

## **Type and Dependency of R&D Cooperation Partners and Innovation Performance: An Empirical Study with Korean Venture Firms\***

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The purpose of this study is to suggest an efficient way for ventures to achieve innovation performance through R&D cooperative arrangements. Achieving innovation is one of the critical factors for the survival of ventures. Unlike established firms, ventures often do not have the specialized assets necessary to take technological developments to the product and market stages. Young and resource-constrained firms can achieve innovation by finding and accessing to the complementary resources from R&D cooperation. In the current business environment, many firms are likely to engage in multiple simultaneous R&D cooperations with different partners. Recent research stream addresses the importance of efficient cooperation management from the holistic portfolio perspective. Since maintaining the multiple cooperative relations require substantial amount of time and effort, managing cooperative relationships play a more important role to resource-constrained firms. In order to find an efficient composition of R&D cooperative partners, we mainly focus on the diversity of partner type and dependence level in partnership.

We analyze the data on Korean manufacturing ventures collected in the Korean Innovation Survey (KIS) which was conducted by the Science and Technology Policy Institute (STePI). The KIS questionnaire assesses the existence of cooperative relationships with different types of partners respectively. The types of cooperating partners are affiliated companies, suppliers, clients & customers, competitors or other firms in the same industry, consulting firms, universities, and research institutes.

We confirm that ventures obtain relatively higher benefits from R&D cooperation compared with established firms in terms of innovation performance. The results show that a moderate level of diversity in cooperative partner type composition increases innovation. Moreover, diversity of cooperation dependency among the partners enhances innovation performance. Likewise, concentrating on the quality aspects of cooperative composition, such as diversity of partners and degree of dependencies, this study offers some implications for ventures in managing partners from an integrative perspective.

**Keywords :** Ventures' Innovation, R&D Cooperation, Cooperative Partner Type Diversity, Cooperative Partner Dependency Diversity

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## *I. Introduction*

Innovation has been acknowledged as the primary source of competitive advantage and success. Then, how can an individual firm achieve innovation? Researchers have reached a consensus that innovations rarely arise in isolated context, but occur interactively among multiple players (Monjon and Waelbroeck, 2003; Schumpeter, 1942; Tether, 2002). Different actors work together to generate new ideas and translate them into a potentially profitable product or service.

One of reasons why firms face difficulty in pursuing innovation in an isolated context is that they cannot possess all the required knowledge and resources. Much resources and knowledge exist beyond the boundary of a firm. In this regard, inter-organizational cooperation can be a breakthrough solution for firms to access resources and knowledge beyond boundaries (Mention, 2011). Therefore, inter-organizational cooperation has been recognized as crucial in supplementing the internal innovative activities of firms (Deeds and Rothaermel, 2003; Hoffmann, 2007).

Procuring external resources to supplement internal resources are key drivers of cooperation. Considering this, cooperative strategies are especially important for start-ups (Aggarwal and Hsu, 2009). Since nascent firms are likely to possess limited resources and information, support from external organizations is critical (Kim and Lee, 2012; Lichtenthaler, 2006).

Ventures are defined as start-ups based on high technology that involve high potential returns as well as high risk. Pursuing innovation is one of the decisive factors for the performance of ventures (Hwang, 2012). Ventures, unlike established firms, often do not have the specialized assets necessary to take technological developments to the product and market stages. Ventures face the liability of newness and they are exposed to highly uncertain situations compared with established firms that are relatively settled (Eisenhardt and Schoonhoven, 1990). To overcome these issues, engaging in cooperative relationships with external parties for

procuring supplementation is very important for ventures' innovation.

In today's business environment, most firms engage in multiple simultaneous R&D cooperation with different partners (Wassmer, 2010). As a result, researchers have emphasized the importance of efficient cooperation management from the portfolio perspective (Lavie, 2007). Early cooperation literature focuses on the one-to-one cooperative relation as the unit of analysis. In recent years, however, a firm-level perspective has emerged. A firm's cooperative relations are viewed as a portfolio with a focus on the entire composition of cooperative partners (e.g., Jiang, Tao, and Santoro, 2010; Lavie, 2007). Since building and maintaining multiple cooperative relationships require substantial amount of time and managerial effort, it is critical to achieve effectiveness through firms' overall cooperative portfolio strategy. Considering ventures' inherent nature of lack of resources, searching for a beneficial way of building an effective cooperative partnership portfolio is vital. Moreover, maintaining proper dependency is relatively important issue for ventures when they manage cooperative arrangements. However, previous studies examining composition of cooperation, such as alliance portfolios, have primarily focused on established firms. The context of nascent firms in multiple R&D cooperation arrangements still remains unexplored.

