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A Study on Relationship among Knowledge State, IT Support, Knowledge Sharing Process and Outcomes in Startup Teams*

Seyoon Lee** · Hyejung Lee*** · Jungwoo Lee****

■ Abstract ■

Start-ups do not have enough resources such as financial capital and established customer base. Knowledge base of start-up team members is the crucial and unrivaled resource. This study tries to explicate the knowledge sharing process occurring in this knowledge base of start-up teams. Adopting the knowledge process view, detail process of knowledge sharing process model is constructed consisting of knowledge sharing speed, quality and quantity in a form of nomological net and empirically tested. In addition, preceding antecedents and consequential outcomes of this knowledge sharing is also posited as part of the research model : knowledge state of the team leading to team creativity and agility via the explicated knowledge sharing process model. Also, as this knowledge based view are triggered by the advance of IT in general, IT support is conceptualized as an antecedent and measures are operationalized. 230 data points were collected from start-up teams. Via data analysis using PLS, theoretical relationships from knowledge state, IT support, knowledge sharing process and knowledge consequences are found to be empirically supported except a few not supported. Most of all, team agility and team creativity are theoretically supported and empirically validated as critical outcome variables beyond performance measures. Though agility and creativity has been discussed as critical construct in start-up teams, it has not be much validated empirically. Also, interestingly, IT support are found to be significantly impacting the knowledge sharing process as expected. Academic contributions and implications for practice are discussed at the end with limitations and further research.

Keyword : KnowLedge State, Knowledge Sharing Process, Knowledge Sharing Speed, Knowledge Sharing Quality, Knowledge Sharing Quantity, Team Creativity, Team Agility

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** Research Fellow, Center for Work Science at Yonsei University
*** Research Professor, Institute of East and West Studies, Yonsei University
**** Corresponding Author, Director, Center for Work Science

1. Introduction

There are two opposing scenarios predicting the future of world of work. Pessimistic scenario predicts that machines will take away many human jobs, disrupting labor markets and giving rise to inequality while optimistic scenario predicts that the labor market will be rebuilt with creative jobs that cannot be replaced by machines (Brynjolfsson and McAfee, 2014). As industrial trend moves toward intelligent, flexible, and creative machines, the relevance of large-scale facility and huge organization, which has been found optimal in the age of mass production and automation, will decline dramatically in the future. On the contrary, it is expected that future firms will aim for small and flexible organizational structures and knowledge-based work methods in order to achieve high levels of expertise and creativity. Knowledge-based, post-industrial firms' success and survival will depend upon creativity, innovation, discovery, and inventiveness (Martins and Terblanche, 2003).

In this regard, it is proposes here that start-up teams are the archetypes of future work. Start-up refers to firms in the early stage of development. Start-up faces challenges such as conceptualizing and producing new products or services, building a customer base, and establishing organizational procedures (Klotz et al., 2014). Unsettled organization procedures may be the weakness of the start-up, but on these can be strengths in that they present flexibility for organizational structure and process. It is a hallmark of start-ups that each staff member tends to participate actively in establishing a business strategy due to the small size of the organization (Klotz et al., 2014). Start-ups are composed of diverse people with varied professional knowledge. Many start-ups also have a range of external networks such as advisory panels and start-up communities. In addition to such intra-firm composition and external linkages, open and effective communication forms a basis from which start-up creates new ideas.

Because start-up does not have enough resources such as financial capital and established customer base, knowledge base of members is a crucial resource. Thus, integrating knowledge among team members is an important and urgent issue in order to be successful. In this regard, this research makes efforts to address following research questions.

(RQ1) What are the key success factors for start-up teams and their antecedents?
(RQ2) Does IT contribute to enhancing the success factors of start-up teams by supporting the knowledge process?

The knowledge-based view of the firm was suggested as theoretical framework. The knowledge-based view of the firm proposes that knowledge is the most important and unique resource of competitiveness (Spender, 1996). According to the knowledge-based view, agility in decision-making and problem-solving, and creativity regarding new ideas and solutions originate from the knowledge process of individual people, teams, and/or firms. The knowledge-based view defines the knowledge process in three stages : knowledge context knowledge-sharing process knowledge-integration outcome (Kearns and Sabherwal, 2006).

A research models is constructed and proposed here, taking into account the internal and external factors of start-up. Team members with diverse backgrounds and experiences, external partners, customers, and advisors were considered in the knowledge context of start-up. In addition, IT support was presented as an important technical factor that facilitates the knowledge process. IT is a crucial enabler of the knowledge process by supporting information exchange, searches, and storage (Choi, et al., 2010). To empirically validate and support this research model, data were collected from workers in start-ups.

2. Theoretical Background

2.1 Knowledge Based View of the Firm

In the knowledge based view of the firm, transferring and sharing team members' knowledge is critical for achieving and maintaining a firm's competitiveness (Kogut and Zander, 1992). Further, a firm is considered a dynamic, evolving, quasi-autonomous system that use knowledge to produce outcomes (Spender, 1996).

In start-ups, as beginning is usually done by a small team, each team member tends to play a unique role and function, thus aggregating each member's knowledge into integrated outcomes is the foundation of firm's competitiveness itself.

Similar to start-ups, bringing innovation to small software firms can be explained by the knowledge based view. The knowledge base of small software firms can introduce innovation (technology sensing and experimentation), and thus this process is the one for building the absorptive capacity of the firm (Carlo et al., 2012).

