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The Role of Structural Holes in Uncertain Environments in Channel Relationships

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Abstract

Purpose - Although marketing networks are crucial competitive advantage in terms of firm's new information and resource acquisition ability, their impact on new product development performance remains vague, especially under environmental uncertainty. The principal objective of this research is to provide a better understanding of effects of technological uncertainty and volume uncertainty on first tier supplier's perceived performance of new product development under conditions reflecting varying levels of structural holes. Specifically, this research examines the moderating effect of structural holes on the relationship between environmental uncertainty and new product development performance.

Research design, data, and methodology – To test the hypotheses, a questionnaire survey was conducted with a Korean engineering firm's major first-tier suppliers in the context of internal network entities, manufacturer-supplier-subsupplier relationships, and to verify the proposed hypotheses, structural equation modeling was established. Construct measures were based on existing measures and previous research.

Results – The survey results indicate that technological uncertainty and volume uncertainty differentially affect NPD performance under conditions of high and low structural holes.

Conclusions – This study offer some theoretical and practical implications among distribution channel members, especially, this study suggests that interfirm networks have critical competitive advantage in uncertain environments. The distinctiveness of engineering industry might limit the generalizability of the results. Thus, future research should consider a wider range of industries.

Keywords: Technological Uncertainty, Volume Uncertainty, New Product Development (NPD), Interfirm Network, Channel Relationships.

JEL Classifications: C42, D3, D81, D83.

1. Introduction

Firms in many industries need frequent innovation and high quality to survive in the market (Ragatz et al., 2002; Ishaq et al., 2012), especially new product development (NPD) performance in technology-centered industry (Zhatkanbaev et al., 2015). These firms need to make and external exchange with their channel partners for NPD performance that is one of the crucial competencies (Song & Motoya-Weiss, 1998). In this study, Channel relationships in this study mean that the context of internal network entities, including the manufacturer-supplier-subsupplier relationships.

Environmental uncertainty, which refers to the extent to which environments change rapidly and the difficulty of making accurate predictions about the environments in the interfirm network (Klein et al., 1990; Achrol et al., 1983), destroying the competence poses significant challenges for firms (Young, 2001). Heide and John(1990) have identified two dimensions of environmental uncertainty: technological uncertainty, volume uncertainty. This study refers to technological uncertainty, in relation to engineering parts, as the perceived unpredictability that result from rapid technological changes in related fields, an increase in part complexity, and the novelty of part function(Chen & Paulraj, 2004; Hoetker, 2005; Patersen et al., 2003; Wasti & Liker, 1999). The study also refers to Volume uncertainty as 'the volume of major product in the market is volatile(Gupta & Maranas, 2003). Thus, the inclusion of volume uncertainty results in better risk management across the supply chain.

To acquire resources under the uncertain environment, firms try to not only exploit internal knowledges but also develop external resources (Caloghirou et al., 2004). However, environments surrounding the firms have become increasingly complex and uncertain, so it is not easy to

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manage all resources within one firm (Hwang & Suh, 2017). Therefore, building the network relationships with exchange partners has become important (Lechner & Dowling, 2003). For example, engineering firms, which offer consulting and technical services to clients, with finished products supplied by first-tier subcontractor needs enormous amount of communication between the exchange partners and acquisition of new information.

Interactions between buyers and first-tier suppliers during product development have been broadly examined (Mishra & Shah, 2009; Hsuan, 1999). Recently, researchers have moved their focus from buyer-supplier dyadic relationship to network studies because marketing networks have critical competitive advantage between inter-firm relationships (Gulati, 1999). Since firms are related through their members' connections, such as joint suppliers and industry associations, network members can attain sources of information about competitor behavior, of new technological developments, and of other industry trends (Walker et al., 2000). Resources also flow through the interfirm network (Wasserman, 1994), that enhances firm's capabilities for competitive advantage.