Previous studies clarify that developing inter-organizational cooperation with diversity of partners can improve organizations' innovative capabilities (Faems, Looy, and Debeckere, 2005; Monjon and Waelbroeck, 2003). The determinants of R&D partnerships differ depending on the type of R&D cooperation partners (Belderbos, Carree, and Lokshin, 2004). Although considerable research has been conducted to examine this point, there are few studies that focus on the complete picture of cooperation arrangements of firms. Since different cooperative partners will not have the same impact on focal firms' innovation, firms have to consid-

er the proper composition of their cooperative partners. Although previous studies regarding the types of cooperation examined the benefits from different types of partners (Faems et al., 2005), less attention has been paid to the composition of different types of partners.

This study, however, focuses on the quality aspect of each partner from the portfolio perspective. We attempt to ascertain how different types of cooperative partners affect the innovative performance of ventures in terms of diversity of both partner type and their dependency levels. The main research question of this study is how ventures can enhance innovation performance through R&D cooperative portfolio. Understanding different partnership features and dependency management of cooperative relationships of the firm would have useful implications. Ventures lacking internal resources particularly have to manage an efficient portfolio of R&D cooperative relationships consistent with their intended goals.

This study examines whether diversity in partner type guarantee better innovation performance and how diversity of partnership dependency on R&D cooperation partners affects ventures' innovation performance. For this purpose, the study considers seven major types of ventures' partner-specific cooperation strategies: cooperation with affiliated companies, suppliers, clients & customers, competitors or other firms in the same industry, consulting firms, universities, and research institutes.

Our empirical analysis is based on a large sample of ventures from the Korean Innovation Survey (KIS) implemented in 2010, which was conducted by the Science and Technology Policy Institute (STEPI) and based on the Community Innovation Survey.

## ***II. Literature Reviews and Hypotheses***

### **2.1 R&D Cooperation**

In the strategy literature, cooperative ar-

rangements, including alliances, have been touted as new ways of organizing innovation (Tether, 2002). As a result, cooperative arrangement has become one of the well-discussed topics in the literature. Because of the interactive characteristic, innovation has recognized distributed process among the cooperative actors (Monjon and Waelbroeck, 2003). As cooperation becomes prevalent, boundaries of a firm are becoming unlimited and no longer work as constraints.

Researchers have discussed various motives that incite firms to cooperate on R&D (Belderbos et al., 2004; Contractor and Lorange, 2002). The reasons why inter-organizational R&D cooperation offers benefits for an innovation are numerous. First, firms might reinforce their deficient resources by accessing complementary assets that belong to the cooperative partners (Eisenhardt and Schoonhoven, 1996; Hagedoorn, 1993). Resource complementarity can turn into a cooperative synergy (Harrison, Hitt, Hoskisson and Ireland, 2001). Second, knowledge spillovers can be achieved by working together with other organizations. Collaboration can promote the transfer of both explicit and implicit knowledge (Ahuja, 2000; Anand and Khanna, 2000; Lambe and Spekman, 1997). This might result in the creation and development of resources which otherwise are difficult to mobilize (Cuervo-Cazurra and Un, 2010; Das and Teng, 2000). Not only the collaborative process but also the complementary resources bring opportunities for improved learning (Harrison et al., 2001). Third, efficiency can be pursued from the economies of scope and scale (Das and Teng, 2000; Kogut, 1988). Partners' economies of scope can be profitable for forming alliances (Rothaermel, 2002). Fourth, as firms confront a complicated environment, they are required to transform themselves rapidly in order to respond proactively. Accordingly, firms select strategic alliances depending on their dynamic needs (Miles, Preece, and Baetz, 1999). Finally, firms can share risks and costs through inter-organizational collaboration in the face of uncertain techno-

logical developments (Hagedoorn, 2002; Lopez, 2008; Tyler and Steensma, 1995; Veugelers, 1998). R&D cooperation helps to spread the costs of R&D among different parties and considerably reduce the risks associated with R&D-intensive innovation projects.

Empirically, researchers have observed an association between the propensity to engage in R&D cooperation and a variety of organizational attributes, including firm size, age, scope, and resources, by focusing on a single cooperation framework (Burgers, Hill, and Kim, 1993; Shan, Walker, and Kogut, 1994). Some researchers recognize the necessity of analyzing the overall picture of cooperative arrangement held by a firm. For example, various alliance researchers point to alliance portfolios, which are defined as “a firm’s collection of direct alliances with partners” (Lavie, 2007), as an important additional unit of analysis (Jiang et al., 2010; Wassmer, 2010). Focusing on all types of cooperation of a firm is theoretically important because they have aggregate properties that affect the focal firm’s innovation performance, but are not noticeable when focusing on a single cooperation framework (Wassmer and Dussauge, 2010).

