

Impact of tie strength on knowledge sharing: Focusing on the moderating effect of environmental uncertainty

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유대강도가 지식공유에 미치는 영향: 환경불확실성의 조절효과를 중심으로

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Abstract This study aims to investigate how tie strength in business networks affects successful knowledge sharing, as well as the impact of environmental uncertainty on the relationship between knowledge sharing and tie strength. We gathered data through a questionnaire-based survey of 310 employees affiliated with a high-technology industry in Korea. The results highlighted the positive influence of strong ties on tacit knowledge sharing and weak ties on explicit knowledge sharing. Additionally, in this study, we determine that strong ties are strengthened to share tacit knowledge with exchange parties when environmental uncertainty is high, whereas weak ties may remain unaffected by environmental uncertainty. This study contributes to the literature on tie strength and knowledge sharing by applying social capital theory to a high-technology industry. The findings suggest that firms must take advantage of strong and weak ties to facilitate knowledge sharing to enhance competency, create novel knowledge, and obtain a competitive advantage.

Key Words : strong ties, weak ties, tacit knowledge, explicit knowledge, environmental uncertainty

요약 본 연구의 목적은 비즈니스 네트워크의 유대강도가 지식 공유에 미치는 영향과 환경 불확실성이 유대 강도와 지식 공유에 미치는 영향관계를 조사하는 것이다. 국내 첨단산업 종사자 310명의 설문조사 결과를 바탕으로 통계적 분석 및 제안된 가설들을 검증했다. 분석결과, 강한 유대는 암묵적 지식 공유에 영향을 미치고 약한 유대는 명시적 지식 공유에 긍정적인 영향을 미치는 것으로 나타났고, 환경 불확실성이 높을 때 강한 유대는 암묵적 지식 공유를 강화하는 경향이 있는 반면 약한 유대는 환경 불확실성의 영향을 받지 않는 것으로 확인할 수 있었다. 본 연구는 사회적 자본이론을 첨단산업에 적용하여 유대강도 및 지식공유를 연구함으로써, 기존의 기업간 유대 및 지식공유 연구를 뒷받침한다. 이 연구 결과는 기업의 역량, 새로운 지식 창출, 경쟁 우위확보를 위한 중요 요인인 지식 공유를 촉진하기 위해 유대강도를 전략적으로 활용해야 함을 시사한다.

주제어 : 강한 유대, 약한 유대, 암묵적 지식, 명시적 지식, 환경 불확실성

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1. Introduction

A majority of firms retain valuable knowledge about conducting business, including the experiences and skills concerning management, technologies, and processes of their employees[1,2]. However, an individual firm cannot possess all avenues for growth and innovation without interacting with other firms. As such interaction intensifies, technological innovation through research and development activities becomes significant[3]. Thus, companies are required to interact with partnering companies to obtain knowledge, such as related to technology and business, for continuous development, growth, and maximum advantage[2-7].

Knowledge sharing is dependent on the social interaction between employees and organizations[8,9], facilitating an increase in agility, competency, and quality of the processes. Additionally, it reduces the cost of obtaining knowledge, improves productivity, and strengthens performance and innovation capabilities[10-12].

Knowledge-based theory emphasizes interfirm knowledge sharing, providing explanation of knowledge production for sustainable and competitive advantage and strategic decision-making[1,6,7,13]. However, various knowledge-sharing studies have shown that organizations focus on their strategies to guide employees regarding knowledge sharing as a valuable asset for all levels, including individuals, teams, departments, and organizations[4,10,11,14-17]. Although the importance of employing external capabilities, such as knowledge has been underscored by literature[5,9], significant research on inter-organizational knowledge sharing is lacking[2].

The extant literatures recognize social capital as a crucial factor in facilitating knowledge sharing[16,18,19-23]. Social capital lies in the relationships between network members[24]. Firms embedded in the social network within the

industry obtain interfirm cooperation and facilitate knowledge sharing through members' interactions[9,25,26]. These social networks are characterized by tie strength, such as strong and weak ties, in terms of the frequency of interaction and level of emotional intensity[27].

A few studies indicate that strong interfirm ties provide high-quality and in-depth knowledge [11,22,28], whereas weak ties provide the firm access to a diverse and novel knowledge base, and reduce redundancy[12,29]. These ambiguous findings motivated us to investigate how tie strength, as a structural dimension of social capital in business networks, affects successful knowledge sharing.