Interfirm network offers information benefits, which helps firms to overcome uncertain environments quickly (Gulati, 1998). Although exchange partners find it difficult to expect firm performance in the uncertain environments, there is a growing body of evidence that structural holes have a critical role in such environments (Ahuja, 2000; Burt, 1992, 1997, 2000). Structural holes are 'the bridges between two separate clusters possessing non-redundant information and provide network benefits that are in some degree additive, rather than overlapping' (Burt & Ronald 1992). The presence of structural holes facilitates the partners' access to innovative information and opportunities, which results in the partners' greater adaptation and information benefits.

Relatively few empirical approaches have been attempted to examine technological uncertainty and volume uncertainty effect on new product development (NPD) performance. In particular, moderating effect of structural holes between these uncertainties and new product development performance has not been discovered. Researchers propose consistently that structural holes improve buyer's performance (Ahuja, 2000; Zaheer & Bell, 2005). In the vertical channel relationship, the first tier supplier could perform the role of structural holes, bridging the supplier's clusters and the buyer's cluster.

The principal objective of this research is to provide a better understanding of effects of technological uncertainty and volume uncertainty on first tier supplier's perceived performance of NPD under conditions reflecting varying levels of structural holes. Specifically, this research examines the moderating effect of structural holes on the relationship between environmental uncertainty and NPD performance.

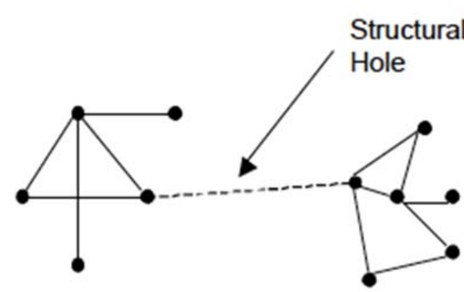
This paper's specific contribution to literature, then, is in two ways. First, the study empirically examines effects of technological uncertainty and volume uncertainty on NPD performance under structural holes. Yet little empirical researches about this effect have examined so far. Second, the study empirically explains structural holes influence differently, according to the contextual environments. The study proposes that technological uncertainty has positive effect on NPD performance, if suppliers have the capability to cope with the technological uncertainty. However, in the volume uncertainty circumstance, it is better to cooperative with its parties than accepting new information through the structural holes.

In the following sections, we present theoretical foundations for a research model, and propose effects of technological uncertainty and volume uncertainty on NPD performance under structural holes. Then, we describe the research design and the analysis method. Finally, we present the conclusion and discuss the limitations of study.

2. Theoretical Background and Hypotheses

2.1. Structural Holes

Since structural holes work as the bridge between a network and other networks, firms enjoy interfirm exchange not only from within the network but also from the ties of external network (Burt, 1992). Structural holes generate gaps in information flows between firms but not linked to each other (Ahuja, 2000). These holes serve as a third referral and help connect two separate firms as indicated in <figure 1>. Therefore, structural holes allow firms to discover business opportunities through non-redundant contacts (Burt, 2005).



<Figure 1> Structural hole, Burt (1992, 1997).

By occupying the holes, firms take the role of flowing information between the two different networks and therefore are able to manipulate or use information to take advantages. Consequently, as the number of non-redundant contacts between or among networks increases, structural holes can maximize benefits from the contact. More specifically, the theory of structural holes (Burt, 1992, 1997) suggests that firms with networks rich in structural holes have some benefits: access to new information, control through brokerage position and building efficiency (Burt, 1992).

The new information benefit is the brokerage advantage accessing to non-redundant information, opportunities, referrals and resources (Cross et al., 2001). Because information is more homogeneous within firms, firms that bridge the holes are more creative and more likely to see a way to implement their ideas (Burt, 2005).

Additionally, firms bridging structural holes can access resources from unique parts of their network, and hear about impending threats and opportunities quickly. Moreover, they can find out about the quality of possible exchange partners (Powell & Smith-Doerr, 1994; Uzzi, 1996). Because knowledge is developed partially through firm interaction (Nahapiet & Ghoshal, 2000), firms which bridge structural holes will be able to develop new understandings, especially regarding emergent threats and opportunities. More generally, firms can add values by bridging others, monitoring information more effectively, and moving information faster and more (Burt, 2000).

