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Implementing Inter-Organizational Knowledge Collaboration to Improve Supply Chain Performance

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Abstract

With the trend of globalization, increased customer demand and advancement in technology development, firms are seeking to collaborate with their trading partners to manage supply chain knowledge for competitive advantages. This study follows the research stream of Tornatzky and Fleisher (1990), Rogers (1995), and Iacovou et. al. (1995) to empirically analyze the drivers of Collaborative Knowledge Management Practice (CKMP) and the impact of implementing CKMP on knowledge quality and supply chain performance. The results would advance our understanding to inter-firm knowledge collaboration and provide firms with guidance to implement CKMP.

Keywords: Knowledge management; supply chain management; collaborative system

1. Introduction

In the dynamic post-industrial environment, characterized by global competition, changing customer demand, shorter product life cycles, increased market diversity, and rapid advancement in technology (Doll and Vonderembse, 1991), firms are left with no choice but to become more responsive to various external and internal changes. As firms are diving into a new wave of outsourcing key business functions to unprecedented number of trading partners, it is an overwhelm challenge to manage such complex cross functional collaboration in the supply chain. The traditional information-sharing systems, such as EDI and ERP, become increasingly powerless to address these new challenges of post industrial supply chain relationship management, because these IT systems are not equipped to sufficiently process the large volume of context-rich contents from cross functional collaboration, store and transmit tacit and experiential organizational knowledge in inter-firm work process flow. To maintain long-term competitiveness, a new set of practices must be introduced to manage supply chain knowledge assets as strategic resources, and to facilitate inter-firm collaborative decision making, so that trading partners can integrate their operations and compete as a team with other supply chains.

The supply chain knowledge can be defined as the collection of understandings, insights, and expertise supply chain partners possess regarding their markets, products technologies, and organizational structures that would contribute to the achievement of supply chain objectives (Civi, 2000). Knowledge sharing in supply chain is not a new concept in the literature. Several studies analyzed with various way of classification the type of knowledge assets being shared between supply chain partners (e.g. Pakstas, 1999; Holland, 1995; Hult et al, 2004). Lin et al (2002) also confirmed extensive amount of knowledge is exchanged across organizational boundaries in all six functional linkages of typical manufacturing supply chains.

Some other researchers (e.g. Mansell and Wehn, 1998; Skakkas et al. 1999; Cormican and O'Sullivan, 2003; Hult et al., 2004) approach supply chain knowledge by analyzing its implication to firm performance. It has been generally agreed upon that firms have no choice but to share organizational knowledge with trading partners, and the entire supply chain does benefit from knowledge collaboration in terms of end product quality improvement, time to market reduction, firm innovativeness, and transaction process optimization etc.

Despite the research community's continuous interest in supply chain knowledge collaboration, there are only studies which are either purely conceptual or fragmented in scope. The literature lacks comprehensive research work to empirically observe the inter-firm knowledge management behaviors, until Li, Rao and Tarafdar (2008) proposed a new concept, collaborative knowledge management practice (CKMP), to capture the specific organizational activities for supply chain knowledge collaboration. The study followed the popular knowledge process perspective (e.g. Lee and Yang, 2000; Alvai and Leidner, 2001; Cormican and O'Sullivan, 2003;

Gunasekaran and Ngai, 2006; Kumar and Thondikulam, 2005-2006) to indentify knowledge management activities in the entire knowledge life cycle and defined CKMP as the organizational undertaken of collectively generating, storing, accessing, disseminating and applying knowledge assets across organizational boundaries to achieve the business objectives of the entire supply chain. The purpose of CKMP is to facilitate intra and inter organizational knowledge management activities and to leverage knowledge assets collaboratively with supply chain partners.

The current study is to extend the Li, Rao and Tarafdar (2008) study and to answer the question about when organizations should get involved in knowledge collaboration with supply chain partners by exploring the adoption antecedents for collaborative knowledge management practice (CKMP). We will also examine the potential performance improvements that can be achieved from CKMP for the entire supply chain.

