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Potential Complementary Knowledge, Collaborative Elaboration, and Synergistic Knowledge*

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Despite the importance of knowledge complementarities (KC) to firm performance, very little is known about exactly what constitutes KC and how synergistic knowledge is created in KC. This research looks into the dimensionality of KC and how synergistic knowledge as an essential component of KC is generated in a process innovation (PI) project. We propose that KC consists of potential complementary knowledge, collaborative elaboration (CE) process, and synergistic knowledge.

The model is investigated quantitatively, using a sample of 26 matched-pairs of client and consultant who participated in a PI project, and then qualitatively using interviews of a sub-sample of 7 matched-pairs of client and consultant. Data were collected in a longitudinal way at four different points during the four month project period. Results show that consultant's learning about the client's business occurs first and then client learning about IT capabilities follows through CE. With this enhanced clients' knowledge about IT capabilities, clients play an initiative role in designing the To-Be business processes, while consultants play a supporting role by introducing best practices or making suggestions based on their experiences. Future research implications as well as practical implications are also discussed.

Keywords : IS Management, Potential Complementary Knowledge, Collaborative Elaboration, Synergistic Knowledge, Process Innovation

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Ⅰ. Introduction

According to the resource-based view (RBV), resource complementarity is central to understanding why firms exist. Complementarity represents an enhancement of resource value and arises when a resource produces greater returns in the presence of another resource than by itself [Milgrom and Roberts, 1995]. Firms are superior to markets in managing complementary resources to foster cooperation and coordination within a team of resources and thereby producing greater returns. As an extension of RBV, the knowledge-based view of a firm treats knowledge as the firm's most strategically significant resource [Grant, 1996]. This perspective asserts that heterogeneous knowledge bases and capabilities among firms are the main determinants of sustainable competitive advantages and superior performance [Kogut and Zander, 1992]. Complementary knowledge can present opportunities for enhanced learning as well as for the development of new capabilities [Harrison *et al*., 2001].

Despite the central role of knowledge complementarities (KC) in firm performance, few researchers in management and information systems (IS) have examined, to date, the KC concept [for exceptions, see Tanriverdi, 2005; Tanriverdi and Venkatraman, 2005; Zhu, 2004]. Furthermore, in the few prior studies that included KC in their research design, the definition of the term has not been well articulated as a guide to subsequent research. Some researchers have used the term without defining it clearly [e.g., Antonelli, 2003; Roper and Crone, 2003]. Thus, very little is known about exactly what constitutes KC and how it is implemented.

The concept of KC is rooted in the economic theory of complementarities [Milgrom and Roberts, 1990, 1995]. Tanriverdi [2005] states that "a set of knowledge resources is defined to be complementary when doing more of any one of them increases the returns to doing more of the others. Jointly, a set of complementary knowledge resources produces greater returns than the sum of their individual returns" (p. 315). This statement indicates that an essential component of complementarities is the synergistic value that becomes feasible only when both complementary resources are present. For knowledge resources, organizations serve as mechanisms by which new synergistic knowledge is created from complementary knowledge. In addition, the definition implies that, in order to generate synergistic value, two components are necessary: (1) complementary resources that are used as "raw materials" to create synergistic value and (2) the interaction process among the complementary resources, which is ***time-consuming***. Therefore, we propose that KC consists of three components: (1) potential complementary knowledge; (2) the collaborative elaboration process; and (3) synergistic knowledge as a realization of potential complementarities.

Existing empirical studies on KC have treated it as a single construct [e.g., Tanriverdi, 2005], inclusive of multiple KC components such as complementary knowledge, the process dimension, and synergistic value. However, it would be difficult, if not impossible, to investigate KC if it is modeled as a single construct encompassing cause and effect variables in addition to the process. This is especially true when one of the components, e.g., synergistic value in KC, appears in different time-phases as a result of interactions among the other components of KC.

Furthermore, few studies have attempted to determine how synergistic value is created in KC. There is a distinction between the structural dimension, where complementary knowledge resources lead the participants to cooperate for economic purposes, and the process dimension, which seeks the potential gains from cooperation [Parkhe, 1991; Madhok, 1995]. The former has more to do with the choice of a partner, while the latter is crucial to the success or failure of the interactions between complementary knowledge resources [Tallman and Shenkar, 1994]. The significance of the process dimension underscores the importance of the quality of the interaction. Furthermore, it is important to recognize that the interaction process is not linear but circular in nature [Zajac and Olsen, 1993], containing feedback loops characterized by "a repetitive sequence of negotiation, commitment, and execution stages, each of which is assessed in terms of efficiency and equity" [Ring and Van de Ven, 1994, p. 97]. In addition, there is an element of mutual education involved in the process, in terms of teaching and learning, which enables partners to better understand, receive, and process each other's complementary knowledge [Nooteboom, 1996].

In this study, we attempt to answer the following research questions: (1) what constitutes KC and (2) how is synergistic knowledge created in KC. By answering these questions, this paper makes novel contributions to the literature in two ways: First, we attempt to identify multiple components of KC, including the quality of the interaction process. Second, we investigate the causal relationships among these components in a time-phased field study. We assert that there are complex interactions among complementary resources and that each component may play a different role at different time phases.

This study investigates the KC concept in the context of inter-organizational teams working on business process innovation. The research model is investigated quantitatively, using a sample of 26 matched-pairs of clients and consultants, and qualitatively, using interviews of a sub-sample of 7 pairs of clients and consultants who participated in a process innovation (PI) project as a prerequisite to enterprise resource planning (ERP) systems implementation in a mass rail transportation company. When a company adopts an ERP system, the system needs to be configured to suit the particular organizational context. This configuration process involves PI which includes the following activities: (1) mapping existing organizational processes ('As-Is'); (2) identifying the organizational processes that are embedded in the ERP software; and (3) defining new organizational processes ('To-Be') that fit both the software and the organization [Soh *et al.*, 2000]. For its PI, the client firm outsourced consultants from a global consulting company to obtain help in designing new IT-enabled business processes. The dynamic knowledge interactions between clients and consultants during the PI project provide a good context in which to study KC. The unit of analysis in this study pertains to the matched-pair of client and consultant.

In what follows, we briefly discuss the conceptual background for knowledge complementarities and develop our research framework and hypotheses. We then describe the research methodology and key results. We conclude the paper by discussing the implications of our findings for future research and practice.