This study contributes to the extant literature in three forms. First, it contributes toward social capital in the interfirm context by interpreting how social capital facilitates knowledge sharing between companies. Second, it introduces interfirm tie strength and investigates the effects of tie strength levels on tacit and explicit knowledge sharing. This study is meaningful in expanding the impact of tie strength levels on both, tacit and explicit knowledge by focusing on interfirm relationships within high-technology industries, which have not been previously investigated. Third, it explains how environmental uncertainty affects the relationship between tie strength and knowledge sharing. As interfirm relationships are impacted by changing environments[30,31], we expect the relationship between tie strength and knowledge sharing to also be affected.

2. Theoretical Backgrounds and Hypotheses

2.1 Tacit and Explicit Knowledge

In accordance with the social network theory, network ties allow access to resources embedded

in social relationships[22,24,25]. Knowledge is claimed to be the most valuable resource[4,11,14,15,17,19,20].

It can be divided into tacit and explicit knowledge[26,32,33], both of which are critical factors of organizational knowledge for learning novel technology, creating competencies, and solving problems[7,33,34].

Tacit knowledge comprises personal experiences, learning, and practical skills[26]. As tacit knowledge is inherently complicated, unique, and ambiguous, it is challenging to articulate and learn, and time consuming to replicate and transfer[4,15,26,34,35]. The ability and willingness of the individuals concerned are crucial to the complex process[11,35]; therefore, face-to-face interaction, dialogue, and observation of behaviors in certain situations are the best approaches for sharing and learning of tacit knowledge[35]. Thus, the transfer of tacit knowledge is likely to be predicated on the intensity of the relationship between the exchange parties[2,11].

An individual's tacit knowledge is the foundation for an organization to create knowledge, because experiences, ideas, and skills that might not have been elaborated thoroughly can be resources that turn knowledge into products and services, and prevent imitation by a competitor[15]. Tacit knowledge, thus, helps build core competencies, develop new products, and plays a vital role in innovation and competitive advantage of an organization[15,26,33].

Meanwhile, explicit knowledge, which includes well-written documents, reports, handbooks, textbooks, and manuals, is coded, stored, articulated, and externalized[26,32]. This knowledge can be easily accessed by members and used as a source of organized formal knowledge[7,26,32].

The attributes of explicit knowledge simplify sharing and transmission among organization members through multidirectional and formal procedures[15]. As compared to tacit knowledge,

less effort is required to interact with explicit knowledge transfer[15]. Furthermore, explicit knowledge sharing strengthens an organization's capabilities, as it promotes the creation of novel knowledge through reintegration of knowledge within the organization[4,6]. It also facilitates collaboration, coordination, and integration between members and departments, and enables the organization to adapt to changes in the environment[6].

However, when an organization shares its explicit knowledge with other firms, it risks its exploitation, as explicit knowledge can be easily scattered and replicated[6,29]. Exchange parties are also prevented from free riding and are encouraged to find methods to reduce costs associated with exploring and accessing valuable knowledge[14].

Knowledge sharing between exchange parties is crucial for strategic decision-making, problem-solving, and business sustainability, as well as for gaining an interfirm competitive advantage[4,7,8,9]. As a precondition for successful knowledge sharing between them, exchange parties are required to build a trusting relationship and be motivated to share valuable knowledge[15,21]. Furthermore, knowledge sharing, recognized as a performance enhancer, fosters innovation capability of organizations, and accelerates success[4,22]; this has been argued to result from knowledge and experience of exchange partners[9,19].

2.2 Strength of ties

The ties among exchange parties organize an interfirm network, acting as social capital composed of networks, norms, values, and social trust in an organization[27]. These ties expedite collaboration and coordination for mutual benefit among social actors[24]. Social capital is embedded in the relationships that support an organization in gaining a competitive advantage[36], unlike physical and human capital

that enable production[24]. The features of social capital have been divided into three dimensions: structural, relational, and cognitive[22,27].