Structural holes also allow firms to take advantage of controlling the exchange partner (Burt, 1992). Firms which take the role of the third parties are located on its superior network position. Through this position, firms can get control over the exchange partner such as information control and resource gains (Burt, 1992; Aldrich, 1999). Also, parties having power of control can regulate problems between partners (Zaheer & Bell, 2005). That is, this control benefits mean that having an advantage in the negotiation with partners (Prell, 2012). Because firms located on the brokerage position have various alternatives, they have a more strong bargaining power rather than other firms. For this reasons, the firms are able to control a flow of information within network members.

2.2. Structural Holes as Social Capital

Social capital, the sum of resources that accrue to firms by possessing durable network relationships (Koka, & Prescott, 2002), has become a general metaphor in the study of network relationships (Gargiulo & Benassi, 2000). Generally, structural hole theory gives specific meaning to the concept of social capital (Burt, 1997), because social capital refers to features of social networks that can gain competitive advantage of structural holes (Putnam, 2000). Burt (1992) argues that structural hole means a 'gap' between exchange members, and it connected by bridging ties. Therefore, their position in the structure can be an advantage in its own right. That advantage is social capital.

This notion of social capital is present implicitly or explicitly in research streams (Gargiulo & Benassi, 2000; Zaheer & Bell, 2005). This research streams mainly focus on how the structure of social ties promotes actor's ability to achieve their goals (Gargiulo & Benassi, 2000). Also, in the study of how the network structure enhances firm benefits, Zaheer and Bell (2005) argued that a firm occupying an advantageous network position can directly benefit from that position.

Traditionally, social capital stresses the positive effect of densely embedded networks or closed network on developing social norms between network members (Coleman, 2000). Network closure around the bridges creates reputation pressures that encourage collaboration and constraint (Burt, 2005). Therefore, in this network, firms have access to social capital, in which resource helps the constraint of self-seeking and the development of cooperation.

However, according to an alternative view by Granovetter (1985), who focus on the positive effect of third parties. Firms in network able to build trust and curtail the risk of opportunism among network parties (Zhou & Xu, 2012). Because third parties play a role as an incentive to present a cooperative image and as a deterrent to opportunistic behavior (Gulati, 1995). Therefore, actors linked through ties embedded in third-party relationships are more likely conform to the norm of reciprocity (Gargiulo & Benassi, 2000). Reciprocity may be helpful for parties to diminish damage from opportunistic behaviors and lead to enjoy future benefits from social capital.

Social capital is thus a valuable additional asset for managing inter-organizaional relationships since it constrains a firm's partner (Walker at al., 2000). Firms with less social capital are more likely to partner's opportunism over time. Therefore, they have to spend a lot of time and effort monitoring the relationship. That is, the contribution of social capital to network relationships is achieved by reducing transaction costs between firms such as search costs, monitoring and decision costs (Nahapiet & Ghoshal, 2000).

In the present paper, the social structure is the interfirm network. The amount of social capital depends on the firm's position in the network structure. The action facilitated by this structure is the formation of new relationships. These arguments lead to the central proposition that firms in network positions with higher social capital are likely to have more relationships with new partners in the following time period.

2.3. Technological uncertainty

According to the resource dependence theory, human actors in organization can perceive, interpret, and evaluate technological environment (Caldeira & Ward, 2003). Song and Montoya-Weiss (2001) argued that firms have perceptions of technological uncertainty regarding the application of technology to the project or regarding impending changes in that technology. We refer to technological uncertainty as the perceived unpredictability that result from rapid technological changes in related fields, an increase in major product part complexity, and the novelty of major product part function in the NPD process (Hoetker, 2005; Chen & Paulraj, 2004; Petersenetal., 2003; Wasti & Liker, 1999). In our study context, technological uncertainty can be associated with engineering-related software and materials that are used for building a plant. For example, a supplier may experience uncertainty following changes in the standards or specifications (Heide & John, 1990) of steel materials, as energy drilling is expending to extreme are as such as the deep sea.