2.2 Antecedents : Knowledge Breadth and Depth

Knowledge based view proposes three epistemic dimensions preceding and impacting the knowledge process : knowledge diversity, knowledge depth, and knowledge linkage (Carlo et al., 2012). The external innovation adoption process is associated with all three epistemic dimensions, however the internal innovation creation process relates to knowledge diversity and depth (Carlo et al., 2012). As dealing with internal team knowledge process, this research considers knowledge breadth and depth as the key antecedents of internal team knowledge process. Managing knowledge breadth, as the horizontal aspect of team knowledge state, is essential for knowledge sharing process, so that teams can pursue creating value (Tsai et al., 2014). In addition, knowledge depth is a vertical aspect of knowledge state of teams (De Luca and Atuahene-Gima, 2007). The depth of knowledge is critical for the adoption of radical and incremental innovations (Dewar and Dutton, 1986).

2.3 Outcomes : Team Agility and Creativity

In this research, team agility and team creativity are regarded as outcomes of the knowledge-sharing process. Based on previous research, agility can be defined as the fast-sensing and fast-moving ability to take advantageous opportunities and avoid negative consequences by assembling resources in a continuously changing environment (Sambamurthy et al., 2003; van Oosterhout et al., 2006; McCann et al., 2009). Start-ups and turn-around management demand speed and urgency. Agility and nimbleness provide timeliness, grace, purpose and benefit (Dove, 1999).

Team creativity is an inherently social process, and team members contribute to elements of team creativity (Tiwana and McLean, 2005). Organizational creativity is a part of the broader construct of innovation, and innovation is a part of the broader domain of organizational change (Woodman et al., 1993). Building team creativity needs the process of individual knowledge aggregation and integration (Leenders et al., 2003).

2.4 Knowledge Sharing Process

Adopting the knowledge based view, this research attempts to elaborate the knowledge sharing process in terms of three components : quality, quality and speed of knowledge sharing. Also, attempt is made to build a nomological network of these three components in terms of precedence.

2.4.1 Quantity and Quality

In creativity research, two thinking modes are differentiated : divergent thinking and convertgent thinking (Paletz and Schunn, 2010). The divergent thinking demands and processes a large quantity of information and knowledge for effective information searches and analogies building. Thus, it is related to the quantitative aspect of knowledge sharing (Park et al., 2013).

The convergent thinking is related to quality of knowledge sharing because it is the process of deriving high quality outcomes by evaluating and selecting relevant information and knowledge. Thus, the quantity and quality of knowledge sharing are involved in different cognitive pathways and processes. Previous research supports this differentiation (Chang and Chuang, 2011).

2.4.2 Speed

The quantity and quality of knowledge sharing may not be completely explaining the knowledge sharing process in teams. If knowledge sharing process takes a lot of time, it will be hard to gain competitive advantage using this shared knowledge. Even though excellent quality and quantity of knowledge is achieved, if the speed of sharing is too slow, it would be difficult to reach wanted outcomes at this age of speedy innovations.

It has been shown that the qualitative aspect of knowledge flow has positive associations with subsidiary performance because it reduces confusion and misunderstandings (Tran et al., 2010). Since timely decision-making can be more important than the right decision in this fast-changing competitive market, the speed aspect of knowledge-sharing seems to be more and more critical.

Innovation creates changes and generates positive values applying novel knowledge, meaning that unapplied knowledge is worthless (Dove, 1999). Agile innovative firms require the right knowledge in the right place at the right time (Dove, 1999). Generally, the right knowledge corresponds to the quality of knowledge, the right place an appropriate person, and right time when necessary. Thus, the temporal aspect of knowledge is clearly distinguishable from the other aspects of knowledge.

In this regard, the current study adopted knowledge-sharing speed as the temporal dimension of knowledge sharing. The study of speed as one of the sub-dimensions of knowledge sharing is rarely conducted. Comprehension and speed have been investigated as crucial factors of knowledge transfer in a joint venture context (Khan et al., 2015).

Knowledge sharing can be distinguished from knowledge transfer by its bi-directional nature and it is a special type of knowledge transfer (Tiwana and McLean, 2005). Thus, knowledge-sharing speed can be defined as the level of rapidity of sharing knowledge among members in a team. Sharing peed is an essential sub-dimension of knowledge-sharing in addition to quantity and quality.

2.5 IT Support in the Knowledge Sharing Process

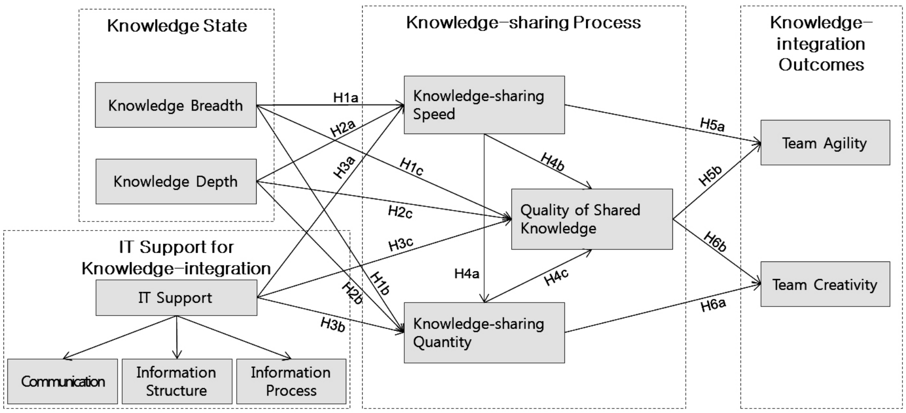
In information systems research, efforts have been made to show that technology and systems may enhance and help social relations and knowledge-sharing activities (Lee et al., 2011; Park et al., 2015). At the organizational level, technology also plays a supporting role in an organization by creating, sharing, storing, and using knowledge (Muthusamy et al., 2005).