First, the structural dimension. It includes social and network relationships that define how exchange parties connect, and to whom[17,22]. This dimension can be measured by such attributes as network ties, network density, interaction intensity, social interaction, and hierarchy[8,20]. The structural dimension of social capital is assembled by bonding and bridging, focusing on the network structure when divergent networks and norms exist[24]. Putnam (1995) asserted that social capital derived from bridging weak ties is inclusive and improved, for linkage to external resources and information diffusion. This notion fits with Granovetter's (1983) seminal research on job seekers, which argues that members of networks in the bridging dimension of social capital are able to explore connections with external assets and disseminate information.

By contrast, strong ties, such as bonding, are exclusive, rather than inclusive[24]. The actors with bonding social capital have comparatively less diversity in their backgrounds; however, they possess stronger connections. This bonding develops when strongly connected individuals provide emotional or substantial support to one another[24].

Some researchers argue that there is no comprehensive measure of social capital that distinguishes strong and weak ties; this is because the two types of structural dimensions are related, but are not mutually exclusive[12,24]. However, Ramos-Pinto (2006) insisted that there was a methodological limitation when the contradictory aspects of both networks and norms were placed in a single category. Furthermore, some researchers have studied the role of strong and weak ties as antecedent variables[18,38]; similarly, certain extant literature has distinguished strong ties from weak

ties to posit benefits in knowledge sharing [11,19,20,22]. Thus, in this study, we classify social network into strong and weak ties as separate variables, based on the strength of social relationships and the norm of opportunities to reach out to new resources.

Second, the relational dimension. It refers to the trust that is developed during social interactions to exchange resources[20]. Trust, obligation, reciprocity, and norms contribute to an increase in the awareness of collective goals, reduce opportunistic behavior, and facilitate collaborative behavior among members[22].

Third, the cognitive dimension. It describes resources that enhance comprehension among social actors[17,20]. Shared cultures, goals, and vision are important factors for obtaining a shared understanding, to facilitate the exchange of resources and provide a stable infrastructure for further collaboration and communication[8,17,20].

In this study, we focus on the structural dimension to examine the relationship between tie strength and knowledge sharing.

2.3 The effect of strength of ties on tacit and explicit knowledge

Based on network theory, a network can be a source of innovation that helps create novel knowledge[4,25]. Network theory pays particular attention to the nature of ties. Granovetter (1983) supported the notion that the strength of a tie is divided into strong and weak based on the duration and frequency of interaction, level of emotional intensity and intimacy, and the degree of reciprocity between individuals, communities, and organizations in the social network.

People with strong ties are likely to trust their relationships[16]. When a strong tie exists within a group, it represents shared interests, professions, school relations, geographical location, or other associations, as well as relationships, such as those with family and close friends[27]. The ties in these networks allow

individuals to access and exchange valuable resources[20], such as goods, services, knowledge, information, and social support[2,25,27].

However, the information and knowledge acquired through strong ties in a cohesive network can be redundant[22]. This is because individuals are likely to be connected to each other and be aware of the same information[11,27,36,39]. Therefore, this cohesive network renders inefficient the transmission of less diverse information and knowledge[22]. Moreover, maintaining such a relationship is costly, as strong ties require frequent interaction and investment in the form of time and emotional intensity[10,22].

As exchange parties build strong ties, they assess the other's expertise and skills, seeking advice in areas where others are more competent [16]. Furthermore, strong ties are expected to facilitate the transfer of a greater volume of fine-grained and complex knowledge[11,28], which is rooted in attitudes in a specific context[26], through the observation of close personal relationships[26,32,33].

The extant research highlights the importance of strong ties as a channel of useful knowledge[11,16,22,28]. Subsequently, the willingness to share tacit knowledge with others is influenced by this relationship. This leads to the following hypothesis:

H1: Strong ties are positively related to tacit knowledge sharing.

By contrast, weak ties refer to infrequent interaction, a lower degree of emotional intensity, and a lower reciprocity of feelings[27]. Such ties exist among diverse people with heterogeneous backgrounds, experiences, and knowledge[27,39]. They do not comprise of a close and robust relationship because of their diversity[27,39]. Thus, weak ties appear in social relationships that do not prioritize responsibility

for each other, such as business relationships in a wide range of networks[12,27,39].