2. Theoretical Framework and Research Hypotheses

CKMP is fundamentally changing the philosophy of managing organizational knowledge assets. It is a business process reengineering that innovates the way organization communicates with supply chain partners. To study the drivers of CKMP, we conducted literature review based on theories and frameworks that explore technology adoption and innovation.

Many of the technology adoption studies (e.g. Agarwal and Prasad 1999, Pick and Roberts 2005, Verhoef and Langerak 2001, and Venkatesh and Davis 2000) were built on Rogers's (1995) diffusion of innovation theory (DOI), which is concerned with the manner in which a new technological idea, artifact, or technique migrates from creation to use, and describes the patterns of adoption, explains the mechanism of diffusion, and assists in predicting whether and how a new invention will be successful (Hsu et al 2006). Rogers (1995) argued that a firm's adoption and use of innovations was influenced by both the characteristics of such innovation (e.g. relative advantage, compatibility, complexity, trialability, and observability) and organizational characteristics (e.g. centralization, formalization, interconnectedness).

To explain a firm's decision-making process for technological innovation, Tornatzky and Fleisher (1990) proposed the Technology, Organization and Environment (TOE) model. Besides technology and organizational characteristics that had been included in DOI, Tornatzky and Fleisher (1990) recognized the important role of environmental factors such as industry characteristics, organizational infrastructure that support the technology innovation, and relevant government regulations. These factors are very critical in today's competitive business environment, because they pose as both constraints and opportunities for new technology implementation. However, one of the limitations of TOE framework was that it only covers within-a-firm innovation diffusion.

While studying seven firms adopting EDI to collaborate with their trading partners, Iacovou et al. (1995) re-organized the factors of TOE model into in three different categories and added an impact construct to study the consequences of the innovation. As illustrated in figure 1, Iacovou et al's (1995) argued that IT system adoption had three antecedents: 1) organizational readiness: a firm must make strategic and structural preparations for substantial organizational changes coming from adopting a new technology. 2) Perceived system benefit: the firm must be able to clearly identify justifiable direct the potential benefits of the new technology before making serious commitment to the adoption. 3) External pressure is the contextual drivers that push the firm to adopt the new technology. For example, a firm will undoubtedly adopt EDI when its critical trading pattern postulates that EDI is the only way of transaction.

Although the original model by Iacovou et al (1995) was first tested in the context of EDI adoption, a considerable number of studies have applied it to other technologies, including: e-commerce (Chen, Gillenson, & Sherrell, 2002; Koufaris, 2002), digital libraries (Hong, Thong, Wong, & Tam, 2002), tele-medicine technologies (Hu, Chau, Sheng, & Tam, 1999), smart cards (Plouffe, Hulland, & Vandenbosch, 2001), and building management systems (Lowery, 2002). This model is essentially a generic extension to the theory of technology diffusion; it is thus appropriate to use it to analyze the adoption of other technology based process innovation.

Swanson (1994) classified IS innovations into three types: Type I are technical task only innovations; Type II innovations support business administration; and Type III innovations are embedded in the core of the business. According to this typology, CKMP with trading partners should be considered as a Type III innovation, because

CKMP innovate a firm's core business processes – leveraging two-way communication to improve product offering and customer service. Swanson (1994) further examined the adoption contexts of each innovation type, and contended that typical Type III innovations often requires antecedents such as facilitating technology portfolio, certain organizational attributes, perceived benefits, and external drivers that initiate the firm to adopt such innovation. This theoretical argument can be extended to knowledge management and supply chain management domain: CKMP is being enabled by information and communication technology development, requires organizational enablers, motivated by the potential benefits, and entails environmental drivers of the supply chain context. Thus, upon theoretically examining adoption contexts, innovation types, and CKMP features, we believe that the three contexts in the organizational technology adoption model are well suited for studying CKMP adoption and implementation.