An agile firm should have the right knowledge in the right place at the right time (Dove, 1999). If the knowledge is just stored in online storage or repository, it cannot contribute to problem solving and used to achieve outcomes. IT offers the ability to code and share knowledge, and create knowledge directories and knowledge networks (Sambamurthy et al., 2003).

IT support during knowledge application can be divided into two dimensions. One is knowledge reach and the other is knowledge richness (Sambamurthy et al., 2003). Knowledge reach focuses on knowledge itself, it increases sharing and application of knowledge by supporting storing, searching, and retrieving through digital network. Knowledge richness focuses on social interactions, it supports sharing and application of knowledge through effective communication. In these two aspects of richness and reach, IT support contributes to knowledge sharing and knowledge application (Choi et al., 2010). IT support is necessary for initiating and carrying out knowledge management and knowledge sharing (Lee and Choi, 2003).

3. Research Model and Hypotheses

A research model is constructed for this study presenting the relationships among team knowledge state, IT support, the knowledge-sharing



〈Figure 1〉 Research Model

process, and knowledge-integration outcomes, using the framework of knowledge-based view. According to the knowledge-based view, the outcomes originate from the knowledge context by way of the knowledge-sharing process (Kearns and Sabherwal, 2006). In this research, team knowledge state (breadth and depth) and IT support are adopted as constructs of the knowledge context (Carlo et al., 2012).

3.1 Knowledge State and the Knowledge Sharing Process

Knowledge breadth increases the information novelty in teams by making possible access to, and the acquisition of a broad range of knowledge (Narayanan et al., 2014). Diverse knowledge in a start-up increases the possibility of acquiring accurate, timely, relevant knowledge by leading to rapid access, in-depth understanding, and appropriate application (Sullivan and Marvel, 2011). Thus, knowledge breadth in start-up teams may positively influence the quality of shared knowledge.

However, if knowledge in teams becomes more diverse, additional communication efforts are required in order to integrate and exchange heterogeneous knowledge among team members (Narayanan et al., 2014). Teams with high levels of diversity require more time to transfer knowledge. Since knowledge sharing is a specific type of knowledge transference (Gibson et al., 2007) knowledge breadth (diversity) also has a negative association with knowledge-sharing speed.

In sum, team knowledge breadth generates various opportunities for knowledge-sharing, facilitates the quantitative aspect of knowledge-sharing by reducing knowledge-searching cost, and has positive associations with the qualitative aspect of knowledge sharing because of the enhanced level of relevance and the accuracy of shared knowledge through the provision of a wide range of knowledge. However, negative effects on the speed of knowledge-sharing are possible because heterogeneity can cause delays in interaction among team members.

From the above discussions, the following hypotheses are proposed.

H1a : The knowledge breadth of start-up teams is negatively associated with knowledge-sharing speed.

H1b : The knowledge breadth of start-up teams is positively associated with knowledge-sharing quantity.

H1c : The knowledge breadth of start-up teams is positively associated with the quality of shared knowledge.

Knowledge depth represents the expertise of team members. Based on the perception of a partner's expertise, an individual determines the value and decides the level of knowledge exchange with the partner. The perception of credibility, confidence, and trust in a partner's knowledge affects knowledge-sharing (Chen et al., 2013; Park et al., 2014). The level of expertise of others is the basis of evaluation for providing one's own knowledge and the relevance of communication (Park et al., 2014; Park et al., 2015). Knowledge-sharing occurs when members perceive the worth of exchanging expertise with other members, and when shared knowledge is valuable and relevant to their work (Lee et al., 2015a).

Because knowledge exchange occurs more frequently as the value of a counterpart's knowledge increases, the depth of a team member's knowledge positively relates to the quantity of knowledge sharing. If the level of exchanged knowledge is high, the quality of shared knowledge in a team is improved. Moreover, with a sufficient level of knowledge depth in a team, members can perceive that their partners' knowledge is worth exchanging, and can easily adopt knowledge-sharing. Thus, the knowledge depth of start-up teams positively relates to the speed of sharing knowledge.

From the above discussion, the following hypotheses are derived.

H2a : The knowledge depth of start-up teams is positively associated with knowledge-sharing speed.

H2b : The knowledge depth of start-up teams is positively associated with knowledge-sharing quantity.

H2c : The knowledge depth of start-up teams is positively associated with the quality of shared knowledge.

3.2 The Effects of IT Support on Knowledge Sharing

IT plays a facilitating role for knowledge-sharing among team members (Choi et al., 2010). The factors that affect knowledge sharing are categorized as the characteristics of knowledge itself, opportunities to share, and motivations to share (Ipe, 2003).