Weak ties are advantageous for the acquisition and diffusion of diverse information, with novel and varied knowledge[36,40]. This knowledge becomes non-redundant and spread rapidly and widely, between individuals and other groups in the network, as weak ties tend to act as bridges[12,27,39].

Granovetter (1983) argued that weak ties are better sources of novelty than strong ties, as the former link unconnected information and individuals, and combine ideas and knowledge from one resource to another. Thus, weak ties are beneficial for resources, such as information, knowledge, and projects[12,40], which may further contribute to innovation and creative ideas that require explicit knowledge[11]. To promote innovation, organizations require novel and diverse sources of information. Weak ties can contribute to innovation in an organization because, as more diverse organizations form networks, more innovative and creative ideas develop[23].

The social actors connected by weak ties are independent of each other for the most part and maintain a limited relationship such that both, their commitment and cost of maintaining the relationship are low[11,12,29,36]. Thus, weak ties lead to the diffusion of knowledge, as they link different types of people in diverse groups, networks, and communities. These considerations form the basis of the following hypothesis:

H2: Weak ties are positively related to explicit knowledge sharing.

2.4 Moderating role of environmental uncertainty

Environmental uncertainty refers to unpredictable changes in the external environmental circumstances of an organization[41]. Milliken (1987) argued that environmental uncertainty arises from a failure to understand the changes

in the external environment, and from a lack of information about causality, resulting in an inability to predict the outcome of decision-making. Consequently, environmental uncertainty can complicate the prediction of the concrete condition of the environment by the firm[30].

The impact of interfirm relationships on knowledge sharing may diverge in situations of high environmental uncertainty, as such volatility is regarded as a significant factor influencing knowledge sharing[43-47].

In an unstable environment, extant studies suggest that high levels of knowledge should be better leveraged[43,47]. To alleviate the resources, such as information and knowledge constraints imposed by high environmental uncertainty, firms strive to gain access to a variety of knowledge acquisition channels, accelerate efforts for knowledge acquisition, minimize potential risk, and facilitate problem-solving; this, in turn, strengthens knowledge sharing with exchange parties under situations of environmental uncertainty[43,44,47].

By contrast, some researches state that uncontrollable environmental uncertainty motivates exchange parties to make specific investments for transaction, coordination, and governance[30,44]. Such a situation further increases the threat of opportunism, as exchange parties cannot anticipate and specify every contingency[30,31,44,46]. Liao and Hu (2007) found a negative relationship between environmental uncertainty and knowledge sharing, implying that environmental uncertainty could potentially hamper knowledge sharing and encourage firms to develop their own knowledge for a sustained competitive advantage. Long et al. (2014) also posit that environmental volatility hinders knowledge sharing and can enable opportunism, thereby inhibiting knowledge sharing in inter-organizational relationships.

When the environment is relatively stable and predictable, exchange parties can easily identify

the information and knowledge that are valuable to the business. However, in an uncertain environment, the ability to determine whether knowledge is necessary and beneficial decreases, and the demand for knowledge sharing increases, but there is a limit in that it is more exposed to the risk of opportunism[45].

Relationships with exchange parties are crucial for the access, acquisition, and sharing of knowledge[8,10]. Therefore, strong ties relationships are built based on trust[16] are strengthened as a means to facilitate knowledge sharing because the risk of opportunism is low under conditions of environmental uncertainty.

Weak ties that are scarcely dependent on exchange parties and bear a limited relationship, pose a potential risk associated with opportunism [45,46,49] and weaken the relationship between weak ties and knowledge sharing.

Considering these discussions, the following hypotheses are posited:

- H3: The environmental uncertainty strengthens the relationship between strong ties and tacit knowledge sharing.
- H4: The environmental uncertainty weakens the relationship between weak ties and explicit knowledge sharing.

3. Research Methodology

3.1 Research setting and data collection

In this study, we investigated whether tie strength has an impact on knowledge sharing, as well as whether the relationship between tie strength and knowledge sharing is moderated by environmental uncertainty. <Figure 1> presents our research model, which consists of five constructs.

We conducted this research through a questionnaire-based survey; data were collected from employees affiliated with the high-technology

industry in Korea. Specifically, knowledge is considered a strategic asset for the high-technology industry and a basis for competitive advantage [6,13,29]. Employees in a highly creative and technology-intensive industry are required to share knowledge while performing their jobs, and to create new knowledge by sharing and dealing with other parties [1,6,13]. It is, thus, crucial for firms in the high-technology industry to absorb knowledge and obtain insights from their interactions with business partners [3,5].