Ⅱ. Conceptual Background

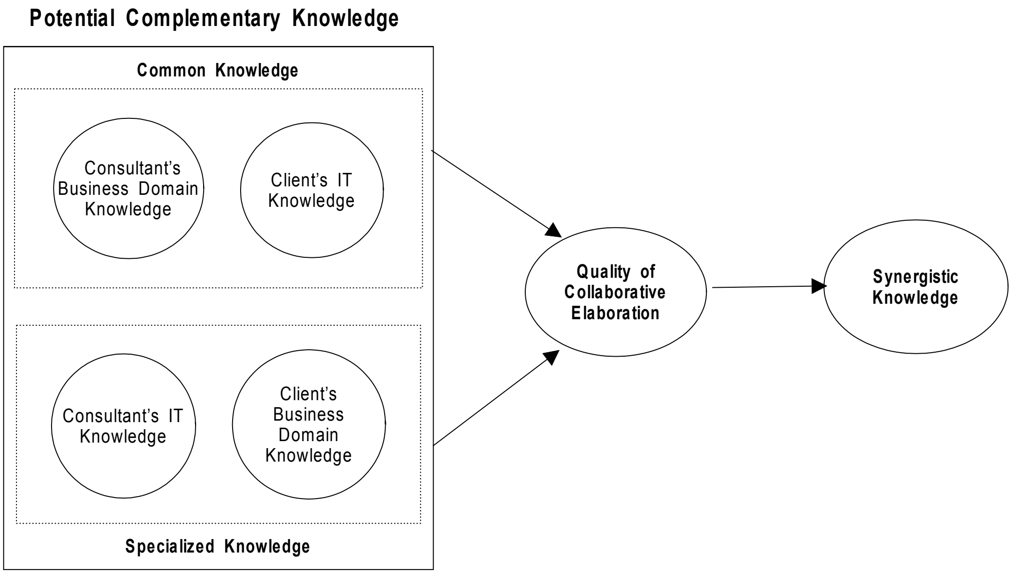
We propose that KC is a formative construct that consists of potential complementary knowledge, collaborative elaboration, and synergistic knowledge. <Figure 1>, showing the conceptual framework of KC, describes the interrelationships among the components of KC.

2.1 Potential Complementary Knowledge

Potential complementary knowledge (PCK) is the relevant knowledge each partner brings to the relationship. It has the capacity to collectively generate greater knowledge than the sum of each partner's individual knowledge. PCK basically serves to provide the "raw material" that is used to create synergistic knowledge.

Resource complementarities generally denote the degree of non-overlapping or specialized resources for participating firms [e.g., Chung *et al*., 2000; Gulati, 1995]. In a PI project, the client usually has specialized knowledge in his/her business domain and the consultant has specialized knowledge in the IT domain. The client's business knowledge refers to its organization-specific knowledge, which is concerned with an understanding of the internal unit functioning of the organization [Bassellier and Benbasat, 2004]. The consultant's specialized knowledge refers to its knowledge of both the technical aspects of IT and IT-business integration. When these two types of specialized knowledge interact, the chances for creating new knowledge increase.

However, specialized knowledge must be effectively amalgamated to realize the synergy [Harrison *et al*., 2001]. Utilization of the specialized knowledge offered by the two parties is facilitated by the presence of common knowledge between them [Cowan and Jonard, 2009; Kim *et al*., 2010; Lane and Lubatkin, 1998]. In the PI con-



<Figure 1> Conceptual Framework for Knowledge Complementarities (KC)

text, the consultant's common knowledge refers to the business knowledge that enables him or her to understand the business domain, speak the language of the business, and interact with their clients [Bassellier and Benbasat, 2004]. The client's common knowledge refers to the client's knowledge of the internal aspects of IT that enables it to understand the IT domain and the IT-business integration.

In summary, PCK in a PI project consists of two types of knowledge possessed by the consultant, namely, IT knowledge (specialized) and knowledge about the client's business domain (common), and two types of knowledge possessed by the client, namely business knowledge (specialized) and IT knowledge (common).

2.2 Quality of the Interaction Process: Collaborative Elaboration

The mere existence of complementary knowledge is a necessary but *insufficient* condition for achieving synergy [Harrison *et al.*, 2001]. Moreland [1999] asserts that team members may be cognizant of each other's knowledge but nevertheless fail to coordinate this knowledge effectively to achieve a common goal. Hence, there is an important distinction between the potential value attainable through a partnership and the realization of such value. The former refers to the theoretical synergies arising from the ideal combination of PCK, while the latter has more to do with the effectiveness of the actual management of the partnership [Madhok and Tallman, 1998]. The differences between potential and realized complementarities can be attributed to the quality of the interaction between the partners.

Drawing on theories about cooperative learning, Majchrzak *et al.* [2005] propose the concept of collaborative elaboration (CE) to explain how client-IS developer teams interact so as to enhance mutual learning. They define elaboration as a strategy in which individuals verbally expand on a concept or knowledge that is new to them. They extend this notion of elaboration to CE, which is a means of cooperative learning. During CE in PI, a client might describe his view of a technology that might work for him even though he may know relatively little about it, and a consultant might describe whatever she knows about the client's business processes. Then, "collaborators surrounding the learner take on the role of encouraging this elaboration process by probing with why questions, reminding the learner of additional analogies …" [Majchrzak *et al.*, 2005, p. 656]. In this process, team members can help each other to self-elaborate by utilizing their common and specialized knowledge.

An effective collaboration process facilitates more intimate interaction and enables partners to generate synergistic knowledge through a more effective amalgamation of the relevant knowledge. Cook and Brown [1999] describe the process of collective knowledge generation as a 'dance', since collaboration within a team can evoke novel associations, connections, and hunches that generate new meanings and insights. Without the appropriate knowing process, an inter-organizational team may not be able to acquire and interpret the knowledge of the partner, thereby inhibiting synergistic knowledge. Thus, the difference between the value realized with a more collaborative, thought-provoking orientation and a less-than-optimal one can be considered the real value of the interaction quality itself.

2.3 Synergistic Knowledge

Synergistic value, in general, can be conceptualized in terms of the ability of the partners to earn rents over and above what could have been achieved in the absence of the partnership [Madhok and Tallman, 1998]. Complementary resources held by partners create super-additive value synergies [Tanriverdi and Venkatraman, 2005]. The super-additive value synergies between resources (a) and (b) make their joint value greater than the sum of their standalone values, i.e., Value (a, b) > Value (a) + Value (b) [Davis and Thomas, 1993]. Thus, synergistic knowledge is *distinct* (new) and created from existing complementary knowledge.

Furthermore, complementary resources are co-specialized if one capability has little or no value without another [Clemons and Row, 1991]. For example, in the context of PI, a consultant possessing a high level of IT expertise may contribute very little to the business process innovation unless s/he understands the client's business well enough to apply the IT knowledge appropriately and thus provide useful IT services. Similarly, a client may clearly possess a high level of business expertise, but his/her ability to capitalize on the consultant's IT services may be partially dependent on having adequate IT knowledge to understand and appropriate the consultant's IT expertise. An inter-organizational team consisting of a client and a consultant collectively develops situation-specific knowledge by combining their existing knowledge into new knowledge and by incrementally learning from the capabilities of information technology. New knowledge may take the form of new IT-enabled business processes, enhanced system capabilities, or new applications.