This indicates connections between the competence of IT support, knowledge reach and knowledge richness (Sambamurthy et al., 2003). The knowledge reach provides a great deal of broad knowledge to team members, enabling them to access, store, and retrieve through knowledge bases and digital networks (Lee, 2015), thereby contributing to the quantity and quality of shared knowledge. The knowledge richness supports systematic communication among team members and contributes to the quantity and quality of shared knowledge.

In order to transfer and apply knowledge, the processes of codifying, storing, and disseminating information and knowledge must be under taken. Thus, a certain amount of time is required for these processes (Chen and Lovvorn, 2011). IT support can increase knowledge-sharing speed by making knowledge-sharing processes more efficient. In particular, IT can diminish or eliminate the barriers of time and space. This leads to rapid and efficient communication among team members, even though they are working separately. This aspect of IT contributes to enhancing the speed of knowledge flow, the timeliness of knowledge, and the quality of shared knowledge. Thus, the following hypotheses regarding the relationships between IT support and the knowledge-sharing process can be derived.

H3a : The IT support of start-up teams is positively associated with knowledge-sharing speed.

H3b : The IT support of start-up teams is positively associated with knowledge-sharing quantity.

H3c : The IT support of start-up teams is positively associated with the quality of shared knowledge.

3.3 Relationships among Knowledge Sharing Dimensions

The speed of knowledge transfer refers to how rapid and timely knowledge is transferred to recipients (Khan et al., 2015). Because knowledge sharing indicates a bi-directional and mutual knowledge-transfer process, knowledge-sharing speed can be defined as how rapid and timely knowledge is shared among team members. If knowledge sharing occurs rapidly, the frequency of knowledge sharing is increased during a certain period; thus, the amount of shared knowledge is also increased.

Moreover, if necessary knowledge can be shared among members with minimum delay, the timeliness of knowledge is maintained. The quality of knowledge is composed of relevance, accuracy, ease of understanding, and timeliness (Delone and McLean, 2003; McKinney et al., 2002). Since timeliness is one of the quality properties, knowledge-sharing speed is considered positively related to the quality of shared knowledge.

As the knowledge sharing quantity is increased, the possibility that the relevant knowledge is included in shared knowledge becomes higher. Since knowledge sharing occurs when a partner's knowledge is worth exchanging (Lee et al., 2015b), the frequent sharing of knowledge means that an appropriate quality of knowledge is sufficiently exchanged among team members. Consequently, the greater the quantity of knowledge that is shared, the higher the chances of finding the most appropriate knowledge during the selection process.

Thus, the hypotheses of the relationships among the sub-dimensions of knowledge sharing (speed, quantity, and quality) are derived as follows.

H4a : Knowledge-sharing speed is positively associated with knowledge sharing quantity.

H4b : Knowledge-sharing speed is positively associated with the quality of shared knowledge.

H4c : Knowledge-sharing quantity is positively associated with the quality of shared knowledge.

3.4 The Knowledge Sharing Process and Knowledge Integration Outcomes

Agility refers to the ability to continuously sense and respond to environmental changes by integrating internal resources (McCann et al., 2009; Sambamurthy et al., 2003). Since knowledge is the most important resource of a firm (Wernerfelt, 1984), the rapid sharing and integration of knowledge can be a core part of agility enhancement. In addition, agile behavior requires the continuous sensing and monitoring of the environment (Lu and Ramamurthy, 2011). Agile decisions and responses can be made when information and knowledge about an environmental change are rapidly shared among decision makers and team members as soon as the change is sensed. Thus, team agility (continuous sensing and rapid responses) can be facilitated by the fast sharing of knowledge in start-up teams.

Agility is also the ability to change swiftly in order to manage unpredictable changes effectively beyond normal flexibility (van Oosterhout et al., 2006). A high quality of knowledge must be shared for effective decisions and rapid responses. In this regard, agile firms require the right knowledge in the right place at the right time (Dove, 1999). The right knowledge is related to relevance and accuracy, and the right place and right time are related to relevance and timeliness among the properties of knowledge quality. Thus, the quality of shared knowledge can be closely related to team agility.

Further to the above discussion, this research proposes the following hypotheses.

H5a : Knowledge sharing speed is positively associated with the agility of start-up teams.

H5b : The quality of shared knowledge is positively associated with the agility of start-up teams.

Team expertise influences team creativity through the expertise-sharing process (Tiwana and McLean, 2005). A combining and integrating process is required for team creativity enhancement (Leenders et al., 2003). Thus, the knowledge-sharing process can be a precedent factor of team creativity and mediates the relationship between team knowledge state and team creativity.

Creative thinking is composed of divergent thinking, which is the idea-generation process, and convergent thinking, which is the evaluation process that derives high quality ideas (Cropley, 2006). Increasing the quantity of knowledge sharing indicates the increasing interaction among team members. In this way, various creative ideas can be generated. Thus, knowledge sharing plays a facilitating role for divergent thinking by providing sufficient knowledge for generating ideas.

Hence, the high quality of shared knowledge means that relevant and appropriate knowledge is shared among team members. If team members share a high quality of knowledge, convertgent thinking is effective because relevant and appropriate knowledge can provide a basis for evaluation and decision making.

Thus, the following hypotheses for team creativity can be derived.