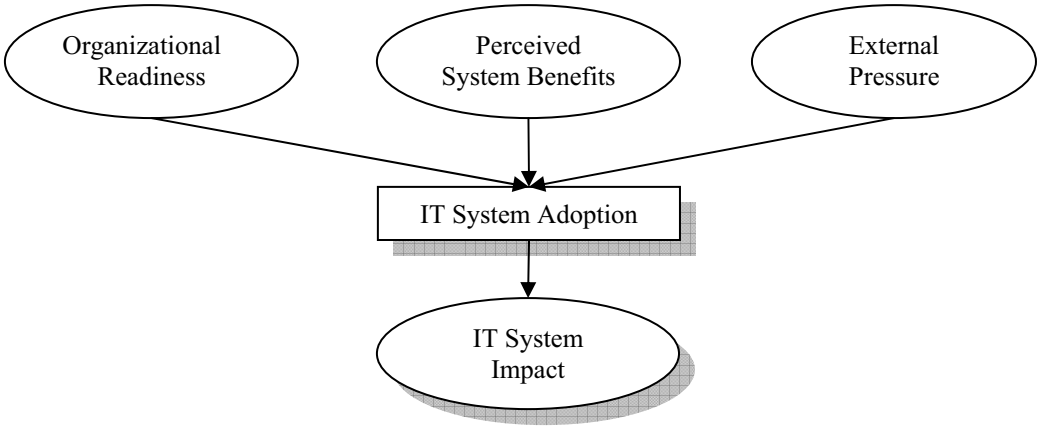

Figure 1 Organizational Technology Adoption Model by Iacovou et. al.

The three organizational technology adoption model antecedents are explored in our model as follow:

- Perceived benefits/relative advantage – expectations of advantages or opportunities reflected by operational and performance improvements related to the adoption of the technology system, such as improved knowledge management operational efficiency, innovation, integrated supply chain relationships.

- Organizational characteristics – We approach this issue from two perspectives: technological Infrastructure looks at the technological preparation of the firm for CKMP implementation; organizational infrastructure studies the whether the firm is structurally and culturally ready for CKMP adopting and implementation.

- External influences – Grandon and Pearson (2004) summarized the technology adoption literature and found that external influences are fairly consistent across different studies. Three dimensions of external influences are identified in our study: environmental characteristics look at factors such as environmental uncertainty, trading partner readiness and perceived external competitive pressure. Knowledge compelmentarity studies the perceived importance and difference of trading partners' knowledge bases. Partner relationship is about the nature of relationship in supply chain (i.e. long term vs. one time partners).

Compared with other IS innovation, CKMP implementation is unique in that it cannot be adopted and used unilaterally. Firms that are motivated to adopt CKMP must either find similarly motivated partners, or persuade their existing market partners into adopting the practice. Moreover, even after CKMP has been adopted, firms must continue making sure the above-discussed antecedents still hold to maintain collaborative relationship with partners in KM to gain sustainable benefits.

Thus, our research will emphasize the implementation process of CKMP by limiting our subject of study to those firms that have already adopted CKMP and explore how these antecedents will facilitate CKMP and what organizational impact CKMP can bring to the supply chain.