The distinctiveness of synergistic knowledge depends not only on PCK but also on capturing and exploiting the collective knowledge embedded in client's and consultant's situated practices and in the dynamic interactions between the client and the consultant. New business process concepts can be formed by combining existing and external knowledge in a search for more concrete and sharable processes. Through the iterative process of CE, new business processes are articulated and developed until they emerge in a concrete form. As such, CE provides opportunities for recognizing complementary knowledge and generating learning outcomes.

Ⅲ. Research Model

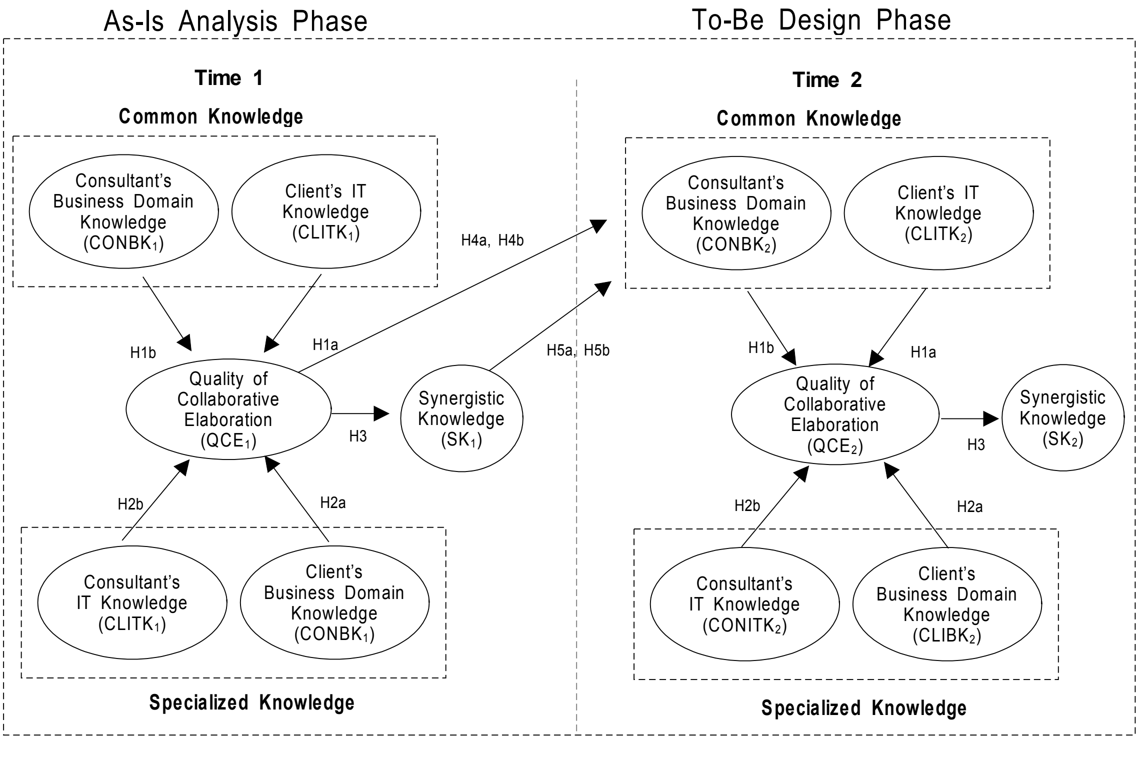
We propose the research model shown in <Figure 2> for our time-phased research investigation. In each phase, PCK consisting of common and specialized knowledge influences the quality of the CE process and, in turn, the quality of the CE process contributes to the creation of synergistic knowledge. The synergistic knowledge produced during the As-Is phase contributes to the common knowledge in the To-Be design phase, since it is the product of teamwork. The quality of CE in the As-Is phase also influences common knowledge in the To-Be phase.

3.1 Hypotheses

3.1.1 Knowledge and the Quality of Collaborative Elaboration

CE initially yields a set of highly divergent problem definitions, distinct solutions, and contrasting interpretations of information, forcing each partner to work his or her way through multiple possible assumptions and perspectives to produce effective outcomes [Majchrzak *et al*., 2005]. To resolve any discrepancies in views and to ensure that the discussions lead to genuine learning, team members attempt to explain their views by using multiple interpretations and different formats [Webb and Palincsar, 1996]. They need to communicate, assimilate cognitive frameworks, and develop shared understanding. This specific CE process requires a synergistic pooling of resources and a substantial degree of interaction between partners in terms of specialized knowledge, common knowledge, communication skills, among other aspects, in order to achieve the objectives by combining knowledge [Madhok and Tallman, 1998].

CE can be considered the sharing and synthesizing of specialized knowledge through ongoing collective processes of constructing and articulating shared beliefs through the social interaction of team members [Alavi and Tiwana, 2002]. Individuals with more specialized knowledge are more suitably skilled for integrating knowledge than individuals with less specialized knowledge [Lofstrom, 2000]. More expertise enables individuals to articulate their knowledge and beliefs about the processes driving performance and to think creatively and critically about problems [Nonaka, 1994]. Meanwhile, team members must have sufficient common knowledge to communicate effectively. Thus, the more (specialized and common) knowledge that team members



<Figure 2> Research Model

bring to the relationship, the better the CE.

H1: Common knowledge positively relates to the quality of CE.
H1a: A client's IT knowledge positively relates to the quality of CE.
H1b: A consultant's business knowledge positively relates to the quality of CE.

H2: Specialized knowledge positively relates to the quality of CE.
H2a: A client's business knowledge positively relates to the quality of CE.
H2b: A consultant's IT knowledge positively relates to the quality of CE.

3.1.2 The Quality of Collaborative Elaboration and Synergistic Knowledge

Alavi [2000] states that "coherent and synergistic organizational knowledge is generated through collaboration, interactions, and relations among individuals" (p. 19). While knowledge is "owned" and "enacted" in the minds of individual employees, the integration of this knowledge at a collective level is both necessary and fundamental [Okhuysen and Eisenhardt, 2002]. The production of synergistic knowledge is inextricably intertwined with the underlying dynamics of knowledge exchange among the parties involved. Existing knowledge can generate new, synergistic knowledge as existing knowledge is resituated in the evolving context of CE. Kogut and Zander [1992] assert that new knowledge is not created in abstraction from current abilities, but produced from the team's combinative capabilities. In PI, combinative capabilities refer to a team's ability to exploit their knowledge and the potential of technology. Thus, a premium is placed on the quality of the CE process.