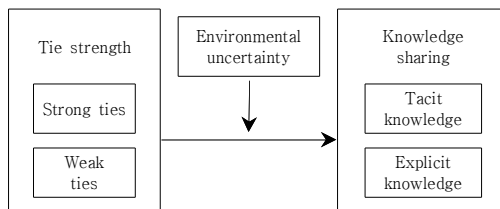


Fig. 1. The research model

Out of the 1,470 employees and managers, 337 respondents provided data for this study, with a response rate of 22.9%. Of these, 27 respondents were excluded for several missing answers, yielding a final sample size of 310 participants. Among them, 60% were male ($n=186$) and 40% were female ($n=124$). The majority of the respondents were in their forties ($n=99$, 31.9%), followed by those in their thirties ($n=84$, 27.1%), and finally those in their fifties ($n=80$, 25.8%). With regard to their professional position, the majority of the respondents were staff ($n=186$, 60%), followed by team leaders ($n=94$, 30.3%), and finally general managers or directors ($n=30$, 9.7%). The work experience of the respondents was classified as 10–19 years ($n=91$, 29.4%), 5–9 years ($n=85$, 27.4%), 3 years or less ($n=54$, 17.4%), over 20 years, and 3–4 years ($n=40$, 12.9%). Thus, 69.7% of the total number of respondents had more than five years of work experience. They were qualified to respond, and exhibited sufficient knowledge and understanding of

business-to-business relationships based on their work experience.

3.2 Method

Each variable in this study was conceptualized as several items. All items measuring the research variable were adopted and revised from prior studies to secure content validity, and were measured using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

We employed four items developed by Levin and Cross (2004) to measure strong ties, which describe the extent of parties' interaction frequency and closeness. The items constructed for the weak ties reflect the substantiality of obtaining novel information and the opportunities to develop relationships with new parties. The items chosen to assess the level of weak ties were selected from Appel (2014) and Williams (2006). Tacit knowledge sharing constructs describe the degree to which a firm shares knowledge and skills with partners, based on their experience. The four items for assessment of tacit knowledge-sharing constructs were developed based on the works of Ganguly et al. (2018), Lee (2001), Lin (2007), and Wang and Wang (2012). We followed a three-item scale for explicit knowledge sharing developed in the same research to measure the extent to which the parties shared knowledge in formal and codified structures. Finally, as for environmental uncertainty, which describes the extent to which firms encounter unpredictable and uncontrollable changes in external environmental conditions – three items based on the research by Noordewier et al. (1990) were used.

4. Results

4.1 Reliability and validity

Before examining the hypotheses, statistical

programs SPSS 24.0 and AMOS 26.0 were employed for analysis. In the first step, Cronbach's alpha coefficients were verified by analyzing the internal consistency reliability. Cronbach's alpha value was greater than 0.7 for all factors (strong ties = 0.824, weak ties = 0.824, tacit knowledge sharing = 0.817, explicit knowledge sharing = 0.752, environmental uncertainty = 0.731), which confirms the internal consistency of the constructs.

We then subjected the items to a confirmatory factor analysis (CFA) and examined reliability to confirm the construct validity and reliability of the variables. The fit indices showed this research model to fit the data sufficiently, with $\chi^2/df = 1.635$, goodness-of-fit index (GFI) = 0.930, adjusted goodness of fit index (AGFI) = 0.904, comparative factor index (CFI) = 0.967, and root mean square error of approximation (RMSEA) =

0.045[50,51]. The all-item loadings were higher than 0.5 with a significance at the 0.001 level. The construct reliability levels of the measurement scale ranged between 0.765 to 0.876, and the average variances extracted (AVE) value ranged between 0.521 to 0.640, thus indicating sufficient convergent validity[50]. A summary of the statistics of the measurement analysis, including the standardized loadings factor of the items, AVE, and construct reliability (CR) employed in the research, is shown in Table 1.

The discriminant validity of the measurement scales was confirmed by testing whether the value of correlation coefficient $\pm 2 \times$ standard error (SE) did not equal 1[52]. Discriminant validity for all variables that met the validity criteria is presented in Table 2.

