural features have a bearing on cross-border knowledge building and sharing. Likewise, Huang *et al.* (2008) found that certain distinct cultural factors in a specific country (China) are positively correlated with KM capabilities. Hence, it will be intriguing to examine the impact of these supply chain situational factors (geographical, organizational and cultural) on KM capabilities and firm performance.

Conclusions

With a greater emphasis on SCM and KM, there is a growing need to investigate the relationships between these two approaches towards firm performance. For the purpose of investigating these relationships, a comprehensive, valid and reliable instrument for assessing the key attributes was developed. The instrument was tested using a three-phase statistical analysis which comprised phase one (convergent validity, reliability and discriminant validity), phase two (mediated regression analysis) and phase three (path analysis). This study contributes to the management theory and literature by providing empirical evidence regarding the impact of SCM practices on KM and firm performance. This is considered as a vital contribution since after all, the ultimate aim of management is to improve firm performance.

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Appendix 1

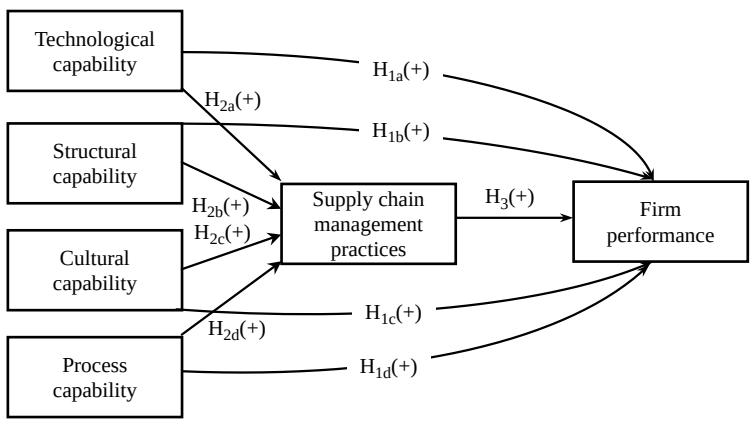

Figure A1.
Proposed research model

Latent constructs	Structural capability	Cultural capability	Process capability	SCM practices	Firm performance
Technological capability	0.356	0.388	0.201	0.345	0.415
Structural capability	–	0.492	y0.303	0.259	0.363
Cultural capability		–	0.235	0.366	0.215
Process capability			–	0.421	0.298
SCM practices				–	0.389

Note: All coefficients significant at $\alpha = 5$ percent

Table AI. Correlation matrix of the six latent constructs – KM capabilities, SCM practices and firm performance

Latent constructs	Technological capability	Structural capability	Cultural capability	Process capability	SCM practices	Firm performance
Technological capability	–	0.127	0.150	0.040	0.119	0.172
Structural capability			0.242	0.092	0.067	0.132
Cultural capability				0.055	0.134	0.046
Process capability					0.177	0.089
SCM practices						0.151
Average variance extracted (AVE)	0.650	0.643	0.597	0.636	0.397	0.525
Cronbach's α	0.853	0.753	0.7873	0.821	0.732	0.705
Composite reliability	0.789	0.708	0.780	0.825	0.753	0.686

Notes: Acceptable level: AVE ($\geq$0.50), Cronbach's α ($\geq$0.60) and composite reliability ($\geq$0.70)

Table AII. Squared correlation values, reliabilities and average variances extracted

Fit indices	Values	Acceptable level
RMSEA	0.035	$\leq$ 0.07
NFI	0.98	$\geq$ 0.95
GFI	0.99	$\geq$ 0.95
AGFI	0.95	$\geq$ 0.95
CFI	0.98	$\geq$ 0.95

Table AIII. Values of the fit indices

Predicted antecedents (KM capabilities)	Model 1 SCM practices	Model 2 Firm performance	Model 3 Firm performance
(a) Technology	0.185 *	0.130 *	0.121 *
(b) Structure	0.077	0.151 *	0.128 *
(c) Culture	0.095	0.165 *	0.133 *
(d) Process	0.230 *	0.192 *	0.165 *
Adoption of SCM practices			0.090 *
F	25.19 *	31.28 *	25.12 *
R^2 (%)	15.80	18.30	19.10
Adjusted R^2 (%)	15.50	17.92	18.25
ΔR^2			0.008 *
ΔF			2.274 *