Synergistic knowledge arises when complementary knowledge resources from both partners are combined into a synergistic bundle that enables outcomes that the partners could not achieve in the absence of the collaboration. These returns depend not only on knowledge being exchanged but also on how it is exchanged [Madhok and Tallman, 1998]. In essence, the nature of the interaction between partners is a critical aspect of the relationship [Madhok, 1995]. CE affords more than an exchange in which the net sum of knowledge remains the same; it dynamically affords a generative dance within which the creation of new knowledge and new ways of using knowledge is possible [Cook and Brown, 1999]. By potentially yielding a higher level of return than would be attainable in the absence of "true" mutuality, the relationship in and of itself behaves as an intrinsic source of value. Cook and Brown [1999] further assert that the generative interplay between knowledge and knowing is a source of innovation as when a team invents new ways of working more effectively.

H3: The quality of CE positively relates to synergistic knowledge.

3.2 Temporal Model of Knowledge Complementarities

Brandon and Hollingshead [2004] assert that a group project involves a cycle of constructing and evaluating hypotheses about other team members' knowledge, abilities, and credibility. Other researchers [e.g., Kanawattanachai and Yoo, 2007] describe the evolutionary changes in teams and suggest that teams with clear milestones or deadlines often go through major transitions as they progress toward key temporal landmarks. Before the transition point, team members often have different ideas about the goals and the ways in which they work together. Following the transition point, however, team members will likely have spent a significant amount of time together and have gained experience with the task and the other team members. Thus, we expect that the factors influencing the generation of synergistic knowledge will be different according to the time phases of the PI project.

In the early stage of a PI project, i.e., the As-Is analysis phase, team members try to understand each other by evaluating other team members' knowledge, clarifying organization-specific characteristics, and the IT capabilities for specific business applications (e.g. software functionalities). That is, the main goal of this phase is to identify problems and weaknesses in the existing processes and explore potential IT solutions for those problems. As teams begin to investigate new business processes and start receiving performance feedback, such as during the To-Be design phase, team members gain a better understanding of others' expertise and may work more productively.

3.2.1 Quality of Collaborative Elaboration in the As-Is Analysis Phase and Common Knowledge in the To-Be Design Phase

The process of creating group knowledge is circular in nature, consisting of feedback loops from the outcomes of previous stages. The repeated circularity of the process entails partner-specific efforts involving constant knowledge exchange and reconfiguration in the light of equity and efficiency considerations. Researchers describe the circular process of knowledge creation in various ways, such as in Nonaka and Takeuchi's [1995] description of the spiral of knowledge creation and Kogut and Zander's [1996] consideration of the interplay between individuals' social knowledge and the organizing principles of work. In another research study, Cook and Brown [1999] distinguish knowing from knowledge; knowing is the "epistemology of practice," while knowledge is the "epistemology of possession." They further emphasize the mutually enabling roles between knowledge and knowing in knowledge creation. New knowledge originates from the use of existing knowledge as a tool of knowing within situated interactions in the social and physical world.

The CE process is circular in nature in that collaborative learning occurs with using existing knowledge to produce knowledge which is used as common knowledge for later interactions. Specifically, the CE process among the team members allows for a dynamic exchange of knowledge. The exchange of partners' knowledge during the CE process in the As-Is phase helps to increase the common knowledge shared between the team members. For example, knowledge about the outside area of the party's expertise, i.e., client's IT knowledge and consultant's business knowledge, can be improved through the CE process. The knowledge acquired during the CE process becomes common knowledge for the team, since both parties participate in the learning process and are aware of the partner's learning. This common knowledge can be used for new knowledge creation during the To-Be design phase.

The CE process can also generate new knowledge, since each remark can yield new meaning as it is resituated in the evolving context of the conversation [Cook and Brown, 1999]. The new synergistic knowledge created as a result of CE during the As-Is analysis phase will be part of the group's common knowledge for the next phase, since both the client and consultant participate in the knowledge creation process. Thus, the following hypotheses:

H4: The quality of CE during the As-Is analysis phase positively relates to common knowledge in the To-Be design phase.
H4a: The quality of CE during the As-Is analysis phase positively relates to the client's IT knowledge in the To-Be design phase.
H4b: The quality of CE during the As-Is analysis phase positively relates to the consultant's business knowledge in the To-Be design phase.

H5: Synergistic knowledge generated during the As-Is analysis phase positively relates to common knowledge in the To-Be design phase.
H5a: Synergistic knowledge generated during the As-Is analysis phase positively relates to the client's IT knowledge in the To-Be design phase.
H5b: Synergistic knowledge generated during the As-Is analysis phase positively relates to the consultant's business knowledge in the To-Be design phase.

Ⅳ. Method

4.1 Overview

This study employed both quantitative and qualitative data collection and analysis in a two-phase approach. First, we conducted a quantitative study to measure the perceptions of clients and consultants on research variables using questionnaire surveys. Data were collected longitudinally at four different points during the four-month project period. Second, 14 semi-structured interviews were conducted to gather rich qualitative data about the phenomenon.

The data for the study were collected from two distinct sources, i.e., clients and consultants who participated in the PI project. We briefly discuss the methods and results of the quantitative phase, followed by a description of the qualitative phase. Before we begin these descriptions, we discuss the research site, since it is common to both phases of the study.

4.2 Research Site

The public metro firm (henceforth referred to as SM to ensure confidentiality) owned by the city has about 10,000 employees. SM was conducting a PI project as a prerequisite to its ERP implementation. The PI project was organized into fifteen modules including strategic management, financial accounting, management accounting, etc., and for each module multiple teams were assigned specific tasks. A team consisted of a client from SM and a consultant from an IT consulting firm. Every team member belonged to only one team. The consultants participating in the PI project worked full time at the client site for the entire project. Every client and consultant team was scheduled to regularly meet at least once a day, including weekly and monthly group meetings, during the PI project.

The PI project consisted of two phases, i.e., the As-Is process analysis phase and the To-Be process design phase. First, the As-Is process analysis phase analyzed current business processes and the problems or inefficiencies that might afflict them. Second, the To-Be process design phase designed the best feasible business processes reflecting the organizational requirements and the capabilities of ERP. Performing PI tasks requires knowledge about the business domain in which a particular IT application is situated, as well as knowledge about the IT capabilities used in the specific business domain [Tiwana and Mclean, 2005]. The nature of PI tasks forces the team to interact and learn from each other's knowledge in order to achieve their objectives.

4.3 Data Collection and Measures

4.3.1 Data Collection

The quantitative data was gathered by soliciting survey responses from 29 pairs of clients and consultants who participated in the PI project. A survey packet was delivered by one of the authors to the office of this group of 29 pairs. The packet included a cover letter explaining the nature of the study, the instructions for survey completion and an explanation of the procedures we would be using to ensure confidentiality of the responses. The PI project lasted 18 weeks and we gathered the survey responses four times during this period, specifically in the 3rd week, 8th week, 18th week of the PI project, and after the project was over. <Table 1> shows the data collection process.

During the third week, participants were asked to answer questions about their partner's common/specialized knowledge.