Table 1. Summary of the confirmatory factor analysis (CFA) results

Constructs	Measurement items	Standardized loading	CR	AVE
Strong ties	Our firm has a very close working relationship with partners.	0.842	0.876	0.640
	Our firm has enough interaction with partners.	0.767		
	Our firm frequently meets partners.	0.655		
	Our firm frequently communicates with partners.	0.727		
Weak ties	Interacting with partners gives me new people to talk to.	0.741	0.856	0.598
	Based on the partners with whom I interact, it is easy for me to gain new information.	0.672		
	Interacting with partners makes me want to try new things.	0.755		
	Interacting with partners makes me feel like part of a larger community.	0.778		
Tacit knowledge	People in our firm and partners frequently share knowledge based on their experience.	0.673	0.860	0.606
	People in our firm and partners frequently share skills (methodologies, tools, process) and knowledge with others based on their expertise.	0.749		
	People in our firm and partners will share lessons from past success and failures stories.	0.733		
	Learn-by-observing and learn-by-doing for individuals directly involved in use of the knowledge.	0.754		
Explicit knowledge	People in our firm and partners frequently share official documents including reports and manuals with each other's.	0.745	0.765	0.521
	People in our firm and partners can freely access to majority of documents and information.	0.714		
	The business routines and processes of our firm and partners are documented and can be easily imitated	0.656		
Environmental uncertainty	It is very difficult to estimate the demands for our major products in the market.	0.608	0.768	0.527
	Our major products in the market are highly volatile.	0.801		
	It is very difficult to estimate the change of technology for our major products.	0.666		

$\chi^2=204.330$ (df=125, $P<.001$), $\chi^2/df=1.635$; GFI=0.930; AGFI=0.904; CFI=0.967; RMSEA=0.045

Table 2. Discriminant validity

Construct		Construct	Estimate	2* S.E.	-	+
Strong ties	<->	Weak ties	0.754	0.072	0.682	0.826
Strong ties	<->	Tacit knowledge	0.708	0.064	0.644	0.772
Strong ties	<->	Explicit knowledge	0.541	0.066	0.475	0.607
Weak ties	<->	Tacit knowledge	0.805	0.084	0.721	0.889
Weak ties	<->	Explicit knowledge	0.748	0.090	0.658	0.838
Tacit knowledge	<->	Explicit knowledge	0.844	0.088	0.756	0.932
Explicit knowledge	<->	Environmental uncertainty	0.349	0.072	0.277	0.421
Weak ties	<->	Environmental uncertainty	0.326	0.070	0.256	0.396
Tacit knowledge	<->	Environmental uncertainty	0.295	0.062	0.233	0.357
Strong ties	<->	Environmental uncertainty	0.163	0.050	0.113	0.213

4.2 Hypothesis test

In this study, AMOS (version 26.0) for Windows was used to test research model based on theories and the hypotheses. The model fit analysis results showed $X^2=359.807$; $df=177$; $X^2/df=2.033(p=0.000)$; $GFI=0.907$; $AGFI=0.867$; $NFI=0.843$; $IFI=0.914$; $CFI=0.912$; $TLI=0.896$; and $RMSEA=0.058$, thus indicating the appropriateness of the study model for hypothesis testing[50,51].

Table 3. The result for H1 and H2 testing

H	Description	Estimate	C.R.	P	Results
H1	Strong Ties -> Tacit Knowledge	0.801	6.788	$P<0.001$	Supported
H2	Weak Ties -> Explicit knowledge	0.811	5.392	$P<0.001$	Supported

$X^2/df=2.033$; $GFI=0.907$; $AGFI=0.867$; $CFI=0.912$; $RMSEA=0.058$

Table 3 shows the hypotheses and analysis results. Strong and weak ties were employed as independent variables, while tacit and explicit knowledge sharing were employed as the dependent variables. Strong ties influenced tacit knowledge sharing ($P<0.001$), thus supporting H1. Strong ties are built based on trust, and are likely to facilitate exchange parties in sharing tacit

knowledge based on an individual's experience and skills.

Weak ties had a significant positive effect on explicit knowledge sharing ($P<0.001$), thus supporting H2. Weak ties are beneficial for sharing codified knowledge that can be easily transferred.