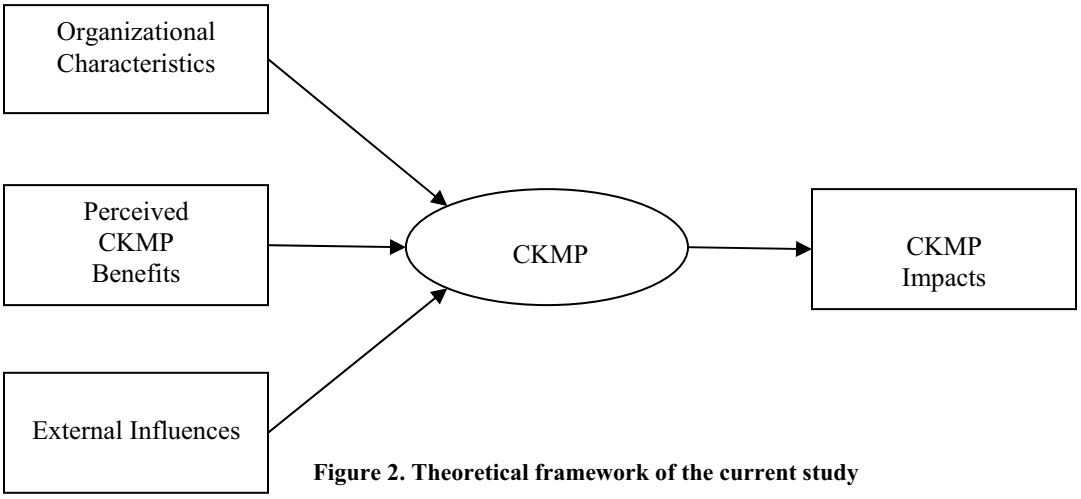

Figure 2. Theoretical framework of the current study

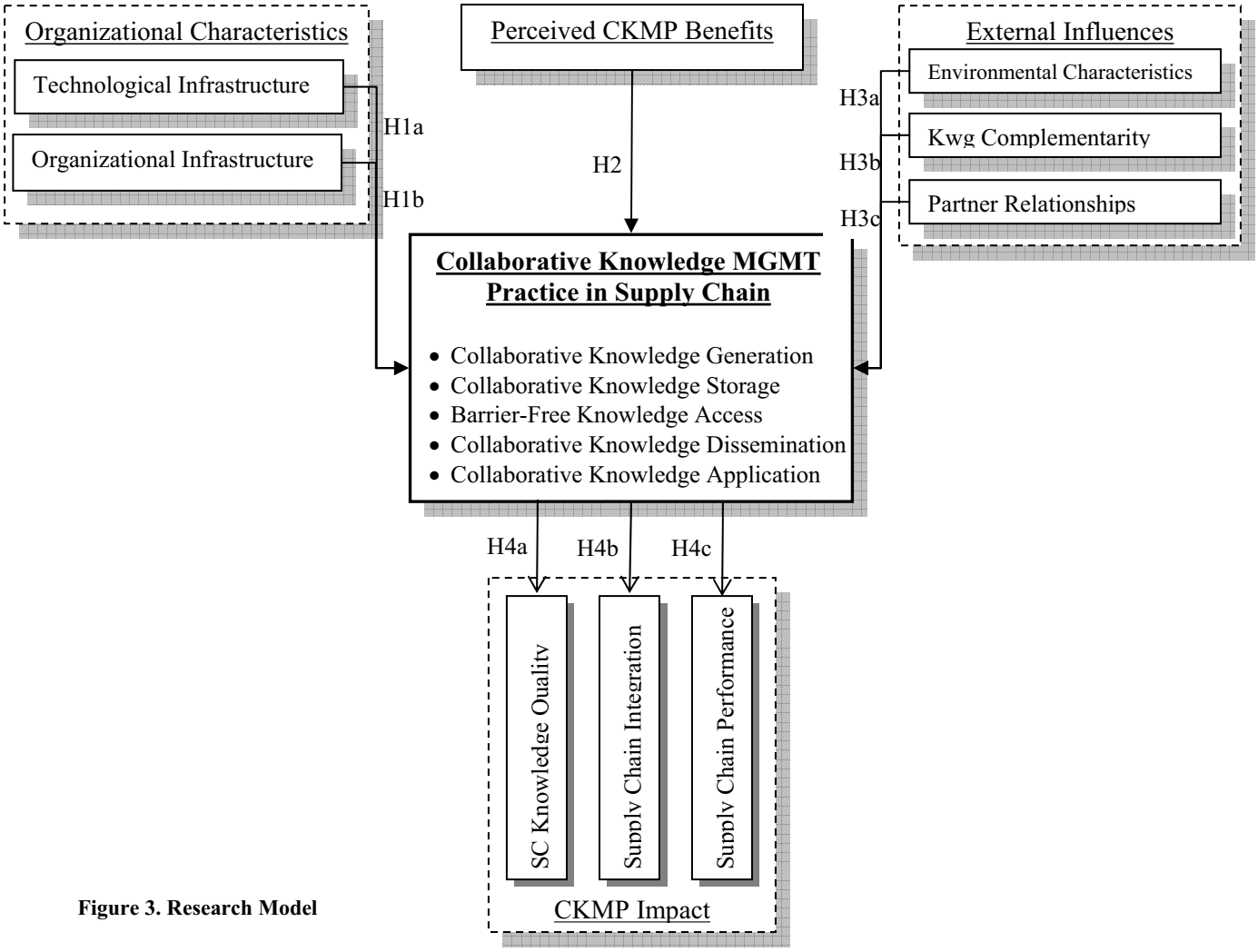

Figure 3. Research Model

3. Research Methodology

Survey research method was used in this study. Since our research framework includes several new constructs that had not been measured in the existing literature, we have to create instruments for these constructs, and validate the measurement model before evaluating the structural model. These new constructs include: 1) collaboration supportive culture (sub-construct of Organizational Infrastructure), 2) employee empowerment (sub-construct of Organizational Infrastructure), 3) Perceived CKMP benefits, 4) partner readiness for CKMP (sub-construct of Environmental Characteristics), 5) knowledge complementarity, 6) CKMP, 7) Supply chain knowledge quality. All other constructs are measured with instruments verified in previous research by Li (2002, 2006) and Narasimhan and Kim (2002).

Items for the new constructs were created based on extensive literature review. Then 4 professors with expertise in knowledge management, supply chain management and manufacturing management from two state universities in the US were invited to review and critique the face validity, item brevity and understandability. After a few minor revisions based on their feedback, the items were submitted to 3 pairs of supply chain professionals from a multinational manufacturing company for pre-test study. A "Q-Sort" methodology was applied in the process, where in each round, a pair of the professionals (as judges) was asked to sort from the pool of all items into different construct categorizes. Their sorting results were compared and evaluated with the inter-judge agreement level, Moore and Benbasat's hit ratio (Moore and Benhassat 1991) and Cohen's Kappa (Cohen 1960). The process resulted in the deletion of 1 item and revision of another 4. The final round demonstrated superior content validity of each of the 7 new constructs (inter judge agreement ratio = 94%; Moore and Benbasat's hit ratio = 93%; and Cohen's Kappa Coefficient = .91).