Researchers argue that firms can obtain relatively higher benefits from multiple cooperation arrangements than from a single arrangement. By managing the cooperation portfolio, firms can spread the risk and uncertainty to the multiple cooperative partners (Hoffmann, 2007). Researchers also suggest that firms can accumulate experience from multiple cooperative partners, which lead to considerable learning effects (Anand and Khanna, 2000).

Studies considering a composition of cooperation, such as alliance portfolios, have focused on cooperation arrangements. The influence of size and efficiency of alliance portfolios have been analyzed (Baum, Calabrese, and Silverman, 2000; Deeds and Hill, 1996). These studies have focused on the quantity aspects instead of quality of each partner. Characteristics of alliance partners

are more important than the absolute number of partners (Hagedoorn and Schakenraad, 1994). Researchers also pointed out the importance of partner characteristics for alliance outcomes (Stuart, 2000). Some researchers emphasized differences in impact across cooperation partner types (Belderbos et al., 2004). Researchers turn their attention to how different sets of cooperative partners affect performance of focal firms.

Recently, Jiang et al. (2010) examined the relationship between comprehensive alliance portfolio diversity and firms’ financial performance. Regarding partner diversity aspect, they focused on partner industry diversity and national diversity. Studies also focus on the effect of alliance portfolio diversity on firms’ innovation outcomes (Cui and O’Connor, 2012; Oerlemans, Knobens, and Pretorius, 2013). However, most of previous studies concerned on established firms. The context of nascent firms in multiple R&D cooperation arrangements need to be explored.

## 2.2 Resource Dependence Perspective

Resource dependence theorists have argued that an organization inevitably relies on the surrounding environment in order to acquire external resources. Obtaining resources requires the organization to interact with others who control those resources. For this premise, researchers have focused on firm behavior for controlling the dependency. Pfeffer and Salancik (1978: 113) state, “If the exchange is important for the organization, the organization should attempt to manage its interdependence by extending its own control into those vital areas.” Likewise, we can confirm that organizations have a strong drive to manage their dependency and try to reduce the dominance of others.

According to the resource dependence theory, strategic independence is the most important motivation to build strategic cooperation. Firms seek additional partners as one way of managing their interdependence. According to Pfeffer and Salancik (1978),

firms tend to decrease the influence of other organizations by reducing their dependence on single critical exchanges. Therefore, examining the composition of cooperative arrangements provides important implications for firms. If the influence of cooperative partner composition is clarified, focal firms may be able to manage their cooperative partner pool efficiently. For example, more R&D partners may not be always better. Considering firms' current resources, capabilities, and cooperative partners, firms will form and maintain adequate cooperative composition.

### 2.3 R&D Cooperation and Innovation Performance of Ventures

Researchers have argued that young firms have higher failure rates than established ones (Baum et al., 2000; Stinchcombe, 1965). New entrants have higher probability of failure because they typically lack stable relationships and sufficient resources. Stinchcombe (1965) emphasized that underlying the failure of young firms is their scarce resources. Limited resources make young firms particularly vulnerable to even slight inefficiencies (Van de Ven, Hudson, and Schroeder, 1984) and constrain their ability to shift to more favorable circumstances through innovation. To overcome such disadvantages and develop themselves, ventures need to follow a cautious approach of overcoming their resource scarcity. Each venture has different capability of accessing resources, and these differences may influence its survival rate (Fichman and Levinthal, 1991). Researchers suggested that the success of small businesses depends on their accessibility to business networks (Davidsson and Honig, 2003; Street and Cameron, 2007; Vissa, 2011). Building cooperative relationships seem to play a more important role in an entrepreneurial context. In line with the burgeoning literature on alliance networks, R&D cooperation is likely to be particularly beneficial to young and resource-constrained firms, thus enabling

them to overcome their liabilities of newness. Young firms can achieve innovation by finding and accessing the complementary resources from R&D cooperation.

Newly established firms often need considerable resources to invest during inception and can achieve competitive advantage from continuous innovation. However, due to the lack of financial support, ventures can easily turn toward strategic myopia (Eisenhardt and Schoonhoven, 1990). Ventures find it difficult to afford large investment for innovation, although it is crucial for their survival.

To overcome this dilemma, ventures tend to find partners who can share the burden. Under the highly uncertain situation faced by ventures compared with established firms, young entrepreneurial firms rely on the relationship with other organizations, which can disperse the inherent risks of innovation. Because of high uncertainty and risks, ventures are less likely to invest on innovation alone. Since ventures are considered having low trustworthiness for generating profit, acquiring external financing by themselves can be quite difficult (Gans and Stern, 2003). Less is known about ventures and their future is far from certain. Young and small firms can obtain an implicit certificate from the cooperative relationships (Stuart, 2000). These cooperations can strengthen the reliability of ventures and facilitate acquisition of necessary resources for the innovation. Thus, we hypothesize the following:

*Hypothesis 1: The relationship between R&D cooperation and innovation performance is stronger in ventures than in established firms.*

### 2.4 Diversity of R&D Partner Type and Ventures' Innovation Performance

In view of the above discussion, R&D cooperation fosters innovation performance of firms. However, some researchers raise questions about the relationship between the number of cooperation partners and innov-

ation performance of firms. Burt (1992) discussed the potential growth in information redundancy in the number of R&D cooperation agreements. Researchers also argued that the marginal returns of innovation performance diminished as the number of cooperation agreements increased (Deeds and Hill, 1996). Firms, thus, have to consider the efficiency aspect when building R&D cooperative relationships. Some researchers suggested that it is not the number of collaborative agreements per se, but rather the diversity of the firm's cooperative network that influences the innovation performance of the firm (Baum et al., 2000). Especially, building efficient R&D cooperation is significant for ventures that have insufficient resources in terms of managing collaborative relations.

Each type of cooperative partner provides different benefits for the innovation. Partners who are closely connected with one another in the business process, such as suppliers, clients, and customers serve as sources of vital knowledge (Almeida, Dokko, and Rosenkopf, 2003). Previous research views the collaborations with customers and suppliers as more exploitative in nature because development efforts remain predominantly sited within a given value chain (Tripsas, 1997). Cooperation with customers and suppliers has been considered as instrumental in optimizing existing core competencies (Brown and Eisenhardt, 1997). Firms also collaborate with the knowledge producers represented by universities and institutions. They contribute to the increase in new knowledge of the firm rather than directly involving in the firm's business process. Researchers highlight that universities play a significant role in suggesting new ideas (Cohen, Nelson, and Walsh, 2002). Cooperation with such partners focuses on the creation of insights relating to new technologies that can be translated ultimately into commercial development (George, Zahra, and Wood, 2002). Strategic coalitions can be a way of sharing the resources and information possessed by one's partners. Firms attain different knowledge from different types of

cooperation. According to the types of partners, acquired know-how will obviously produce different outcomes for focal firms. Thus, developing inter-organizational R&D cooperation with diversity of partner type will contribute to increasing firm's innovative capabilities. Thus, we can assume that diversity in R&D cooperation partner type will increase ventures' innovation performance.

However, does greater diversity in R&D cooperation partner type always lead to increased innovation performance of ventures? Researchers pose that R&D cooperation involves substantial costs and is time consuming (Stuart, 2000). Moreover, selecting and maintaining such cooperation partners need high level of attention. Because of the limited rationality, venture firms have difficulty focussing on and managing highly diversified cooperation partners. When we consider attentional engagement of the firms (Ocasio, 2011), ventures are not likely to capture the consequences of cooperation from the highly fragmented partner types.

The predicted relationship is one where diversity of R&D cooperation partner type initially increases the innovation performance of ventures. However, beyond a certain point, diversity increases costs and time inefficiency, attentional engagement, and eventually, overwhelms the positive aspects that result from the diversity. The arguments outlined above suggest an inverse relation between R&D cooperation partner type diversity and innovation performance of ventures beyond a certain point. Therefore, by considering the whole reasoning, we can suggest the following hypothesis:

*Hypothesis 2: Diversity of R&D cooperation partner type will have an inverted U shaped relationship with ventures' innovation performance.*

## **2.5 Diversity of R&D Partner Dependency and Ventures' Innovation Performance**

From the resource dependence perspec-

tive, the basic notion is that firms want to minimize their dependence on other firms and maximize the dependence of others on them (Miles et al., 1999; Pfeffer and Salancik, 1978). Dependence is considered as an important issue when firms engage in inter-organizational relationships (Katila, Rosenburger, and Eisenhardt, 2008). Firms have strong motivation to manage their dependency levels. Although dependency is recognized as an important factor in cooperative relations, few studies analyze the diversity of partner dependency from the portfolio perspective.

Owing to the limited resources and network, entrepreneurial firms are likely to limit their cooperative relationship with few partners (Baum et al., 2000). Although seeking the benefits encourages ventures to form intensive partnerships, the over-dependency problem has to be considered. The dependency toward each R&D cooperation partner can be one of the important determinants for ventures' innovation performance. It is meaningful to examine the extent to which alliance partners' dependency diversity enables a venture's innovation performance enhancement.

Heavily relying on partners implies that the partner holds power in the relationship. Researchers have addressed this balance in power and control between partners increase cooperation stability and enable better cooperative performance (Muthusamy and White, 2006). Spreading dependency among the partners will provide the ability of managing power balance in cooperative relationship.