H6a : Knowledge sharing quantity is positively associated with the creativity of start-up teams.

H6b : The quality of shared knowledge is positively associated with the creativity of start-up teams.

4. Research Method

4.1 Operational Definitions and Measurement Items

In this study, team knowledge depth is defined as the expertise level (Crosby et al., 1990). The scale for knowledge depth was adapted from the assessment measure of the expertise of service providers (Spake and Megehee, 2010). Knowledge breadth refers to how members differ in their current expertise and cognitive structures with respect to ongoing tasks (Tsai et al., 2014). Knowledge breadth measure was adapted from three items of knowledge heterogeneity (Tsai et al., 2014).

Knowledge sharing consists of three sub-dimensions : speed, quantity and quality. Speed refers to how rapidly knowledge is shared among team members. The scale for knowledge-sharing speed was adopted from knowledge-transferring speed of Pérez-Nordtvedt et al. (2008). Knowledge-sharing quantity refers to the volume of knowledge sharing in a team, and the quality of shared knowledge refers to the nature and helpfulness of the content and knowledge shared in a team (Chang and Chuang, 2011). The scale for knowledge sharing quantity was modified from three items from Chang and Chuang (2011). The quality of shared knowledge was adapted from six items from Chiu et al. (2006).

Team agility is defined as the ability to detect and seize competitive market opportunities through necessary assets, knowledge, and relationships (Sambamurthy et al., 2003). With regard to team agility, three items were adopted from Lu and Ramamurthy (2011) measuring operational adjustment agility. Team creativity refers to the degree to which a team's processes are novel in the context of the team's objectives and are measured by three items from Tiwana and McLean (2005).

IT support refers to the use of IT tools that support knowledge sharing process with the provision of features that encourage certain communication and collaboration practices (Choi et al., 2010). IT support was conceptualized as three components-communication, information processing, and information structuring. The measurement items for IT support were adopted from the measurement items of IT characteristics of Lee and Park (2016) and Lee (2015). Operationalized measurement items are presented in Appendix A.

4.2 Data Collection and Respondents Characteristics

A survey were conducted against start-up teams less than five years old since inception. The total number of respondents was 297. But 230 responses were used for analysis after eliminating 67 inappropriate responses. Sample characteristics are presented in <Table 1>.

The percentage of respondents in firms with five employees or fewer was 34.8% (80 samples). The percentage in firms with 6~10 employees was 29.1% (67 samples), and the percentage in firms with 11~20 employees was 20.4% (47 samples). Thus, most respondents 84.3%) were in firms with 20 employees or fewer.

〈Table 1〉 Sample Characteristics

Categories		No.	%
Firm Size (Employees)	less than 5 members	80	34.8
	6~10 members	67	29.1
	11~20 members	47	20.4
	21~30 members	15	6.5
	31~40 members	10	4.3
	41~50 members	11	4.8
Firm Sales	₩ 0.1 billion	55	23.9
	₩ 0.1~1 billion	107	46.5
	₩ 1~3 billion	43	18.7
	₩ 3~5 billion	15	6.5
	₩ 5~10 billion	6	2.6
	More than ₩ 10 billion	4	1.7
Team Project Duration	less than 6 months	126	54.8
	0.5~1 year	69	30.0
	1~3 years	27	11.7
	3~5 years	8	3.5
Team Size	less than 5 members	188	81.7
	6~10 members	38	16.5
	More than 11 members	4	1.7
Respondent Experience	less than 3 years	167	72.6
	3~5 years	40	17.4
	More than 5 years	23	10.0
Respondent Job	General affairs & HR	26	11.7
	Finance	20	8.7
	Sales & Marketing	50	21.7
	R&D	25	10.9
	Planning & Strategy	56	24.3
	IT Development & Management	29	12.6
	Security	2	0.9
	Production & Distribution	9	3.9
	Etc.	12	5.2
Total		230	100.0

With regard to the sales of respondents' firms, the percentage of those with sales of ₩100 million (about US$90,000) or fewer was 23.9% (55 samples), the percentage of those with sales of ₩100~1,000 million was 46.5% (107 samples), and the percentage of those with sales of ₩1~3 billion was 18.7% (43 samples). Thus, most respondents (89.1%) were in firms with sales of ₩3 billion or fewer.

With regard to the characteristics of respondents' teams, 54.8% (126 samples) of respondents were in teams that had been operational for six months or fewer, and the percentage in teams that had been operational for six months-one year was 30.0% (69 samples). Most respondents (81.7%, 188 samples) were in teams with less than five members.

5. Results

The partial least squares (PLS) method was applied for the analysis of the research model. Since this method is based on an element-based approach, it tends to be more generous with sample sizes or distributions (Lohmoller, 1989). In addition, PLS is advantageous for the simultaneous analysis of a measurement model and a structural model (Chin, 1998). The PLS method is also relevant for analyzing a relatively small size of samples and for exploratory study (Gefen et al., 2000). This research chose the PLS method for analysis because the conceptual framework was based on theories, whereas the detailed relationships and hypotheses among the variables and their sub-dimensions were derived through an exploratory approach.

SmartPLS 2.0 software were used with bootstrapping and a PLS algorithm. The next section presents the results of the measurement model analysis for reliability and validity among the measurement items and constructs. A structural model analysis section then follows in order to verify the research model and hypotheses.