When technological uncertainty increases, firms face unexpected problems involving R&D cost increases and high-failure rates of NPD performance (Auster, 1992). For example, if no network member has the pertinent capability to cope with difficulties related to technological uncertainty, greater coordination cost and project delay, causing damage to the network members, will occur. Also, when the technology used in a main product is standardized, it increases the adaptability of firms. However, if there is no standardized technology, technological uncertainty increases (Stump & Heide, 1996). In such situation, continuous efforts on the part of firms are required in order to not fall behind in the competition. Thus, we assume that the extent to which firms' perception of the technological uncertainty results in their decisions and actions associated with NPD project distinctively. Accordingly, the following hypotheses can be derived:

<H1> There is a negative relationship between technological uncertainty and new product development performance.

2.4. Volume Uncertainty

Volume uncertainty is that the extent to which volume estimates for the major product are perceived to be uncertain (Walker & Weber, 1984). Volume uncertainty has been increasing in recent years due to lengthening supply chains, global recession and macroeconomic events (Gupta & Maranas, 2003). It can be identified as one of the key sources of variability in any supply chain; therefore, failure to account for major demand fluctuations may either lead to unsatisfied customer demand and loss of market share or excessively high costs (Gupta & Maranas, 2003).

Volume uncertainty depends on the assessment of fluctuations in the demand for a component and the confidence placed in estimates of the demand (Siddiqui, & Erum, 2016). When volume uncertainty is high, suppliers experience unexpected production costs or excess capacity and buyers experience stock-outs or excess inventory. These events increase transaction costs because of mid contract renegotiation. Since the firm should be able to coordinate variations in its own production stream more efficiently than variations with suppliers.

The inclusion of volume uncertainty results in better risk management across the supply chain(Gupta & Maranas, 2003). Volume uncertainty creates a burden for the business. Goals of inventory management usually include minimizing stock-outs while avoiding the high cost of holding excess inventory. When suppliers can't accurately predict volume, they run risks of one of these happening. It may over-buy inventory to protect against running out. This leads to the need to store extra products, offer discounts or throw out excess. If supplier buys less to prevent waste, high volume can lead to stock-outs. Based on the argument, this study hypothesized as follows.

<H2> There is a negative relationship between volume uncertainty and new product development performance.

2.5. The Moderating Effect of Structural Hole

Applying to inter-firm network contexts, when a new supplier bridging structural holes is enter into a business relationship, the newly entered supplier provide new information regarding external environment to a buyer. It is helpful for a buyer to cope with uncertain environment situation. In this regard, structural holes function as a governance mechanism through its network position, which automatically reduce the likelihood of opportunistic behavior (Brown et al., 2000). Because the new information and resources from the structural holes can reduce information asymmetry between exchange parties (Wathne & Heide, 2000).

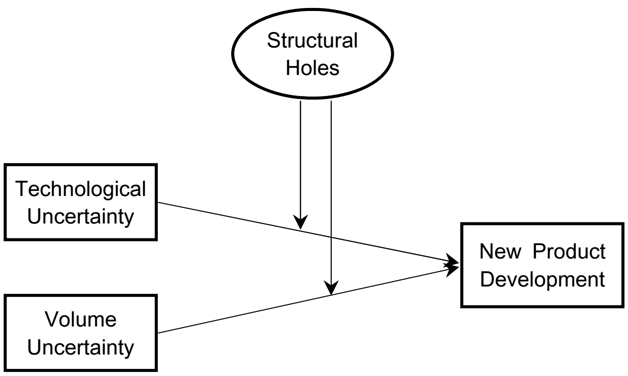
In addition, firms bridging structural holes may be able to access resources from unique parts of their network, may hear about impending threats and opportunities more quickly. Furthermore, firms may find out about the quality of possible exchange partners and potential members (Powell & Smith-Dorr, 1994; Uzzi, 1996). Because knowledge is developed partially through firm interaction (Nahapiet & Ghoshal, 2000), actors bridging structural holes will be able to develop new understandings.

As a result, Structural holes allow network members to attain new information and resources (Brown et al., 2000), and through it, the problem of information asymmetry between exchange parties may be solved. Therefore, the level of structural holes may moderate the effects of environmental uncertainty on new product development performance.