The large scale survey was administered to 4,049 procurement/materials/supply chain/operations vice-presidents, directors and managers, whose names were obtained from CSCMP member database and a mailing list purchased from RSATeleservices.com. After 2 rounds of individualized emails to our targeted respondents, 411 valid responses were collected, yielding a response rate of 11.6%, which was considered acceptable for email surveys (Dillman 2000). Based on Chi-square comparison on firm and demographic characteristics of the responses from the first and second emails, no response bias was detected.

Table 1. Research hypotheses

H1a	Technological infrastructure has direct and positive relationship with collaborative knowledge management practice in supply chain.
H1b	Organizational infrastructure has direct and positive relationship with collaborative knowledge management practice in supply chain.
H2	Perceived CKMP benefits have direct and positive relationship with collaborative knowledge management practice in supply chain.
H3a	Environmental characteristics have direct and positive relationship with collaborative knowledge management practice in supply chain.
H3b	Knowledge complementarity has direct and positive relationship with collaborative knowledge management practice in supply chain.
H3c	Partner relationship has direct and positive relationship with collaborative knowledge management practice in supply chain.
H4a	Collaborative knowledge management practice in supply chain has direct and positive relationship with the quality of supply chain knowledge.
H4b	Collaborative knowledge management practice in supply chain has direct and positive relationship with supply chain integration.
H4c	Collaborative knowledge management practice in supply chain has direct and positive relationship with supply chain performance.

Among the 411 responses, 323 were from organizations that had already adopted CKMP. Their answers were used for further instrument validation and structural model evaluation. The instrument refining processes for the 7 new constructs involved the assessment of 4 measurement parameters: 1) the dimension level item-total correlation (CITC) scores and Cronbach's alpha; 2) the dimension level exploratory factor analysis; 3) the construct level confirmatory factor analysis; 4) the final Cornbach's alpha reliability coefficients. Several items were dropped from the instrument in the purifying process. The final sets of measurement items for each constructs demonstrate satisfactory reliability and discriminate and convergent validity.