If ventures highly count on their cooperation partners when developing their innovation capabilities, they may be exposed to the risk of losing their own internal R&D competence. For example, some research suggests that alliance strategy has a negative effect on internal R&D capability (Miles and Snow, 1992). If firms engage in rigid cooperative relationships to create innovations, they can reduce the need to invest in R&D (Cuervo-Cazurra and Un, 2010). Internal R&D capability is a core asset for ventures

that aim to achieve continuous innovation. Since innovation is essential for their further growth, they have to maintain their own R&D capability.

The increase in the dependency toward partners might increase the negative effect on the internal innovation. Overdependence on any single relationship can weaken the overall performance (Miles et al., 1999).

Thus, ventures need to achieve a balance in the degree of dependency to increase innovation performance. We hypothesize the following:

*Hypothesis 3: Diversity of R&D cooperation partner dependency will positively affect ventures' innovation performance.*

### **III. Method**

#### **3.1 Data**

The data for empirical analysis are drawn from the Korean Innovation Survey (KIS) that was conducted in 2010 by the Science and Technology Policy Institute (STePI). KIS was based on the Community Innovation Survey (CIS) that has been used extensively in innovation research (e.g., Belderbos et al., 2004; Faems et al., 2005; Lopez, 2008; Monjon and Waelbroeck, 2003; Park and Kim, 2014; Tether, 2002).

KIS provides information on the technological innovation process of Korean manufacturing firms for the period of 2007~2009. A questionnaire was sent to 7,692 firms chosen through stratified multi-stage sampling among 41,485 firms in the manufacturing sector. The proportion of firms that responded was 51.03% and the survey data includes 3,925 firms. We used 22 items from the rather lengthy, 15 page survey questionnaire. If firms do not reply to any of these questionnaire items which is needed for the measures of this study, we excluded them from the sample. The final sample used in this study comprised 1,467 firms. Among these sample firms, 451 firms were designated as venture firms, which accounted

for 30.7% of the total sample. KIS asked the respondents to check whether they were certified by the government as ventures.

The KIS data that we used for analysis contains distinctive features. The data includes information on whether a firm used knowledge emanating from different types of cooperative partners in order to innovate. The survey inquires about the degree of novelty of an innovation and informs us whether an innovation is new to the firm or new to the market. We can also get a direct measure of dependency toward cooperative partners during the innovation process. Thus, we can obtain a direct measure of innovation information, and do not need to rely on proxies.

For the analysis of Hypothesis 1, we used total firm samples, and samples of ventures were used for the remaining hypotheses' testing.

## 3.2 Variables

### Dependent Variables

*Innovation performance:* Ventures' innovation performance was measured using the composition of revenue, which shows how innovation contributed to the total sales of the firms for 2009. We used total firm sales revenues from innovative products in 2009 that were derived from technologically new products introduced during 2007~2009. In this study, technologically new products mean that their technological characteristics or intended application differ significantly from those of previously produced products. Such innovation can involve radically new technologies or existing technologies in new uses.

Revenue can come from (1) technologically new products introduced from the market's viewpoint from the beginning of 2007 to the end of 2009; (2) technologically new products introduced from the firm's perspective; (3) other existing products. The proportion of revenue attributed to products new to the market as well as those new to the firm is considered as an indication of overall innovation performance (Escribanoa,

Fosfuri, and Tribó, 2009; Faems et al., 2005; Leiponen and Helfat, 2011).

**Independent Variables:** *R&D cooperation* is measured as the total number of R&D cooperative partners that focal firms owned. The KIS questionnaire assessed the existence of cooperative relationships with different types of partners separately. The types of cooperation partners were affiliated companies, suppliers, clients & customers, competitors or other firms in the same industry, consulting firms, universities, and research institutes. *Diversity of cooperation partner type* were measured by counting the number of partnership type the focal firms held.

The KIS questionnaire also inquired how much each partner type contributed to innovation on a five-point Likert scale (1 = not at all to 5 = very much). To measure the *diversity of R&D partner dependency*, we use the Blau's index, an Entropy measure broadly used in diversity studies (Blau, 1977). From the questionnaire, we can obtain the degree of dependency of focal firms on each type of R&D cooperation partnership for their innovation. By calculating Blau's index, we can clarify how the degree of dependency spreads from the category of weak partners to strong ones. The expression for the formula is as follows:

$$\text{Entropy} = 1 - \sum_{i=1}^n p_i^2$$

Where  $P_i$  represents the proportion of the dependency degree in the  $i$ th category of dependency diversity. The entropy value asymptotically ranges from 0 to 1, with a higher score indicating greater heterogeneity among R&D partners' dependency, and a lower score representing greater homogeneity among cooperation partners' reliance.