To assess the moderating effect of environmental uncertainty, we conducted a multi-sample analysis using AMOS and divided the sample into two groups[53]: low environmental uncertainty and high environmental uncertainty, at the mean of environmental uncertainty, and further assessed regression weights and critical ratios for group differences[53].

Table 4. Path wise moderation effect – group differences for H3 and H4

H	Description	Low environmental uncertainty		High environmental uncertainty		Z-score
		Coefficient	t	Coefficient	t	
H3	Strong Ties -> Tacit Knowledge	0.478	3.211**	1.105	9.117***	2.095*
H4	Weak Ties -> Explicit knowledge	0.577	5.206***	0.737	7.218***	1.052

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

The results in Table 4 indicate that strong ties have a significant positive effect on tacit knowledge sharing in both, low ($B=.478$, $t=3.211$) and high ($B=1.105$, $t=9.117$) environmental uncertainty. The effect of strong ties on tacit knowledge sharing is stronger in the high environmental uncertainty group than in the low environmental uncertainty group, with a significant difference ($Z\text{-score} = 2.095$)[52], thus supporting H3. Weak ties have a significant positive effect on explicit knowledge sharing in both, low ($B=.577$, $t=5.206$) and high ($B=.737$, $t=7.218$) environmental uncertainty. However, as a result of the moderating effect testing, there is no statistically significant difference ($Z\text{-score} = 1.052$) between the low and high environmental

uncertainty groups for the effect of weak ties on explicit knowledge sharing. Therefore, H4 is not supported. In sum, environmental uncertainty moderated the relationship between strong ties and tacit knowledge sharing; however, it did not moderate the relationship between weak ties and explicit knowledge sharing.

5. Conclusion

This study aimed to determine the influence of tie strength, as the structural dimension of social capital on knowledge sharing, as well as how environmental uncertainty affects the relationship between tie strength and knowledge sharing.

We focused on the effects of strong ties on tacit knowledge sharing. Because strong ties are built on a high level of interaction, they encourage trustworthiness among exchange parties. Tacit knowledge is challenging to articulate and learn, and requires more time and investment to share and imitate. Eventually, exchange parties encourage each other to share tacit knowledge that is mutually beneficial because they maintain a stable and reliable relationship based on trust.

Our results demonstrate that weak ties, which are likely to be rooted among organizations in a wide range of networks, facilitate the sharing of explicit knowledge. The exchange parties in weak ties relationships can obtain novel, non-redundant, and codified knowledge. However, exchange parties must consider the risk of unethical sharing because explicit knowledge can be easily shared and replicated.

Finally, we focused on the effects of environmental uncertainty on knowledge sharing. Based on the results, strong ties are strengthened to share tacit knowledge with exchange parties when environmental uncertainty is high. In contrast, weak ties may not be affected by environmental uncertainty. Consequently,

knowledge sharing is likely to be influenced by environmental uncertainty, based on the relationships with exchange parties.

Given the growing importance of social network research and knowledge sharing, these results have several implications.

First, this study contributes to the literature on social capital in the interfirm context and addresses the structural dimension of social capital that enhances knowledge sharing. The structural dimension facilitates and plays a crucial role in effective knowledge sharing. This view is supported by the extant literatures[16,18,19,20–23].

Second, this study introduces interfirm tie strength and investigates its effect on tacit and explicit knowledge sharing. Knowledge is provided through a social network, as tie strength is an antecedent of knowledge sharing among exchange parties. Thus, exchange parties have reliable relationships that motivate them to share valuable knowledge, regardless of it being tacit or explicit, and facilitate organizations in gaining a competitive advantage[4,8,19,21]. Specifically, prior researches have indicated that strong ties promote a greater motivation to facilitate the transfer of a greater volume of fine-grained information and complex knowledge[11,21,28], while weak ties facilitate sharing of explicit knowledge[29]. The findings of this study adhere to these results. Most studies have focused on the relationship between a particular attribute of ties and a specific type of knowledge, such as tacit or explicit[4,8,19,21]. Furthermore, this stream of research has been conducted in an intrafirm manner[10,11,14,16,17], rather than in an interfirm manner[12]. In the present study, we conclude by examining the impact of tie strength levels on both, tacit and explicit knowledge, simultaneously. This study contributes to the literature on tie strength and knowledge sharing by focusing on previously unexplored interfirm relationships in high-technology industries.