We expected that it would take at least two weeks for clients and consultants to be able to evaluate each other's knowledge. During the eighth week when the As-Is analysis phase ended, participants were asked to answer questions about the quality of CE and synergistic knowledge. The evaluation of CE and synergistic knowledge should be performed after sufficient interaction between clients and consultants. The quality of synergistic knowledge produced during the As-Is analysis phase was self-evaluated, because the syn-

<Table 1> Quantitative Study Data Collection

Informants	Constructs Measured	As-Is Phase		To-Be Phase	After the PI Project
		3^{rd} week	8^{th} week	18^{th} week	
Client	Consultant's Business Domain Knowledge	O	NA	O	NA
	Consultant's IT knowledge	O	NA	O	NA
	Quality of Collaborative Elaboration	NA	O	O	NA
	Synergistic knowledge	NA	O	NA	NA
Consultant	Client's Business Domain Knowledge	O	NA	O	NA
	Client's IT Knowledge	O	NA	O	NA
	Quality of Collaborative Elaboration	NA	O	O	NA
	Synergistic Knowledge	NA	O	NA	NA
Supervisor	Synergistic Knowledge	NA	NA	NA	O

ergistic knowledge was still developing. The questions answered by both the client and consultant (i.e., QCE and synergistic knowledge) were averaged to obtain a team score.

During the 18th week, the final week of the To-Be design phase, participants were asked to answer questions about all the constructs, i.e., common and specialized knowledge and the quality of CE. After the project was over, team supervisors, who were not part of the project, evaluated synergistic knowledge as the final output of the PI project in order to ensure independent evaluation. Of the 29 pairs of participants who returned the completed questionnaires, three pairs completed only one or two surveys and were therefore excluded from the sample, resulting in 26 matched-pairs of clients and consultants in the final sample.

4.3.2 Measures

In order to measure our research variables, existing scales were adapted to the study context, all of which were multi-item, seven-point Likert scales. The client's or consultant's knowledge refers to the relevant knowledge stock possessed by the client or the consultant in each domain, IT or business, respectively. Each knowledge component, i.e., the client's IT knowledge, the consultant's IT knowledge, the client's business knowledge, and the consultant's business knowledge, was measured by a four-item instrument (16 items altogether for the four knowledge components) adapted from Kim *et al*. [2010].

CE refers to a method of cooperative learning in which individuals verbally elaborate on a concept or knowledge that is new to them, while others surrounding the learner encourage the elaboration process. Six items measuring the quality of CE were adapted from Majchzak *et al*. [2005]. These items measure the extent to which both clients and consultants (1) generate several alternatives that accomplished at least one shared goal; (2) compare alternatives to fallback positions; (3) ask about the other party's unstated reactions to ideas; (4) use multiple ways to describe an idea; (5) identify differences that were not immediately obvious to the participants; and (6) focus on conceiving or achieving others' personal goals.

Synergistic knowledge refers to the new knowledge embodied in the new process maps, which is created from the super-additive potential of existing complementary knowledge. The six items, adapted from Gray and Meister [2004], include (1) a better understanding of the right way to do the work; (2) enhanced knowledge about proven methods and procedures; (3) revision and adaptation of existing knowledge; (4) new developments at work; (5) innovative thinking; and (6) revolutionary ways to improve job performance. The participants performed an intermediate evaluation of synergistic knowledge. Both clients and consultants answered the questions, and their responses were averaged to obtain team scores. However, the final evaluation was conducted by supervisors who did not participate in the PI project but were directly influenced by the performance of the project.

Three iterative stages of instrument validation were performed as conducted by Churchill [1979]: (1) A review of the face validity of the instrument by professors who are knowledgeable about PI projects; (2) pretests with three pairs of clients and consultants involved in the PI project; and (3) item-by-item debriefing sessions with those who participated in the pretests. Pretests were performed to ensure that the target participants understood the wording as intended by the researchers. The respondents were asked to indicate their responses to each of the survey questions that had a seven-point scale ranging from "not at all" to "very much so." Consequently, some questions were modified to improve clarity. The complete questionnaire appears in Appendix 1. The employees who participated in the pretests were not part of the final sample.

4.4 Results

4.4.1 Statistical Technique

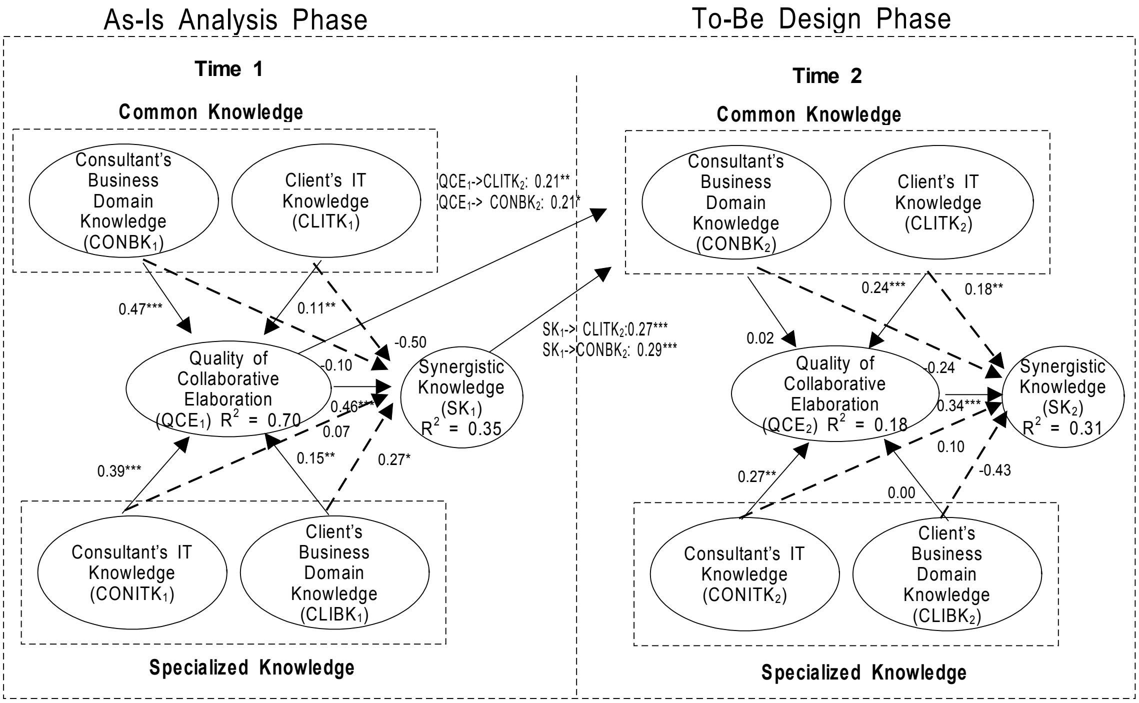
The theoretical model has multiple stages, suggesting the need for a structural equation modeling technique. We used PLS as the main statistical technique for the several reasons. First, PLS is most suitable during the early stage of theory development because it works well with small sample sizes and complex models [Chin 1998]. Second, PLS not only generates estimates of standardized regression coefficients for the model's paths, but also takes measurement errors into account [Wold 1985]. Finally, assumptions of normality and interval scale data are not necessary [Chin 1998].