Because of its rigorous power to test a set of inter-related relationships simultaneously, path analysis within the LISREL structural equation modeling (SEM) framework was used to test the hypotheses of the current study. Our study displays very good structural model fit. For Overall Fit Measures, **Goodness-of-Fit Index (GFI)** equals .92, **chi-square/degree of freedom (χ^2 / df)** is 2.86, and **Root Mean Square Residual (RMSR)** yields a value of .044, all well within the suggested cut-off values according to Segars and Griver (1993) (GFI > 0.90), Carmines and McIver (1981) (χ^2 / df < 3), and Joreskog and Sorbom (1984) (RMSR < .05). For Comparative Fit Measures, the model's **Normed Fit Index (NFI)** equals .91, larger than recommended value of 0.90 (Hair et al., 1992). For Parsimonious Fit Measures, **Adjusted Goodness-of-Fit Index (AGFI)** was used to relate goodness-of-fit of the model to the number of estimated coefficients required to achieve such level of fit. The model AGFI also demonstrates satisfactory value (0.90), according to Segars and Griver (1993) (AGFI > 0.80). As illustrated in Table 3, out of the 9 hypothesized relationships, 7 but 2 were found significant at the 0.05 level.

4. Discussions of Structural Modeling and Hypotheses Testing Results

The significant relationships hypothesized in H1a and H1b confirmed the instrumental roles of technology tools as well as organizational factors. Undoubtedly, information systems including communication support system, collaborative system, knowledge management databases, enterprise information portal, and decision support systems function as infrastructural enablers for CKMP. Firms interested in adopting CKMP must invest in putting up these systems and commit themselves to the usage of the systems through extensive organizational planning and employee training.

CKMP involves revolutionizing the traditional way of handling organizational knowledge. From organizational behavior perspective, the initiation of adopting CKMP can be regarded as a large-scale organizational change. As what is argued by Wyer and Mason (1999), managing an organization is a people business. H1b indicated that support from top management, a positive organizational culture favoring supply chain collaboration, and employee empowerment were all critical factors in pushing through such organizational change.

Out of the researcher's expectation, the construct of perceived benefits was not found as a significant antecedent for CKMP (H2). The result demonstrated the dynamic nature of organization's perception at different stage of implementing CKMP: during initial decision-making stage, firms could get obsessed with the power of CKMP and over estimate its potential benefits. After making huge investment and commitment to CKMP, it was possible that these firms may find CKMP was not as omnipotent as they had expected to solve all of their business problems, particularly during the initial implementation stage when the system had not been stable and users were at the beginning of a learning curve for using CKMP. All of our respondents in the current study were firms that had already involved in CKMP. Their sense of disappointment could be exaggerated in answering survey questionnaire. The other possible reason for the non-significant relationship in H2 may due to our respondent's role in supply chain. A considerable numbers of our respondents were medium sized non-supply chain master organizations. As indicated in the comments section of our questionnaire, they cited a major reason for their CKMP adoption was the pressure from their major trading partners (supply chain master). They were forced to implement CKMP in order to maintain partnership with the supply chain master, thus less likely to take CKMP benefits seriously.

Table 3. Hypotheses testing results

Hypotheses	Relationships	Standardized Estimate	t-value	Significant?
H1a	TI → CKMP	.53	6.95	Yes
H1b	OI → CKMP	.51	3.35	Yes
H2	BF → CKMP	.18	.72	No
H3a	EC → CKMP	.33	3.72	Yes
H3b	KC → CKMP	.57	3.32	Yes
H3c	PR → CKMP	.24	1.02	No
H4a	CKMP → KQ	.83	10.29	Yes
H4b	CKMP → SI	.76	8.86	Yes
H4c	CKMP → SP	.45	6.15	Yes

GFI = .92, χ^2 / df = 2.86, RMSR = .044, NFI = .91, AGFI = .90

All t-values are significant at .05 level (t>1.65 at one tail test), if not otherwise noted.