Note: *Parameters/coefficients statistically significant at $\alpha = 5$ percent

Table AIV.
Mediated regression analysis

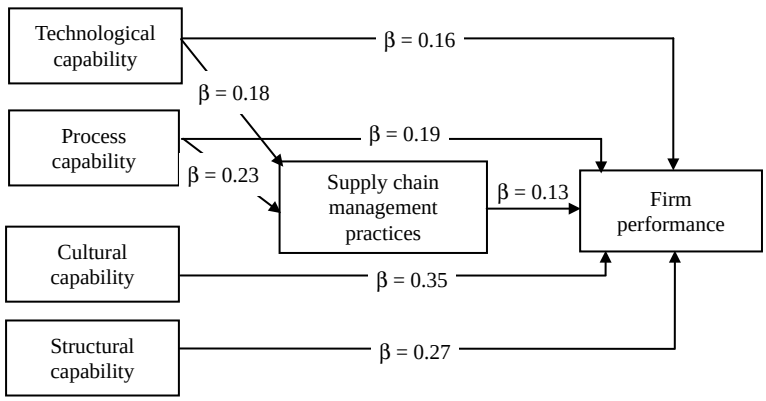

Figure A2.
Path model

Appendix 2

Variable name	Item
My organization [. . .]	
TI1	Has clear rules for formatting or categorizing its product knowledge
TI2	Has clear rules for formatting or categorizing process knowledge
My organization uses technology that allows [. . .]	
TI3	It to monitor its competition and business partners
TI4	Employees to collaborate with other persons inside the organization
TI5	Employees to collaborate with other persons outside the organization
TI6	People in multiple locations to learn as a group from a single source or at a single point in time
TI7	People in multiple locations to learn as a group from a multiple source or at multiple points in time
TI8	It to search for new knowledge
TI9	It to map the location (i.e. an individual, specific system or database) of specific types of knowledge
TI10	It to retrieve and use knowledge about its products and processes
TI11	It to retrieve and use knowledge about its markets and competition
TI12	Generate new opportunities in conjunction with its partners

Table AV.
Item measures for KM technological infrastructure

Variable name	Item
My organization ('s) [. . .]	
SI1	Structure[a] of departments and divisions supports interaction and sharing of knowledge
SI2	Structure promotes collective rather than individualistic behavior
SI3	Structure facilitates the discovery of new knowledge
SI4	Structure facilitates the creation of new knowledge
SI5	Bases our performance on knowledge creation
SI6	Has a standardized reward system for sharing knowledge
SI7	Designs processes to facilitate knowledge exchange across functional boundaries
SI8	Has a large number of strategic alliances with other firms
SI9	Encourages employees to go to where they need knowledge regardless of structure
SI10	Managers frequently examine knowledge for errors/mistakes
SI11	Structure facilitates the transfer of new knowledge across structural boundaries
SI12	Employees are readily accessible

Note: [a]Structure is defined as the rules, policies, procedures, processes, hierarchy of reporting relationships, incentive systems and departmental boundaries that organize tasks within the firm

Table AVI.
Item measures for KM structural infrastructure

Variable name	Item
In my organization [. . .]	
CI1	Employees understand the importance of knowledge to corporate success
CI2	High levels of participation are expected in capturing and transferring knowledge
CI3	Employees are encouraged to explore and experiment
CI4	On-the-job training and learning are valued
CI5	Employees are valued for their individual expertise
CI6	Employees are encouraged to ask others for assistance when needed
CI7	Employees are encouraged to interact with other groups
CI8	Employees are encouraged to discuss their work with people in other workgroups
CI9	Overall organizational vision is clearly stated
CI10	Overall organizational objectives are clearly stated
CI11	Shares its knowledge with other organizations (e.g. partners, trade groups)
CI12	The benefits of sharing knowledge outweigh the costs
CI13	Senior management clearly supports the role of knowledge in our firm's success

TableAVII.
Item measures for KM cultural infrastructure

Variable name	Item
My organization [. . .]	
PC1	Has processes for acquiring knowledge about our customers
PC2	Has processes for acquiring knowledge about our suppliers
PC3	Has processes for acquiring knowledge about new products/services within our industry
PC4	Has processes for acquiring knowledge about competitors within our industry
PC5	Has processes for converting knowledge into the design of new products/services
PC6	Has processes for converting competitive intelligence into plans of action
PC7	Has processes for transferring organizational knowledge to individuals
PC8	Has processes for absorbing knowledge from individuals into the organization
PC9	Has processes for applying knowledge learned from experiences
PC10	Has processes for using knowledge in development of new products/services
PC11	Has processes for using knowledge to solve new problems
PC12	Has processes to protect knowledge from inappropriate use inside the organization
PC13	Has processes to protect knowledge from inappropriate use outside the organization
PC14	Has processes to protect knowledge from theft from within the organization
PC15	Has processes to protect knowledge from theft from outside the organization

Table AVIII.
Item measures for KM process capability

Variable name	Item
In my organization [. . .]	
SCM1	We use formal information sharing with suppliers and customers
SCM2	We seek new ways to improve integration of activities across the supply chain
SCM3	We deliver customers' orders on time
SCM4	We always aim to reduce response time across the supply chain
SCM5	We communicate customers' future strategic needs throughout the supply chain

Table AIX.
Item measures for SCM practices

Variable name	Item
Over the past two years, my organization has improved its [. . .] compared to its major competitors	
F1	Market share
F2	ROI assets
F3	Overall product quality
F4	Overall competitive position
F5	Overall customer service level

Table AX.
Item measures for firm performance

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