4.4.2 Measurement Model

For the measurement model, each construct was modeled to be reflective. We tested the measurement model by examining individual item reliability, internal consistency, convergent validity, and discriminant validity. For all the constructs, internal consistency and convergent validity were evaluated by examining item-construct-loading, composite reliability, and average variance extracted (AVE). For individual item reliability, item loadings should be higher than 0.6 [Yoo and Alavi, 2001], and, because of this, we excluded seven items that showed poor factor loading from our final analysis (for specific items dropped, see Appendix 1). For the remaining items, Appendix 2 shows descriptive statistics, item reliability, and the average variance extracted (AVE). As shown in Appendix 2, the values of composite reliabilities all exceed 0.8, which is above the 0.7 guideline suggested by Nunnally and Berstein [1994], and the values of AVE all exceed the recommended threshold of 0.5 [Fornell and Larker, 1981]. Next, Appendix 3 shows that all items correlated most strongly with their intended construct and that the square root of AVE for these constructs was larger than any respective inter-construct correlations, providing evidence for discriminant validity [Gray and Meister, 2004]. To verify adequate discriminant validity, no measurement item should load more highly on a construct other than the construct it intends to measure. An examination of factors and cross-factor loadings showed that all items satisfied this criterion for both samples. We assessed multicollinearity among variables using the variance inflation factor (VIF) values from the SPSS regression module. The results show that the VIF scores for constructs ranged from 1.20 to 3.45 which were well below the threshold value of 10 [Myers, 1990, Kanawattanachai and Yoo, 2007], indicating that multicollinearity was not a problem in this study (see Appendix 2). These results, taken together, suggest good measurement properties for all indicators.

4.4.3 Structural Model

After performing the measurement model analysis, we employed the surviving indicators



<Figure 3> PLS Results

<Table 2> Summary of Hypotheses Testing

Structural Model		Time 1				Time 2			
		Path co-efficient	t-value	p-value	Result	Path co-efficient	t-value	p-value	Result
H1a	Client's IT Knowledge$_t$ → Quality of Collaborative Elaboration$_t$	0.11	1.99	0.03	Yes	0.24	3.12	0.00	Yes
H1b	Consultant's Business Knowledge$_t$ → Quality of Collaborative Elaboration$_t$	0.47	8.60	0.00	Yes	0.02	0.17	0.43	No
H2a	Client's Business Knowledge$_t$ → Quality of Collaborative Elaboration$_t$	0.15	2.05	0.03	Yes	-0.01	0.01	0.49	No
H2b	Consultant's IT Knowledge$_t$ → Quality of Collaborative Elaboration$_t$	0.39	7.19	0.00	Yes	0.27	2.02	0.03	Yes
H3	Collaborative Elaboration$_t$ → Synergistic Knowledge$_t$	0.46	3.45	0.00	Yes	0.34	4.60	0.00	Yes

Temporal Model		Path coefficient	t-value	p-value	Result
H4a	Quality of Collaborative Elaboration$_{t-1}$ → Client's IT Knowledge$_t$	0.21	2.32	0.01	Yes
H4b	Quality of Collaborative Elaborationt$_{t-1}$ → Consultant's Business Domain Knowledge$_t$	0.21	1.76	0.05	Yes
H5a	Synergistic Knowledge$_{t-1}$ → Client's IT Knowledge$_t$	0.27	3.26	0.00	Yes
H5b	Synergistic Knowledge$_{t-1}$ → Consultant's Business Domain Knowledge$_t$	0.29	3.98	0.00	Yes

to test the hypotheses. A full model that contains both the structural model with two (As-Is and To-Be) phases and the temporal model with the paths between the phases was constructed and tested. The statistical significance of path coefficients was estimated by employing the bootstrapping technique, as recommended by Chin [1998].

In order to partial out the direct effects of existing knowledge (PCK) on the new knowledge, we have added control flows from PCK (both common and specialized) to synergistic knowledge, although the relationships were not hypothesized. An accepted rule of thumb regarding the sample size of PLS is consistent with that of a multiple regression [Chin, 1998]. Generally, the number of observations should be greater than five times the highest number of incoming paths to a variable in the model [Chin, 1998]. In our case, the most complex portion of the model has five paths to synergistic knowledge (SK) and our sample size, 26 pairs, is within the recommended range.

We examined the structural model with H1 through H3 for both time periods (T1 and T2), and the temporal model with H4 and H5. <Figure 3> shows the results of our PLS analysis.

At T1, all hypotheses (for H1a, the client's IT knowledge (CLITK) → quality of collaborative elaboration (QCE), b = .11, p = .03; H1b, the consultant's business domain knowledge (CONBK) → QCE, b = .46, p = .00; for H2a, the client's business knowledge (CLIBK) → QCE, b = .15, p = .03; for H2b, the consultant's IT knowledge (CONITK) → QCE, b = 39, p = .00; for H3, QCE → SK, b = .46, p=.00) were supported.

At T2, H1a, H2b, and H3 were supported (for H1a, CLITK → CE, b = .24, p = .00; for H2b, CONITK → QCE, b = .27, p = .03; for H3, QCE → SK, b = .34, p = .00), while H1b (CONBK -> QCE) and H2a (CLIBK -> QCE) were not supported.

Comparing the results between T1 and T2, the findings are as follows: In both phases, the quality of collaborative elaboration turns out to be a significant determinant of synergistic knowledge. However, at T1, both the client's and consultant's business knowledge were significant in determining QCE, whereas they were not significant at T2.

As for the temporal model, the paths from the quality of collaborative elaboration at T1 to the client's IT knowledge (H4a) and the consultant's business knowledge (H4b) at T2 were significant. The paths from synergistic knowledge at T1 to the client's IT knowledge (H5a) and the consultant's business knowledge (H5b) at T2 were also significant. <Table> 2 and <Figure 3> summarize the results of testing the hypotheses. (In <Figure 3>, solid lines represent the hypothesized relationships and dotted lines show the control relationships).