Technological uncertainty Previous studies have shown that knowledge from external ties is critical to NPD performance (Mansfield, 1988; Saxenian, 1990). In other words, NPD performance is largely influenced by firm's ability to attain new information from the external ties (Deeds et al., 2000). This new information inflow usually builds basis for development of capabilities (Teece, 1996), which evolve as new knowledge application ability increase (Deeds et al., 2000). In particular, absorptive capacity, firm's ability to evaluate and assimilate external knowledge (Cohen & Levinthal, 2000), allows firm to recognize and acquire valuable new information, and apply it to the refinement of dynamic capabilities (Deeds et al., 2000) Thus, interaction with the external organization is important to firms' dynamic capabilities, which allow them to enhance NPD performance with accumulated resources such as knowhow or knowledge through organizational learning.

With regard to the structural holes theory, firms can increase new information from external ties by occupying the holes. This information is transformed into knowledge or knowhow, which is necessary for NPD performance of technology intensive industry. Thus, supplier's structural holes which allow new information inflow from the external ties could moderate a negative relationship between technological uncertainty and new product development performance. In this regard, we propose the following hypothesis:

<H3> When the level of structural holes is greater, the negative relationship between technological uncertainty and new product development performance will be reduced.



<Figure 2> Research Model

Volume uncertainty Since volume uncertainty decreases the adaptability of firms, such uncertainty will encourage a buyer to develop relationships with multiple channel partners (Ganesan, 1994). Therefore, the buyer will attempt to increase the level of structural holes to find new information. As the level of structural holes increases, information flow makes easier to verify the state of stock or inventory suppliers have. From the buyer's perspective, it is possible to predict the situation and cope with a problem that related to volume of major product. Under adverse circumstance where volume uncertainty is predict or stable, firms might not experience problem in their NPD project because the external environment does not harm their capability to manage it. Therefore, structural holes may positively moderate the negative influence of volume uncertainty on NPD performance. In this regard, we propose the following hypothesis:

<H4> When the level of structural holes is greater, the negative relationship between volume uncertainty and new product development performance will be reduced.

3. Methodology

3.1. Research Setting and Data Collection

We focused on the relationships between a manufacturer, its major first-tier suppliers, and the suppliers' business partners and sub-suppliers to test the hypotheses about the effects of technological uncertainty and volume uncertainty on first-tier suppliers' perception of buyer's NPD performance. Since manufacturers are rely largely on their supplier's performance, there are substantial interactions between them to increase cooperation and information exchange. We chose the research set based on the theory that major suppliers reflect the most intensive interaction with a manufacturer and the highest level of dependence.

<Table 1> Scale Items and Construct Evaluation

Constructs	Items	Standardized λ*	C.R	Construct Reliability	AVE
Technological Uncertainty (α=.87)	1. The technology used in our main products is changing drastically	0.53	-	0.74	0.55
	2. The changes in the technology used in our main products have been dramatic in recent years.	0.89	7.64		
	3. It is difficult to predict how changes in technology used in our main products will emerge in the future.	0.93	8.12		
Volume Uncertainty (α=.74)	1. Volume forecasting of our company's main products is very difficult.	0.79	-	0.75	0.89
	2. Volume uncertainty for our main products is very high.	0.90	14.92		
	3. Volume for our company's main products is very irregular supply.	0.85	11.67		
Structural Holes (α=.90)	Company A, which has a relationship with our company, has important technology, resources and information required for our company.				
	1. Our company's buying companies and suppliers have established a relationship with our company and are obtaining information from the A company that could not otherwise be obtained.	0.89	-	0.91	0.87
	2. Our company's buying companies and suppliers have established a relationship with our company and are obtaining important technology from the A company that could not otherwise be obtained.	0.99	15.49		

	3. Our company's buying companies and suppliers have established a relationship with our company and are obtaining the resources from the A company that could not otherwise be obtained.	0.91	19.21		
NPD Performance (α=.95)	1. Compared to the previous product, the new product from this buyer is successful.	0.91	-	0.90	0.57
	2. Compared to previous products, this new product from the buyer is successful in terms of profit.	0.94	19.05		
	3. Compared to our previous products, the new products from this buyer helped us achieve our profitability goals.	0.71	17.61		

Note: (80) = 112.128 (p = .010), goodness-of-fit index = .914; adjusted goodness-of-fit index = .871; comparative factor index = .982; root mean square error of approximation = .050. SFL = standardized factor loading, AVE=average variance extracted.