Contextual factors are often get ignored by many managers in adopting a new technology or implementing other organizational change. The confirmed positive relationships hypothesized in H3a, and H3b could raise the awareness of structurally evaluating environmental factors when planning to adopt CKMP. The current study demonstrated that in a more uncertain business context, or when experiencing pressure from trading partners and/or competitors to implement CKMP, firms are more likely to collaborate with other firms for knowledge management. There was direct and positive relationship between partner readiness and CKMP, indicating that CKMP was a multi-party attempt. Partner firms' preparation could impact the ease of adopting CKMP and the effectiveness of implementing CKMP. Firms should also evaluate the knowledge portfolio of their own and that of their supply chain partners'. The current study found that partner firms' organizational knowledge must supplement with each other with considerable degree of difference to motivate knowledge exchange, as well as with considerable degree of overlap so that knowledge users from different firm could share the same foundation to understand each other.

The study did not find the nature of partner relationship in supply chain a significant factor in CKMP adoption (H3c). Theoretically, an organization should not implement CKMP with every single supply chain it involves, but only with those that have strategic importance. Similar results were indicated in other studies (e.g. Ibbott and Keefe 2004; Finnegan et al. 1998) that firm relationship was positively related to inter organizational systems like CKMP. Our contradictory result may again due to the large number of non-supply chain master respondents of the current study. When an organization is force by a supply chain partner to commit to an expensive and demanding system, it is less likely that the organization would take a positive attitude toward the relationship with the one that over-shadows it. More studies with more data are required to further analyze this hypothesized relationship.

Performance consequences of CKMP were also examined in this study. Our result confirmed that by implementing CKMP, firms could improve the quality level of their supply chain knowledge (H4a). With full scale collaboration in all knowledge management activities, organizations can generate more knowledge with high accuracy, completeness, and timeliness, store and disseminate knowledge quicker and in a cost effective manner. The result justified the considerable resources and efforts that organizations must devote to adopt and implement CKMP. In dynamic business world, organizations equipped with high quality and easy to use supply chain knowledge can

afford themselves with unique competitive edge, such as better understanding to market change and agility to make adjustments accordingly.

The ultimate objective of all supply chain management activities is to improve the supply chain relationship as well as enhance its performance. H4b was found to be significant with high strength (t-value = 8.86, β = .76), indicating the implementation of CKMP a powerful approach to strengthen relationship with key supply chain partners. CKMP is a relationship building process. By implementing CKMP, supply chain partners can encourage team work spirit and promote inter-firm communication and mutual trust. H4c demonstrated that CKMP had direct and tangible effects on improving supplier performance, system flexibility to internal and external changes, and responsiveness to customer requirements etc. Therefore, supply chain managers should regard knowledge collaboration as one of the approaches to beef up supply chain performance. The research results provide theoretical basis and empirical evidence to the management, who can take as a reference to persuade partner firms to jump on board or convince shareholders for the large investment required for implementing CKMP.

5. Research Contributions

In summary, this study represents a large-scale effort to systematically investigate the issue of supply-chain-wide knowledge collaboration. By linking two popular fields of supply chain management and knowledge management, the study has made a number of theoretical and practical contributions:

First, it provided a clear definition to collaborative knowledge management practice in supply chain and identified its five dimensions: collaborative knowledge generation, collaborative knowledge storage, barrier-free knowledge access, collaborative knowledge dissemination, and collaborative knowledge generation. As Roper and Crone (2003) argued that due to the lack of clear definition to supply chain knowledge collaboration, firms found it difficult to handle cross-boundary knowledge management, even if they had realized the tremendous potential of CKMP. This definition could contribute to better understanding to cross-boundary knowledge sharing transactions in supply chain environment. It opened a new research path in supply chain relationship management. The study could stimulate more research to be done on how trading partners collaborate to leverage knowledge assets for supply chain competitiveness.

Second, the study provides valid and reliable measurement instruments to a number of constructs. Scales for these constructs were vigorously tested through statistical analysis, thus were ready to use in future research. Practitioners can particularly benefit from the instrument for CKMP. The measurement items capture various activities associated with the entire life cycle of supply chain knowledge. Organizations can use the instrument to evaluate their knowledge collaboration activities, and to identify strength and weakness in knowledge management collaboration for performance improvement.