V. Discussion and Limitations

The results of this study bear significantly on existing research. First, the findings of this study are consistent with the current literature about client learning. Several studies in IS development have documented the positive effects of client learning on the success of IS development, especially during the initial design phase of a project [Majchrzak *et al*., 2005; Kirsch and Beath, 1996]. However, the results of qualitative study reveal that *consultant learning* about the unique aspects of a client's business occurs first during the early CE process. For consultant learning, both the consultant's business and IT knowledge are important, in addition to the client's business and IT knowledge. Among these kinds of knowledge and capabilities, a consultant's business knowledge (for CONBK -> QCE, b = .47, p = .000) plays a much more significant role than other knowledge components. This result adds support to the current literature's argument of the knowledge requirements of IT professionals. For example, Bassellier and Benbasat [2004] assert that "the business knowledge of IT professionals plays a key role in the development of closer relationships with business clients by giving IT professionals the language needed to communicate with and understand their clients," (p. 674). For consultant learning, a client's business knowledge plays an educational role. One client in facilities management said,

> *"During the As-Is analysis phase, we talked mainly about our businesses. So, there was a knowledge transfer from us to the consultants. However, in the later phase, we asked a lot of questions about ERP capabilities. By comparing the ERP processes to ours, the level of our understanding ERP was enhanced quite a lot."*

Interactions during the As-Is analysis phase leads to the acquisition of IT knowledge by client. That is, as the project progresses, a client learns about the capabilities of information technology with help from consultant. This enhanced client's IT knowledge plays a critical role in generating the final output. Specifically, in the To-Be design phase, a client's IT knowledge turns out to contribute significantly to synergistic knowledge both directly and indirectly through CE. This implies that the client, not the consultant, is a major player in generating new knowledge. One consultant in financial accounting said,

> *"A major difference between ERP implementation and a traditional IS development project is that in the latter the outside developer takes care of the major development works and all the client has to do is manage the project. Meanwhile, in case of ERP, the role of the client is much more important. The client is directly involved in the innovating processes, making decisions, etc. In that regard, the client partner has to do a lot of work."*

According to the results of our study, the main contributors to ultimate synergistic knowledge are the quality of the CE process and the participants' *IT* knowledge. Effective collaboration allows for more intimate interactions and enables the project team to generate the best solutions (synergistic knowledge) through a more effective reconfiguration of existing knowledge. One client in information technology management said,

> *"During our meetings, many ambiguities tended to be resolved. If not, we asked a lot of questions of each other. Sometimes, we argued with each other and negotiated about the feasibility of solutions. Within our module, we evaluated multiple alternatives comparing the pros and cons of each alternative. Of course, there were disagreements in the evaluation of alternatives, but the gaps in our opinions were resolved through discussions. Then, we could reach a consensus. The more quality discussions we had, the better the solutions we could come up with."*

Synergistic knowledge can be created by reconfiguring and recontextualizing existing knowledge [Nonaka, 1994]. During the CE process in the To-Be design phase, the project team attempts to recontextualize its existing knowledge in order to produce the best feasible business processes. For example, a consultant may introduce the best practice process (existing knowledge) that is working in other companies. The project team then evaluates the applicability of the best practice by comparing the client's context to the case's contex.

Regarding the contribution of different types of knowledge to the creation of synergistic knowledge, specialized knowledge (i.e., client's business knowledge and consultant's IT knowledge) significantly influences synergistic knowledge through CE until the mid-point of the project. As the project moves toward the later stage, the enhanced client's IT knowledge becomes much more significant in creating synergistic knowledge. The interview data confirm that from the mid-point forward the consultant's specialized knowledge about IT-driven best practices in other companies is most beneficial to the client. The client makes a decision about the applicability of the best practices. If they are not applicable, the team devises enhanced business process alternatives (synergistic knowledge) that suit the client's needs. However, the client makes the final decision among the proposed alternatives on the basis of its understanding of IT capabilities. One consultant in facilities management said,

> *"The best way to get a desirable outcome is to help clients understand ERP capabilities. For example, we explained that when company A implemented business processes this way, they encountered these kinds of problems. Of course, we made recommendations based on our experiences in other companies. However, the final decision maker is always the client."*

Contrary to our expectations, neither the client's business knowledge nor the consultant's business knowledge influences the quality of CE during the To-Be process design phase. This result implies that the main discussion during the To-Be design phase concerns IT capabilities, for example, whether ERP would provide specific functionalities such as mutual accountability between buyer and supplier for parts procurement. One client in vehicle management said,

> *"The main tasks of the As-Is phase were to understand the current business processes and identify the problems associated with the current way of doing business. Meanwhile, during the To-Be design phase, we were trying to solve the problems identified in the As-Is phase within the constraints of ERP. In some cases, the proposed ERP did not support the suggested business processes. Thus, the focus of our discussion in the To-Be phase was how we can implement the new business processes within ERP."*

Our study has a few limitations that should be mentioned. The data for this study have been collected from one company, operating in one country. The interpretation of our results is therefore subject to the constraints of one company and the cultural characteristics of one country. In order to increase the external validity of the findings of this study, future research studies should incorporate samples from multiple companies in multiple countries.

Another limitation of this research was the selection of research variables, that is, the model did not cover all antecedents of CE and synergistic knowledge. Instead, the model in this paper included a subset of factors that constitutes knowledge complementarities in order to clarify how synergistic knowledge is generated in KC. However, there are other variables that factor into generating synergistic knowledge, such as the fit between participants in terms of information-processing styles. These omitted variables may have affected the results of this study and, thus, the findings should be interpreted with some caution.

Ⅵ. Conclusion

Much of the prior research on knowledge management at the group level has focused on knowledge transfer and knowledge sharing [e.g., Ko *et al*., 2005]. Some researchers equate knowledge sharing with knowledge transfer [e.g., Huber, 1991], while others view knowledge sharing as a more limited instance of knowledge transfer [e.g., Tiwana and McLean, 2005]. Knowledge is taken to be transferred when the recipient understands the intricacies and implications associated with that knowledge so that he or she can apply it [Darr and Kurtzberg, 2000; Ko *et al*., 2005]. Here, the key aspect of knowledge transfer and sharing is knowledge *movement* and the net sum of *group* knowledge remains the *same* even after the knowledge transfer. However, we assert that complementary knowledge resources among specialists in a team create new, synergistic knowledge that results from interactions, not simply from the zero-sum knowledge movement from one individual to another. It is therefore useful to distinguish KC from knowledge transfer and sharing.

We identify three sub-constructs of KC - PCK, the CE process, and synergistic knowledge, and each of these sub-constructs plays a unique role at different times in the process. Meanwhile, existing research on KC tends to treat the construct as a single variable. Since synergistic knowledge results from the interactions of PCK, future research may benefit from separating the three sub-constructs of KC in its research design. For example, Hill and Hellriegel [1994] distinguish the potential complementarities from implemented complementarities and find that joint-venture partners with distinctive competencies in different areas may experience difficulties in implementing potential complementarities.