We selected major first-tier suppliers through systematic random sampling from a mailing list of a major engineering firm. This firm provided consulting and technical services to clients, with finished products supplied by fist-tier suppliers. We verified the fact that first-tier suppliers' procurement activities played pivotal roles through in-depth interviews with industry experts and managers. We surveyed procurement managers of first-tier suppliers who were appropriate candidates for responding to items regarding their firms and transaction partners because they not only have relationships with second-tier suppliers and business partners but also can reflect intense interaction with engineering firm in terms of supplier's performance. By surveying first-tier suppliers that had various relationships with their transaction partners (i.e., buyer, second-tier suppliers, and other business partners), we examined influence of technological uncertainty and volume uncertainty on buyer's NPD performance under structural holes situation.

We contacted the procurement manger of each firm by telephone and mailed him or her a questionnaire. The procurement managers were in charge of securing parts and materials from subsuppliers, and thus, we expected them to have close relationships with sub-suppliers with expert knowledge about procurement items (Hutt & Speh, 2000) and also reflect interaction with the buyer in terms of its needs. After further phone calls and a second mailing, we collected a total of 148 responses out of 520 delivered (a response rate of approximately 28%).

3.2. Nonresponse Bias

We examined non-response bias in two ways. First, we compared early respondents with late respondents (Armstrong & Overton, 1977). In addition, we compared the mean values for each scale (i.e., technological uncertainty, volume uncertainty, structural holes, and new product development performance). No significant differences were found between the groups, implying that non-response bias does not appear to be a critical problem.

3.3. Measure Development

We collected existing measures of the focal variables from previous research. In addition, we conducted in-depth interviews with three purchasing managers to assess the relevance of the collected measures. Based on these interviews, we revised the wording of some items. We measured all items on a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree). Since the items were in English, we developed a Korean version of the questionnaire for the research setting. To ensure that the Korean version of questionnaire was identical to the English version, a bilingual speaker of English and Korean back translated the questionnaire from Korean to English. The two translators resolved few discrepancies identified through a discussion. We used technological uncertainty to measure the first-tier suppliers' perception of uncertain technology (Chen & Paulraj, 2004; Hoetker, 2005; Petersen et al., 2003). As the level of technological uncertainty increases, the inability to forecast accurately the technical requirements for the product increases. We adapted the items for technological uncertainty from Heide and John (1990) and modified for the research setting.

We use volume uncertainty to measure the inability to forecast accurately the demand for the components in question. It is based on the scale used by Walker & Weber (1984).

We used structural holes to measure the benefits from social capital stem from the first-tier suppliers' brokerage opportunities created by disperse ties (Burt, 1997). As the level of structural holes increases, information inflow from the outside network increases. We developed items for structural holes, based on studies of Burt (1997) and Ahuja (2000) for our research context.

We used NPD performance to measure the firs-tier suppliers' perception of buyer's NPD performance which contributes to economic profits of channel members (Song & Parry, 1997). We also obtained the items for NPD from them and modified for the research setting.

3.4. Measure Reliability and Validity

Reliability analyses were run to see if all the measures show satisfactory reliability by using Cronbach's alpha. Each of item constructs shows a coefficient alpha exceeding the generally accepted level of .70.

We assessed the validity of the constructs—technological uncertainty (TU), volume uncertainty(VU), structural holes(SH), and NPD performance(NPD). We conducted an item-total correlation test to eliminate ill-fitting items.