5.1 Measurement Model Analysis

Reliability and validity tests were conducted for a confirmatory factor analysis. Reliability refers to the internal consistency of measurement items for the latent variables. The reliability analysis was conducted using Cronbach's α. The score of Cronbach's α for each variable is presented in <Table 2>. Every Cronbach's α coefficient exceeded a value of 0.8; thus, reliability for the measurement items was reasonable (Hair et al., 2006). If the factor loading of each measurement item for the designated latent variable exceeds 0.7, the item can be considered valid (Chin et al., 2003). As shown in <Table 2>, the value of the factor loading for each measurement item was over 0.7; however, but KDV3 was discarded because of negative loading (-0.734). Therefore, construct validity was confirmed except KDV3.

Composite reliability (CR) and average variance extracted (AVE) were considered for the convergent validity. The values of CR are presented in <Table 2> and the AVEs are presented in <Table 3>. The CR and AVE for each variable were above 0.7 and 0.5 respectively, indicating that the measurements were acceptable for convergent validity.

In order to determine the discriminant validity, the square root of the AVE and the correlation coefficient of each variable were compared. The square root of the AVEs and the correlation coefficients are shown in <Table 3> (the square roots of the AVEs are underlined). The square root of the AVEs for each variable was higher than the correlation coefficient with other variables. This means that the internal correlation of each latent variable is higher than the others. Thus, it was appropriate that the measurement items have discriminant validity (Fornell and Larcker, 1981).

〈Table 2〉 Indicator Properties of Variables

Variables	Measurement Items				Composite Reliability (CR)	Cronbach's α
	Items	Loading	Mean	S.D.		
Knowledge Depth	EXP1	0.878	4.991	1.125	0.928	0.897
	EXP2	0.845	4.813	1.063		
	EXP3	0.893	4.978	1.063		
	EXP4	0.878	5.087	1.122		
Knowledge Breadth	KDV1	0.869	3.457	1.158	0.883	0.736
	KDV2	0.908	3.265	1.063		
Knowledge-sharing Speed	KSS1	0.835	4.870	1.032	0.893	0.820
	KSS2	0.891	4.870	1.053		
	KSS3	0.846	4.809	1.148		
Knowledge-sharing Quantity	KSQ1	0.863	4.804	1.037	0.913	0.857
	KSQ2	0.889	4.743	1.086		
	KSQ3	0.892	4.730	1.166		
Quality of Shared Knowledge	QSK1	0.773	4.939	1.096	0.936	0.917
	QSK2	0.826	4.848	1.125		
	QSK3	0.879	4.713	1.100		
	QSK4	0.812	4.430	1.183		
	QSK5	0.897	4.852	1.076		
	QSK6	0.859	4.596	1.010		
Team Agility	TAG1	0.793	4.891	0.967	0.925	0.902
	TAG2	0.820	4.713	1.072		
	TAG3	0.846	4.852	1.059		
	TAG4	0.852	4.835	1.044		
	TAG5	0.802	4.783	1.096		
	TAG6	0.804	4.617	1.074		
Team Creativity	TCR1	0.930	4.457	1.034	0.890	0.815
	TCR2	0.884	4.648	1.126		
	TCR3	0.848	4.804	1.062		
Communication	COM1	0.890	5.043	1.253	0.921	0.884
	COM2	0.910	4.978	1.343		
	COM3	0.925	5.000	1.325		
	COM4	0.715	4.387	1.493		
Information Structure	IFS1	0.836	4.748	1.324	0.942	0.923
	IFS2	0.891	4.952	1.262		
	IFS3	0.878	4.887	1.356		
	IFS4	0.884	4.965	1.354		
	IFS5	0.885	5.035	1.341		
Information Process	IFP1	0.868	4.865	1.303	0.939	0.913
	IFP2	0.920	4.874	1.324		
	IFP3	0.891	4.696	1.339		
	IFP4	0.881	4.696	1.313		

〈Table 3〉 Correlations between Variables

Variables	AVE	KDP	KBR	KSS	KSQ	QSK	TAG	TCR	COM	IFS	IFP	TSZ	PDR
Knowledge Depth	0.76	0.87											
Knowledge Breadth	0.79	-0.57	0.89										
Knowledge-sharing Speed	0.74	0.61	-0.51	0.86									
Knowledge-sharing Quantity	0.78	0.56	-0.47	0.71	0.88								
Quality of Shared Knowledge	0.71	0.67	-0.59	0.74	0.76	0.84							
Team Agility	0.67	0.65	-0.42	0.63	0.66	0.73	0.82						
Team Creativity	0.73	0.53	-0.37	0.60	0.63	0.60	0.70	0.85					
Communication	0.75	0.34	-0.27	0.44	0.43	0.42	0.44	0.45	0.86				
Information Structure	0.77	0.37	-0.30	0.47	0.53	0.47	0.46	0.49	0.70	0.87			
Information Process	0.79	0.40	-0.34	0.44	0.43	0.45	0.46	0.47	0.79	0.82	0.89		
Team Size	1.00	-0.11	0.05	-0.09	0.03	-0.06	0.00	0.01	0.00	0.05	0.02	ns*	
Project Duration	1.00	0.01	-0.10	0.04	0.07	0.07	0.03	0.13	0.04	0.03	0.04	0.17	ns*

Diagonal values are square rooted AVE (underlined).
*AVE unavailable because these items are constructed as one item.