Further, we demonstrate that PCK consists of the common knowledge and specialized knowledge that each participant brings to the relationship. Using complementary knowledge resources as raw materials, CE produces synergistic knowledge. Through this research, we have identified how synergistic knowledge is generated in KC. That is, in the PI context, a consultant first learns about the client's business and then the client learns about IT capabilities through CE. With enhanced knowledge about IT capabilities, clients initiate designing the To-Be business processes, while consultants play a supportive role by, for example, introducing best practices or making suggestions based on their experiences. With regard to generating synergistic knowledge in KC, future research should consider the following issues: (1) what is the optimal combination of common knowledge and specialized knowledge? Up to what level of expertise does the client need to learn about IT capabilities? (2) What are the facilitators or inhibitors of collaborative elaboration? The benefits of potential complementary knowledge may not be realized because of the inhibiting factors. These include an unwillingness to share important knowledge [e.g., Alavi and Leidner, 2002], a lack of inter-organizational trust [e.g., Putman, 1993], and unproven knowledge content [e.g. Szulanski, 1996]. Future research may investigate the effect of these factors on KC.

The findings of this study have some implications for practitioners. We find that a client's IT knowledge is a major determinant for successful PI projects. Hence, firms need to educate their employees about IT capabilities. In addition, a consultant's business knowledge turns out to be a significant contributor to CE. Thus, consulting firms should make sure that consultants have sufficient business knowledge before they are assigned to a specific project. Further, the quality of the interaction process between clients and consultants significantly influences the successful generation of desirable outcomes. In order to produce the best feasible processes, firms need to create productive environments for effective collaboration.

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〈Appendix 1〉 Research Instrument

Common Knowledge

Client's IT Knowledge (CLITK) - answered by Consultants

1. The client understands the IT generally needed for its business.
2. The client understands the IT that specifically reflects its business needs.
3. The client understands the potential of IT for solving managerial problems.+
4. The client understands the potential of IT for Process Innovation*+

Consultant's Knowledge in Client's Business Domain (CONBK) - answered by Clients

1. The consultant understands our industry characteristics.
2. The consultant understands the unique characteristics of our organization
3. The consultant understands the managerial issues of our organization
4. The consultant understands the problems of business processes and their solutions+

Specialized Knowledge

Client's Knowledge in Business Domain (CLIBK) - answered by Consultants

1. The client is well aware of the unique characteristics of its business activities.
2. The client is well aware of the unique characteristics of its products/services and its customers.
3. The client knows how to achieve competitive advantages leveraging its own strengths.
4. The client knows the managerial problems that it is facing.+

Consultant's IT Knowledge (CONITK) - answered by Clients

1. The consultant has specialized IT knowledge needed for our industry.
2. The consultant has specialized IT knowledge needed for our products/services.
3. The consultant has specialized IT knowledge for solving managerial problems.
4. The consultant has specialized IT knowledge needed for Process Innovation for our organization.

Quality of Collaborative Elaboration (QCE) - answered by both Clients and Consultants

During the meetings in last one month, to what extent did both client and consultant⋯

1. ask about the other party's unstated reactions to ideas?
2. use multiple ways to describe an idea?
3. identify differences that were not immediately obvious to participants?*
4. focus on understanding or achieving others' personal goals, aside from program specifications?
5. generate several alternatives that accomplished at least one shared goal?
6. compare alternatives to fallback positions?

Synergistic Knowledge (SK) answered by both Clients and Consultants only at T1

1. I now have a much better understanding of the right way to do my work than I did before PI.
2. Compared to the time before PI, I now know much more about proven methods and procedures.
3. I have been revising and adapting my knowledge during PI.
4. During PI, new developments at work have caused me to revisit and update my work-related knowledge.
5. I have been very innovative in my thinking during PI.
6. Over the four months, I have thought of some revolutionary ways that my job could be improved.*

Synergistic Knowledge (SK) answered by team leaders only at T2

1. Our team now has a much better understanding of the right way to do our work than we did before Process Innovation.
2. Compared to the time before PI, we now know much more about proven methods and procedures.
3. We have been revising and adapting our knowledge during PI.
4. During PI, new developments at work have caused our team to revisit and update our work-related knowledge.
5. We have been very innovative in our thinking during PI.
6. Over the four months, we have thought of some revolutionary ways that our jobs could be improved.+

* denotes the T1 items discarded from further analysis due to low loadings (> 0.60)

\+ denotes the T2 items discarded from further analysis due to low loadings (> 0.60)

〈Appendix 2〉 Means, Standard Deviations, AVE, Reliability and VIF

	Number of items	Mean	SD	AVE	Composite Reliability	Cronbach's Alpha	VIF
$CLITK_1$	3	5.05	0.96	0.79	0.92	0.87	1.72
$CONBK_1$	4	4.63	0.99	0.77	0.93	0.90	2.53
$CLIBK_1$	4	5.43	0.76	0.73	0.92	0.88	2.10
$CONITK_1$	4	5.08	0.62	0.70	0.90	0.85	1.81
QCE_1	5	4.83	0.60	0.65	0.90	0.86	3.45
*SK_1	5	4.65	0.45	0.65	0.90	0.87	*
$CLITK_2$	2	5.25	0.47	0.73	0.84	0.63	1.41
$CONBK_2$	4	5.45	0.59	0.71	0.88	0.83	2.20
$CLIBK_2$	3	5.60	0.56	0.71	0.91	0.86	1.47
$CONITK_2$	4	5.73	0.59	0.64	0.88	0.82	2.24
QCE_2	6	5.16	0.50	0.75	0.95	0.93	1.20
*SK_2	5	5.23	0.75	0.66	0.91	0.88	*

Note) * Dependent variable.

〈Appendix 3〉 Construct Correlations and Discriminant Validity

	CLITK1	CONBK1	CLIBK1	CONITK1	QCE1	SK1	CLITK2	CONBK2	CLIBK2	CONITK2	QCE2	SK2
$CLITK_1$	**0.89**											
$CONBK_1$	0.14	**0.88**										
$CLIBK_1$	0.57	0.45	**0.86**									
$CONITK_1$	0.03	0.50	0.18	**0.84**								
QCE_1	0.27	0.74	0.49	0.65	**0.80**							
SK_1	-0.23	0.33	0.18	0.35	0.43	**0.80**						
$CLITK_2$	0.07	0.19	0.05	0.62	0.33	0.36	**0.85**					
$CONBK_2$	0.13	-0.06	0.09	0.22	0.33	0.38	0.25	**0.84**				
$CLIBK_2$	-0.14	-0.01	0.01	0.13	0.08	0.38	0.36	0.43	**0.84**			
$CONITK_2$	0.15	0.11	0.20	0.21	0.36	0.32	0.22	0.72	0.39	**0.80**		
QCE_2	0.01	0.21	0.37	0.41	0.38	0.17	0.31	0.28	0.20	0.34	**0.86**	
SK_2	0.07	0.37	0.24	0.17	0.13	-0.17	0.09	-0.21	-0.36	-0.08	0.28	**0.81**

Note) Diagonal boldface elements were the square root of the average variance extracted.

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