**Control Variables:** We used seven industry and organization control variables as suggested by an extensive literature review. Every industry has a different tendency of maintaining cooperation relationships and innovation performance according to the



characteristics of their main technology and products. We, therefore, controlled industry type according to the Korean Standard Industrial Classification (KSIC) codes. KIS (Korean Innovation Survey) provides three digit industry information. Based on these three digit codes, 77 different sub-industries were included in the total sample. 64 sub-industries were represented for the ventures. Firm type was also controlled. The sample of firms can be classified into the following types: independent companies, affiliated companies of Korean conglomerates, and affiliated companies of foreign conglomerates. These types may affect their R&D cooperation strategy.

Firms' profitability is included since it can influence innovation. According to previous literature, financial performance plays an important role deciding firms' response and reaction toward innovation (Chen, 2008; Cyert and March, 1963; Greve, 2003). In order to rule out the reverse causality, we use the time lag between profitability and innovation. For the dependent variable, innovation performance, survey asked the respondents to answer as of 2009. The control variable, profitability, was calculated as the average during 2007~2009. In general, it has been widely believed that firm size bears a positive relationship with firm innovation (Cohen and Levinthal, 1990). This is because the bigger firms are more likely to have capital and slack resources invested for firm's innovation. Moreover, bigger firms are more likely to endure longer investment horizons. Firm size was included as a control variable and was measured as the log of the number of employees. Since previous empirical findings indicate that firm age is also related to firm's innovative outcomes, it was also included.

R&D intensity was included as well. Since R&D intensity offers the opportunity of higher innovation performance owing to the investment toward the innovation process, it directly influences firm innovation. R&D intensity was determined by dividing a firm's reported 3 years' R&D expenditure by total

sales for 2007~2009. Export-oriented firms are increasingly concerned about their productive innovation, since they deal with a more competitive environment (Cassiman and Veugelers, 2006). Therefore, export intensity was calculated as export divided by sales and included to control.

### 3.3 Statistical Analysis

Dependent variable of this study, firms' innovative performance, in the regression model is censored, since the variable is the percentage of innovative sales and therefore by definition ranges between 0 and 100. Accordingly, a Tobit analysis is applied (Greene, 2000; McDonald and Moffitt, 1980).

## II. Results and Discussion

Table 1 and Table 2 show the means, standard deviations, and correlations among the study variables. Detailed industry dummies among the manufacturing industry and firm type dummies are used but not reported in order to save space.

To assess the potential threat of multicollinearity, we estimate the variance inflation factor (VIF) for two sets of samples. In case of the entire sample, we find that no variable has a VIF greater than 1.78 and the mean is 1.27. For the sub-sample considering only the ventures, the maximum VIF value is 6.1 and mean is 2.08. Both cases are well below the recommended ceiling of 10 (Kleinbaum, Kupper, and Muller, 1988; Neter, Wasserman, and Kutner, 1990). Likewise, multicollinearity diagnostics did not reveal any problem in the regressions.

The results of the analyses are shown in Tables 3 and 4. Hypothesis 1 predicts that the relationship between R&D cooperation and innovation performance is stronger in ventures than in established firms. In Table 3, the result of Model 1 shows a positive moderate effect of ventures on the relationship between R&D cooperation and firms' innovation performance ( $p < 0.10$ ).

Hypothesis 2 posits that diversity of R&D cooperation partner type will have an in-

verted U-shaped relationship with ventures' innovation performance. Model 3 of Table 4 shows a positive coefficient on the partner type diversity term and a negative coefficient on its squared term. Both of these coefficients are statistically significant (partner type diversity,  $p < 0.05$  / partner type diversity squared,  $p < 0.10$ ). Thus, these results support hypothesis 3.

Hypothesis 3 predicts that more diverse R&D cooperation partner dependency will positively affect ventures' innovation performance. Model 4 of Table 4 shows a significantly positive relationship between diversity of R&D cooperation partner dependency and ventures' innovation performance.

This study analyzed a sample of Korean manufacturing ventures to examine the influence of R&D cooperation on firms' innovation. Results suggest that cooperation plays a significant role in ventures' innovation performance. The results show that a moderate level of diversification in cooperation arrangements enhances innovation. This finding suggests that firms may benefit from diverse partner type that provide complementary resources and information as long as it does not exceed the ideal level to the point of not offsetting the positive effect of diversity. Furthermore, we found that diversity of cooperative partnership dependency brings innovation performance.