5.2 Structural Model Analysis

The bootstrapping method and PLS analysis were executed for the structural model analysis. The analysis results show that knowledge breadth seems to have a significantly negative associations with knowledge sharing speed (β = -0.198, t = 3.085); thus, **H1a** is supported. The relationship between knowledge breadth and knowledge-sharing quantity have statistical significance (β = -0.085, t = 1.396); thus, **H1b** is rejected. In addition, the relationship between knowledge breadth and the quality of shared knowledge shows statistical significance but is negatively related (β = -0.159, t = 3.308); thus, **H1c** is statistically not supported.

Among the relationships about knowledge depth and the knowledge-sharing process, the association between knowledge depth and knowledge sharing speed (**H2a**) is confirmed (β = 0.389, t = 5.266). The hypothesis regarding knowledge-sharing quantity, **H2b**, also revealed to be statistically significant (β = 0.135, t = 2.193). The association with the quality of shared knowledge (**H2c**) is also statistically significant (β = 0.207, t = 3.419).

IT support is revealed to maintain a significant relationship with knowledge-sharing speed (β = 0.263, t = 4.534) and quantity (β = 0.174, t = 3.624); thus, H3a and H3b are supported However, the relationship between IT support and the quality of shared knowledge (**H3c**) does not show statistical significance (β = -0.043, t = 0.951).

Next, with regard to the relationships among the sub-dimensions of the knowledge-sharing process, knowledge-sharing speed (**H4a**) shows a significant relationship with quantity (β = 0.587, t = 8.145). Knowledge-sharing speed has a significant relationship with quality (β = 0.254, t = 3.969). Quantity is also significantly associated with quality (β = 0.370, t = 5.643); thus, **H4b** and **H4c** are also accepted.

Both knowledge-sharing speed (β = 0.262, t = 3.029) and quality (β = 0.447, t = 8.590) show significant relationships with team agility; thus, **H5a** and **H5b** are accepted. Knowledge-sharing quantity has a significant relationship with team creativity (β = 0.450, t = 4.272). Quality also has a significant relationship with team creativity (β = 0.278, t = 3.052); thus, **H6a** and **H6b** are accepted.

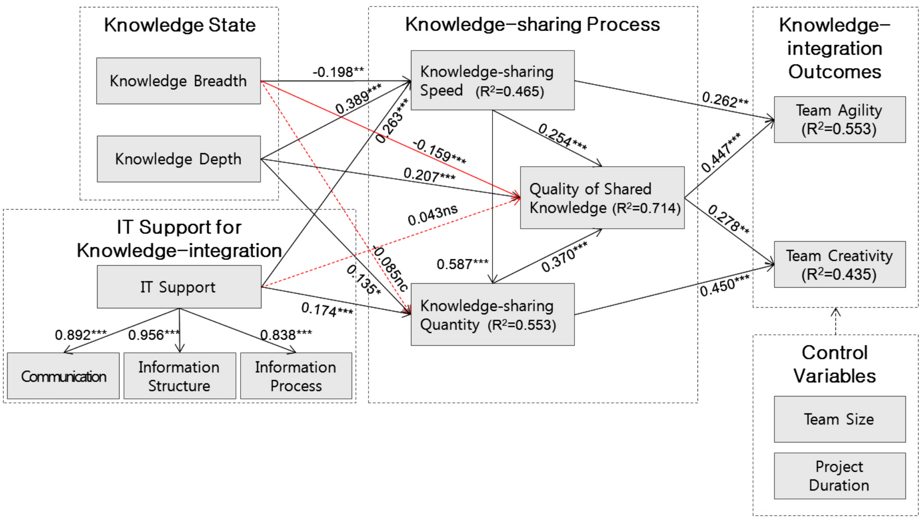
From the squared multiple correlations (R^2) of the endogenous latent variables, knowledge depth, knowledge breadth, and IT support explain 46.5% of the variance of knowledge-sharing speed. Knowledge sate and IT support with knowledge-sharing speed explain 55.3% of the variance of knowledge-sharing quantity. Knowledge-sharing speed and quantity explain 71.4% of the variance of quality. The knowledge-sharing process explains 55.5% and 43.5% of the variance of team agility and creativity.

In order to compare the effect of antecedents, this research additionally conducted an analysis of effect based on path coefficients. Knowledge depth has an indirect effect on team agility through knowledge process (β = 0.299) and has an indirect effect on team creativity with β = 0.286. Knowledge breadth negatively affects team agility with β = −0.165 and team creativity with β = −0.122. The effect of IT support on team agility is β = 0.153 and team creativity is β = 0.182.

6. Conclusions and Implications

6.1 Theoretical Implications

The results of this studies have theoretical implications. First, this study adopted a knowledge-based approach for the agility and creativity of start-up teams. In particular, prior research has rarely conducted investigation of agility and creativity as primary outcome constructs of start-up teams. Thus, future research concerning start-ups may wish to note that this study empirically tested the process of enhancing team agility and creativity by way of the knowledge process.