<Table 2> Means, Standard Deviations and Correlations

	1	2	3	4
1. Technological Uncertainty (TU)	1.00			
2. Volume Uncertainty (VU)	.255	1.00		
3. Structural Holes (SH)	.031	.061	1.00	
4. New Product Development (NPD)	.087	-.048	-.070	1.00
M	3.95	4.07	4.47	2.04
SD	1.25	1.39	1.56	.96

Note: sample size = 148

We then subjected the remaining items to a confirmatory factor analysis using AMOS. Based on this procedure, we identified the measurement model with acceptable fit indices, $\chi 2(80)=112.13$ ($p=.01$), GFI =.91 AGFI =.87, CFI=.98, RMSEA=.05. All factor loadings were significant ($p<.05$), indicating sufficient convergent validity and the unidimensionality of the measures (Anderson & Gerbing, 1988). We evaluated the discriminant validity of all four latent variables through AVE values (Fornell & Larker, 1981). We calculated all the AVE values of constructs to determine whether the values are greater than squared values of coefficient of correlations between variables. The results indicated that discriminant validity was acquired (AVE values ranged from 0.55 to 0.89).

Finally, we measured construct reliability and found that each factor showed a satisfactory level of reliability. Collectively, these results indicate sufficient reliability and validity for the measures. Table 1 indicates that the factor loadings, reliability measures for each construct, and good-ness-of-fit indices, and AVE values. Table 2 shows inter-construct correlations.

4. Analysis and Results

4.1. Hypotheses Test

We used structural models to test the hypotheses. We used supplier's technological uncertainty and volume uncertainty as an exogenous variable and supplier's performance and structural holes as endogenous variables. Technological uncertainty had positive influence on NPD performance ($\gamma 11= .31$, $t= 4.99$), providing no support for H1. And volume uncertainty had negative influence on supplier's performance ($\gamma 11= -.26$, $t= -2.51$), providing support for H2.

To assess the moderating effect of structural holes (i.e., H3 and H4), we conducted a unique multisample analysis using AMOS, based on Jaccard, Jaccard & Wan (1996). We divided the sample firms into two groups (High structural holes and Low structural holes) at the median of structural holes and then ran these two groups through a nested structural model in which technological uncertainty and volume uncertainty was an exogenous variable and supplier's performance and structural holes were endogenous variables.

<Table 3> AMOS Results for H1 and H2

Description	Hypothesis		Coefficient	t value
	Hypotheses	Sign		
TU → P	H1	+	.31	4.99***
VU →P	H2	-	-.26	-2.51*

$X^2(24)=40.535$, $p=.019$. Goodness-of-fit index=.95; adjusted goodness-of-fit index=.90; comparative factor index=.98; root mean square error of approximation=.065.

*Significance at α=.05, **Significance at α=.01, *** Significance at α= .001

<Table 4> AMOS Results for H3 and H4

Description	Hypotheses	High Hole		Low Hole	
		Coefficient	t value	Coefficient	t value
TU → P	H3	.32	4.54***	.27	2.14*
VU → P	H4	-.40	-2.80***	-.00	-.01

$X^2(48)=53.606$, $p=.27$.Goodness-of-fit index=.94; adjusted goodness-of-fit index=.88; comparative factor index=.99; root mean square error of approximation=.027.

*Significance at α=.05, **Significance at α=.01, *** Significance at α=.001

In order to evaluate moderating effect, we adopted two-step approach (Jaccard et al., 1996) structural model by using pooled data from the two groups (i.e., the pooled-sample model). We first estimated its fit before testing of the multi-sample structural model. The pooled-sample model provided a fine fit to the data ($\chi 2=53.61$, df=48), indicating the appropriateness of the multisample model for hypothesis testing. We then estimated the multi-sample model (i.e., High structural holes and Low structural holes) by constraining the path coefficients for both groups to put in the same condition for limited interaction effects. We expected that if structural holes had a moderating effect, then the multi-sample model (constrained coefficients) would provide a inferior fit compared with pooled-sample model (unconstrained coefficients) (Jaccard et al., 1996). The result for the $\chi 2$ difference between the pooled-sample model ($\chi 2=53.61$, df=48), and the multi-sample model ($\chi 2=53.76$, df =49) does not indicate the moderating effect of high structural holes ($\chi 2=0.151$, df=1, $p>.05$) on the relationship between technological uncertainty and the supplier's performance. In case of the relationship between volume uncertainty and the supplier's performance, the result for the

$\chi 2$ difference between the pooled-sample model ($\chi 2$=53.61, df=48), and the multi-sample model ($\chi 2$=57.43, df=49) indicates the moderating effect of structural holes ($\chi 2$=3.818, df=1, p<.05).