**Table 1**  
**Descriptive Statistics and Correlations of All Firms**  
**(Established firms and Ventures)**

Variables	Mean	S.D.	1	2	3	4	5	6	7
1. Innovation performance	0.23	0.28							
2. R&D Cooperation	0.26	0.44	0.19*						
3. Profitability	0.05	0.12	-0.02	0.04					
4. Firm age	24.30	14.86	-0.07*	0.03	0.02				
5. Firm size	4.90	1.23	-0.06*	0.08*	-0.00	0.49*			
6. R&D intensity	0.02	0.09	0.07*	0.01	-0.29*	-0.11*	-0.11*		
7. Export intensity	0.22	0.29	0.04	0.03	0.07*	0.08*	0.26*	-0.01	
8. Ventures	0.08	0.26	0.14*	0.01	0.02	-0.40*	-0.56*	0.19*	-0.11*

$n = 1,467$ ; †  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

**Table 2**  
**Descriptive Statistics and Correlations of Ventures**

Variables	Mean	S.D.	1	2	3	4	5	6	7
1. Innovation performance	0.27	0.30							
2. Partner type diversity	0.68	1.51	0.23*						
3. Dependency diversity	0.07	0.18	0.19*	0.87*					
4. Profitability	0.06	0.14	-0.04	-0.02	-0.01				
5. Firm age	14.82	8.21	0.01	0.03	0.00	0.04			
6. Firm size	3.77	0.99	0.05	0.18*	0.15	-0.03	0.39*		
7. R&D intensity	0.05	0.16	0.04	0.00	0.01	-0.48*	-0.09	-0.02	
8. Export intensity	0.16	0.25	0.09*	0.10*	0.06	0.08	0.02	0.34*	0.03

$n = 451$ ; †  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

**Table 3**  
**Results of Tobit Regression Analysis of Ventures' R&D Cooperation and Innovation Performance (Analysis of H1)**

DV: Innovation performance

Variables	Model 1	Model 2
Profitability	-0.0294 (0.0643)	-0.0467 (0.0632)
Firm age	0.0003 (0.0006)	0.0003 (0.0006)
Firm size	0.0017 (0.0084)	-0.0017 (0.0083)
R&D intensity	0.0686 (0.0837)	0.0548 (0.0822)
Export intensity	0.0367 (0.0281)	0.0400 (0.0275)
Ventures		0.0563** (0.0213)
R&D cooperation	0.0847 (0.0199)	0.0953*** (0.0189)
R&D cooperation × Ventures		0.0739* (0.0346)
Industry dummy	Included	Included
Firm type dummy	Included	Included

$n = 1,467$ ; †  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Note: Industry dummy variables and firm type dummy variables were included, but not reported here. Coefficients are reported with standard errors in parentheses.

**Table 4**  
**Results of Tobit Regression Analysis of Cooperation Partner Type Diversity/ Dependency Diversity and Innovation Performance (Analyses of H2 & H3)**

DV: Innovation performance

Variables	Model 1	Model 2	Model 3	Model 4
Profitability	0.1521 (0.1626)	0.1662 (0.1607)	0.1578 (0.1602)	0.1529 (0.1615)
Firm age	0.0025 (0.0024)	0.0027 (0.0023)	0.0029 (0.0023)	0.0028 (0.0023)
Firm size	0.0084 (0.0341)	-0.0002 (0.0338)	0.0013 (0.0337)	-0.0004 (0.0341)
R&D intensity	-0.0051 (0.1342)	-0.0056 (0.1325)	-0.0155 (0.1322)	-0.0099 (0.1333)
Export intensity	0.0478 (0.0805)	0.0465 (0.0795)	0.0473 (0.0792)	0.0501 (0.0800)
Partner type diversity		0.0385*** (0.0115)	0.1058** (0.0388)	
Partner type diversity 2			-0.0135† (0.0075)	
Dependency diversity				0.2398** (0.0961)
Industry dummy	Included	Included	Included	Included
Firm type dummy	Included	Included	Included	Included

$n = 451$ ; †  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Note: Industry dummy variables and firm type dummy variables were included, but not reported here. Coefficients are reported with standard errors in parentheses.

## ***IV. Conclusion***

The main purpose of the present study was to clarify how efficiently ventures achieve innovation performance through diverse R&D cooperation arrangements. To overcome the liability of newness, ventures should cautiously manage the composition of R&D cooperative arrangement from the overall perspective. Considering efficiency and maintaining dependence are critical issues for ventures when they manage diverse cooperative arrangements.

According to the diversity of cooperation partner type and dependency, this study scrutinizes effective ways to increase the innovation performance of ventures. By showing a non-linear relationship between cooperative partner type diversity and innovation performance, this study suggests an effective composition of R&D cooperative partner type diversity. We also confirm that diversity of partner dependency is preferable for ventures' innovation. Our overarching conclusion is that ventures have to compose a moderate level of diversity in cooperation partner type and maintain the balanced dependence among the partners for achieving innovation performance.

### **5.1 Theoretical and Managerial Implications**

This study has important implications. Although researchers have concentrated on the whole set of cooperation arrangement from a single cooperative relationship, R&D cooperation studies based on a portfolio perspective still remains unexplored and we attempted to fill the gaps.

While previous studies have focused on the quantity aspects of R&D cooperation, this study concentrates on the quality aspects, such as diversity of partner type and its dependency. If partners are considered as quantity aspects, all partners are assumed as same entities. We focused on the different benefits that different partners can provide and examined their influence from the portfolio perspective.