<Figure 2> Results of Structural Model Analysis

Second, this research investigated the detailed mechanisms of the knowledge-sharing process for start-up teams. In particular, knowledge-sharing speed was adopted as a preceding construct for agility and creativity. This study divided the knowledge sharing process into three sub-dimensions (speed, quantity, and quality) and investigated the relationships among them. Knowledge-sharing speed is found to be positively associated with both quantity and quality, and that it mediates the effects of contextual variables of knowledge breadth and width. Moreover, knowledge-sharing quantity has positive relationship with quality.

The hypotheses regarding the mechanism of the knowledge-sharing process were strongly supported. Speed, as one of the sub-dimensions of knowledge sharing, has rarely been considered, but was proposed as worthy of consideration as an important mediator of the knowledge-integration process. In particular, speed fully mediates the association between knowledge breadth and quantity, and quantity fully mediates the association between IT support and quality.

Third, knowledge breadth shows negative relationships with speed and quality of knowledge-sharing, and it does not have significant relationship with quantity. These results can be taken to mean that teams in their early stages such as start-ups do not have sufficient ability to manage excessively heterogeneous knowledge because they are in the stage of building team processes or procedures. This is consistent with the prior researches that suggest the non-linear effects or duality of knowledge breadth (Lee et al., 2012; Tiwana and McLean, 2005).

Fourth, it is interesting that IT support is revealed as having significant relationships with knowledge sharing speed and quantity but does not have a strong direct association with knowledge-sharing quality. Thus, it can be concluded that IT support plays a facilitating role regarding knowledge-sharing speed and quantity.

Finally, it is explicated here that three different but related contextual knowledge states play different roles in the knowledge sharing process. Knowledge breadth has negative relationships with knowledge-sharing speed and quality, whereas relationship with quantity was found to be insignificant.

6.2 Practical Implications

First, it is proposed and partly confirmed that team agility and creativity as a critical outcome of knowledge sharing process, especially in start-up teams. As theoretically, potential for the survival and success of start-ups can be judged from agility and creativity, further studies are needed to explicate antecedents and actual outcomes of these agility and creativity. For investors considering investing in start-ups, agility and creativity can be recommended as practical indicators for evaluating the possibility of growth. Conventional teams also need to regard agility and creativity as key success factors in this rapidly changing environment.

Assuming that start-up consider knowledge as a valuable resource and agility and creativity as core competencies, this research investigated the mechanisms of the knowledge-sharing process and their effects on agility and creativity. The results indicate that teams in start-ups can enhance agility and creativity with appropriate knowledge sharing with breath and depth. The results also confirmed that IT support is significantly associated with knowledge sharing. However, knowledge state and IT support have to be managed with care because knowledge sharing and IT support have a complementary relationship and knowledge breadth has negative associations with knowledge sharing. With regard to early-stage firms, knowledge breadth can have negative effect; thus, common knowledge base must be built at the beginning for effective and continuous knowledge sharing and integration afterwards.

The quality of knowledge sharing is related more to the team knowledge state, and quantity is related more to IT support. In order to enhance the qualitative aspect of knowledge sharing, team knowledge expertise should be raised and the heterogeneity of team members should be lowered. In contrast, in order to increase the quantity of shared knowledge, IT support should be reinforced for knowledge-integration. Because IT support is confirmed as a crucial factor for the knowledge-sharing process, it is recommended that IT support such as communication, search facilities, and information storage are provided in order to facilitate knowledge sharing among team members.

Finally, with regard to team agility, start-up teams need to share high quality knowledge rapidly. In addition, with regard to team creativity, start-up teams should share plenty of varied knowledge among team members.

6.3 Limitations and Future Research

This research has the following limitations. First, data were collected from individual respondents. For team-level analysis, it is recommended that data be collected from multiple sources in each team; however, this research collected data from a single source from each team. There is a possibility that individual bias may exist in the measurement of the team-level constructs.

Second, knowledge linkage-one of the constructs concerning knowledge sate was not included in the research. In order to focus on the internal process of knowledge sharing and its relationships, this study did not consider external factors. However, agility requires continuous sensing of, and responses to, external changes; thus, an external source of knowledge must be considered.

Finally, according to the results, the values of the explanatory power for all dependents are over 40%. This implies that applying knowledge based view on start-up teams is strongly supported. However, interpreting results needed to be done with care about common method bias because measuring variables in this research commonly depends on the perceptions of respondents.

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◈ About the Authors ◈

Seyoon Lee (suyfj77@gmail.com)

Seyoon Lee is a research fellow in Center for Work Science, Yonsei University. He received the BS degree at Seoul National University in 2000, MS and Ph.D in Information Systems from Graduate School of Information (GSI), Yonsei University in 2007. His research interests are communication with ICT, IT project management and changing nature of work.

Hyejung Lee (h.jlee@yonsei.ac.kr)

Hyejung Lee is a Research Professor in Institute of East and West Studies, Yonsei University, and Adjunct Professor of Kyung-Hee University Business School MBA. She received BBA from the Korea University, MS and Ph.D in Information Systems from the Yonsei University. Between BBA and MS, she worked as a Researcher at the National Information Society Agency in Korea. Her research interests include small team, new work environment of the future and IT service related issues.

Jungwoo Lee (jlee@yonsei.ac.kr)

Jungwoo Lee is a Professor of Information Systems and the Director of the Center for Work Science at the Yonsei University, Republic of Korea. He received his PhD in Computer Information Systems from the Georgia State University in 1998. His research interests are focused primarily around social and organizational changes incurred by information and communication technologies.