We tested the multisample model to determine whether uncertainty and the supplier's performance would have significant correlations for these two groups (Jaccard et al., 1996; Mendenhall et al., 1996). Technological uncertainty had a significant positive effect on the supplier's performance in case of both high and low levels of structural hole position, not supporting for H3. Volume uncertainty had a significant negative effect on the suppliers' performance with a high level of structural hole position, whereas there was no significant effect for the group with a low level of structural hole position, providing support for H4.

5. Discussion

The study examined the effects of technological uncertainty and volume uncertainty on NPD performance under structural holes situation. This study also empirically explains structural holes influence differently, according to the contextual environments.

Contrary to the previous network studies, our findings indicate that technological uncertainty increased NPD performance. When technological uncertainty is manipulated with importance of technology and speed of development, if the technical uncertainty is high, the added value of the related parts can be considered to be high. This will ultimately improve the performance of new product development. In addition, as technological uncertainty increases, they will respond to technological uncertainty by creating relevant parts directly or by vertically integrating with competent suppliers, instead of collaborating with suppliers in the development of new products. In this regard, we can conclude that it will enhance the performance of new product development (Oh & Rhee, 2008).

Also, moderating effect of structural hole were not found in H3. The effects of structural holes could be dampened by collectivistic culture for 'ingroup' preference (Xiao & Tsui, 2007), the degree to which an individual tends to offer priority in decision making to whom s/he is familiar with, controls opportunism and nurture B2B trust in a collectivist culture such as Korea (Chung & Jin, 2011). Thus, even if new information inflow from the outside network is active, the information might not be critical to supplier's performance for in-group preference based on collectivism. One thing that should be noted is that structural holes do not always positively influence the conduct of suppliers.

5.1. Practical Implication

Making decisions under uncertainty is an everyday task for most marketing managers, particularly those in new product development. Because sustainable competitive advantage depends on a firm's ability to quickly adapt to the changing environment, new product managers must cope with uncertainty regarding their exchange parties' needs (Mullins & Sutherland, 1998).

Past research suggests that "modes of thinking" differ depending on whether or not managers perceive a plenty of uncertainty about the environment (Hornsby et al., 2002). Resource dependence theory explains that the technological environment is perceived, interpreted, and evaluated by human actors in organizations (Pfeffer & Salancik, 2003). Managers' perceptions become their reality. Thus, the condition of environment is crucial to the extent that they are perceived by managers and result in distinct managerial actions (Pfeffer & Salancik, 2003).

The study propose that technological uncertainty has positive effect on supplier's performance, if suppliers have the capability to cope with the technological uncertainty. However, in the volume uncertainty circumstance, it is better to cooperative with its parties than accepting new information through the structural holes. Therefore, firms should carefully consider how they deal with environmental uncertainties when they make a business decision under structural holes situation.

5.2. Limitation and Future Research

The theoretical scope of our study is limited in that the study focuses only on the moderating effect of structural hole in the relationship between technological uncertainty and volume uncertainty and NPD performance. However, there might be other considerable network dimensions as determinants of supplier's performance. Another limitation involves the collectivistic organizational culture. We obtained the data from Korean domestic firms. Although the business environment in Korea has adjusted to global standard in recent decades, Korean firms are still influenced by high collectivistic culture. In this regard, future research should consider cultural aspects when research model building. In this study, we collected data from sub contractors of major engineering firm in Korea. Plant engineering industry has distinctive characteristics such as long term project and turn-key base system, which require extensive collaboration with suppliers. The distinctiveness of engineering industry might limit the generalizability of the results. Thus, future research should consider a wider range of industries.

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