Previous studies regarding portfolio cooperative arrangement have been largely concentrated on established firms and little extends to nascent firms. Ventures have insufficient resources and information compared with established firms. To cope with difficulties, they have to cautiously select their cooperation partners depending on their intended benefits and efficiently manage cooperation partners from the whole set of perspectives. Therefore, it is necessary to extend the context of ventures in the multiple R&D cooperation studies. This study may bring some insight to pursue efficiency for the ventures' R&D cooperative strategies.

According to resource dependence theory, strategic independence is an important motivational factor to create additional cooperative partnerships for maintaining one's interdependence. Particularly, the dependency issue is significant for the ventures. Therefore, looking into the dependence level from the total set of cooperative partners provide important implications.

### **5.2 Limitations and Future Research**

We acknowledge several weaknesses of this study and discuss possible future directions to further develop R&D cooperation research. This study uses a three-year windows for the analysis. All analyses were conducted based on the period of 2007~2009. Dependent variable, innovative performance, was measured over 2009. Innovation sometimes intrinsically involves long-term performance as well. Thus, the time gap used in this study may not fully reflect the effect of R&D cooperation on innovative performance.

The nature of ventures' cooperative strategies from the portfolio level is still relatively unexplored in empirical terms. Engaging in multiple R&D cooperation arrangements may become continuously important for innovation of ventures. Our study paves the way for future research on nascent firms' multiple R&D cooperation arrangements and offers guidance to start-ups that face the chal-

lence of efficiently managing their cooperative relationships.

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## R&D 협력 파트너 유형 및 의존도와 혁신의 성과: 한국 벤처기업들을 대상으로 한 실증연구\*

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본 연구는 상대적으로 지식과 자원이 부족한 벤처기업이 외부의 다양한 유형의 파트너와 R&D 협력 관계를 효율적으로 활용, 관리하는 것을 통해 혁신 성과에 유의미한 영향을 줄 수 있음을 살펴보고 있다. 혁신은 벤처기업의 생존과도 직결되는 중요한 요인 중 하나로 여겨져 왔다. 일반기업과 달리, 벤처와 같이 자원의 제약이 있는 신생 기업은 R&D 그 자체에 있어 필요한 자원이나 혹은 이러한 신기술 또는 아이디어를 독자적으로 상품화하고 시장에 내놓는데 필요한 자원이 부족한 경우가 많다. 따라서 이를 보완해 줄 외부 협력 파트너를 찾고 효율적으로 관리하는 것이 굉장히 중요한 이슈이다.

오늘날 대부분의 기업들은 하나의 협력 관계만을 보유하지 않고, 다수의 R&D 협력 관계를 동시에 맺고 여러 파트너들과 교류하고 있다. 학자들은 이러한 여러 협력 관계를 포트폴리오적인 차원에서 효율적으로 관리하는 것의 중요성에 대해 언급하여 왔다. 협력 관계를 맺고 유지하는데 있어서도 상당한 양의 시간과 자원 투자가 요구되며 관리차원의 주의(managerial attention)가 필요하기 때문에, 협력 관계를 전사(全社)차원에서 관리하여 효율성을 높이는 것이 중요하다. 자원의 부족이라는 벤처기업의 근본적인 특성을 생각해 볼 때, 벤처기업에게 있어서 더욱이 전사차원의 효율적 협력 관계 관리에 대한 고찰이 절실하게 필요하다고 할 수 있다.

본 연구를 통해 벤처기업의 협력 파트너 종류의 다양성과 협력 파트너에 대한 의존도의 다양성이 혁신성과에 미치는 영향을 살펴봄으로써, 보다 효율적인 협력 파트너 구성에 대하여 포트폴리오적인 시각에서 고찰하고자 한다. 2010년 제조업을 대상으로 한 한국기업혁신조사(KIS) 자료를 분석한 결과, 기존 기업 대비 벤처기업에게 있어서 R&D 협력이 혁신성과에 더욱 중요한 영향을 준다는 것을 확인하였다. 따라서 벤처기업은 이를 전사차원에서 효율적으로 관리하여야 하는데, 외부 파트너 유형의 다양성과 혁신 성과는 비선형적 관계(역 U자형)를 나타내므로, 다양성만을 지속적으로 추구할 것이 아니라 긍정적 효과를 상쇄하지 않는 범위 내에서 이를 유지하는 것이 중요하다는 것을 발견하였다. 더불어 각 파트너들에 대한 의존도는 다양하게 가져가는 것이 혁신성과에 중요하다는 결론을 얻을 수 있었다.

**주제어** : 벤처기업 혁신, R&D 협력, 협력 파트너 유형의 다양성, 협력 의존도 다양성

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