Third, the research investigated the critical roles of a number of organizational and contextual antecedents to CKMP. Future academic researchers can use them as basis to better understand the concepts of inter-firm knowledge collaboration behaviors in supply chain and further explore factors that would facilitate or inhibit those behaviors. Business practitioners can benefits from the results by planning an adoption roadmap to successfully implement CKMP in their organizations.

Fourth, the research reveals the direct results of CKMP. It confirmed the hypotheses that exerting efforts on implementing CKMP would reward organizations with higher knowledge quality, greater level of supply chain integration between internal functions and with customers and suppliers, as well as better supply chain performance in terms of supplier performance, market responsiveness, operation flexibility and partner quality. These findings would greatly stimulate and facilitate theory development in the fields of supply chain management and knowledge management.

References

[1] Alavi, M., & Leidner, D.E., "Review: knowledge management and knowledge management systems: conceptual foundations and research issues", *MIS Quarterly,* 2001, 25 (1), 107-136.

[2] Argote, L. & Ingram, P., "Knowledge transfer: a basis for competitive advantage in firms", *Organizational Behavior and*

Human Decision Processes, 2004, 82 (1), 150-69.

[3] Civi, E., "Knowledge management as a competitive asset: a review", *Marketing Intelligence and Planning*, 2000, 18 (4), 166-174.

[4] Hu, P. J., Chau, P. Y. K., Sheng, O.R.L., & Tam, K.Y. "Model using physician acceptance of telemedicine technology", *Journal of Management Information Systems*, 1999, 16(2), 91-112.

[5] Hult, G.T., Ketchen, D.J. and Slater, S.F., "Information processing, knowledge development, a strategic supply chain performance", *Academy of Management Journal*, 2004, 47 (2), 241-265.

[6] Iaconou, C., Benbasat, I., & Dexter, A., "EDI and small organizations: Adoption and impact of technology", *MIS Quarterly*, 1995, 12, 465-485.

[7] Joreskog, K.G. and Sorbom, D., *LISREL 7 Users' Reference Guide*. 1989, Scientific Software Inc., Chicago, IL.

[8] Li, Y, Tarafdar, M, & Rao, S.S. "Collaborative knowledge management in supply chains: practices and outcomes", *Journal of Operations Management*, 2008, forthcoming.

[9] Lin, C., Hung, H. C., Wu, J. Y. & Lin, B., "A knowledge management architecture in collaborative supply chain", *Journal of Computer Information Systems*, 2002, 42(5), 83-95

[10] Mansfield, E., Romeo, A. & Schwartz, M., "New findings in technology transfer, productivity and economic policy", *Research Management*, 1983, 26(2), 11-20.

[11] Meso, P. & Smith, R., "A resource-based view of organizational knowledge management systems", *Journal of Knowledge Management*, 2000, 4(3), 224

[12] Nonaka, I., Takeuchi, H., & Umemoto, K., "A theory of organizational knowledge creation", *International Journal of Technology Management*, 1996, 11(7/8), pp. 833-846

[13] Pfeiffer, H., *The Diffusion of Electronics Data Interchange*, 1992, Springer-Verlag, New York.

[14] Rogers, E. M., *Diffusion of Innovation*. 4th Edition, 1995, New York: Free Press.

[15] Roper, S. & Crone, M., "Knowledge Complementarity and Coordination in the Local Supply Chain: Some Empirical Evidence", *British Journal of Management*, 2003, 14(4), 339-355.

[16] Siemieniuch, C.E., & Sinclair, M.A., "A framework for organizational readiness for knowledge management", *International Journal of Operations and Production Management*, 2004, 24 (1/2), 79-98.

[17] Swanson, E. B., "Information systems innovation among organizations", *Management Science*, 1994, 40(9), 1069-1092.

[18] Tornatzky, L. G., & Fleischer, M., *The Process of Technology Innovation*, 1990, Lexington, MA: Lexington Books.

[20] Verhoef, P.C., & Langerak,. F., "Possible determinants of consumers, adoption of electronic grocery shopping in The Netherlands", *Journal of Retailing and Consumer Services*, 2001, 8, 275-285.