Finally, this study suggests that environmental uncertainty plays a role based on tie strengths, and seeks to address a gap in the literature by demonstrating that it impacts knowledge sharing. Specifically, environmental uncertainty strengthens the positive relationship between strong ties and tacit knowledge sharing to minimize potential risks and obtain a sustained competitive advantage in interfirm networks, consistent with the findings of Autio et al. (2000) and Xu et al. (2012).

However, from a theoretical perspective, the finding of an insignificant relationship between weak ties and explicit knowledge sharing may not be completely out of place under environmental uncertainty. This finding is also not consistent with the research by Liao and Hu (2007) and Long et al. (2014), which indicated that environmental uncertainty hinders knowledge sharing and negatively moderates the relationship with knowledge transfer.

In this era of rigorous competition, knowledge is essential for a long-term competitive advantage. As a transfer object, knowledge has recently become more complex because of the knowledge-based and technology-intensive characteristics of the high-technology industry. The most significant implication for firms seeking to facilitate knowledge sharing is the development of sustainable and reliable relationships with exchange parties. Our findings demonstrate that both, strong and weak ties are used for different types of knowledge sharing, and provide insights and recommendations on relationships with exchange parties.

Firm managers should stimulate the development of both strong and weak ties, if the firm intends to partake in knowledge sharing. For example, the firm could structure work teams or particular projects that can help build relationships and encourage employees to participate actively in social networking in the industry. Given that prior research has revealed

that weak ties are less expensive to maintain[11], our findings on the benefits of weak ties are particularly encouraging for individual employees. The staff may realize that focusing on the expansion of relationship development is a cost-effective and practical way to facilitate knowledge sharing with exchange parties. Furthermore, managers must provide opportunities to employees who are connected by either strong or weak ties, to spend more time and effort on related projects and activities. From the perspective of strong ties, such projects and activities facilitate motivation to share tacit knowledge, that can be a source of products and services development, and help build competencies[15,26,33]. Weak ties interactions with exchange parties can strengthen the organization's capability and promote the creation of novel knowledge and ideas through reintegration of knowledge[6]. In conclusion, firms should strategically capitalize on strong and weak ties to facilitate knowledge sharing.

This study provides managers with implications for dealing with uncertainty and facilitating knowledge sharing. When uncertainty increases, it is essential for firms to obtain information and knowledge rapidly and accurately. However, environmental uncertainty is beyond the firms' control and originates from external factors. In the case of weak ties that do not comprise of a close and robust relationship[27], it is possible to experience opportunistic behavior[30,31,44,46], loss of knowledge sharing, and concerns of losing the competitive advantage. However, in strong ties, exchange parties can still share expertise and knowledge by encouraging each other to maintain competitiveness, seek solutions, and overcome challenges while responding to uncertainty. Consequently, establishing a sustainable and robust relationship between exchange parties is essential for knowledge sharing, thus leading to strategic decision-making,

innovation, and competitive advantage.

This study has several limitations that can be considered as basis for future research. Thus far, this research provided insights into the relationships between the structural dimensions of social capital, by focusing on tie strength and knowledge sharing. However, other dimensions of social capital, such as relational and cognitive, may also have considerable influence on knowledge sharing [17,19,20,22,34,54,55]. Therefore, future research should consider using other dimensions of social capital for effective knowledge sharing with their partnering company.

Moreover, we primarily focused on tie strength. However, other variables, such as trustworthiness, benevolence, and competence, also play a mediating role in knowledge sharing [12,26]. Future research should consider the role of such variables, add new variables to the research model, and employ qualitative methods to further understand the significance of tie strength and knowledge sharing.

We also intend to expand the measure of knowledge sharing to apply the perceived usefulness of knowledge sharing and collection, and absorptive capacity because the current measures focus only on knowledge sharing. Specifically, absorptive capacity, that refers to people-based activities, is essential in the creation of new knowledge to enhance problem-solving skills and performance [56].

Finally, the results might include some bias, because the sample was collected from the high-technology industry in Korea. Thus, the results must be interpreted and generalized with caution.

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