Determinants of Industry-Academy Linkages and Their Impacts on Firm Performance:

The Case of Korea as a Late-comer in Knowledge Industrialization

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Abstract

This paper utilizes the Korea Innovation Survey data to find out the determinants of industry-university and industry-GRI (IUG) cooperation and its impact on firm performance. We find first that among determinants of IUG cooperation, traditional firm characteristics variables of sizes and R&D intensity are not significant at all, while the participation at the national R&D project turns out be most significant and robust in both cooperation modes. This is in quite contrast to the results from the cases of European countries, and reflects importantly the heavy weight of government policies in promoting the IUG cooperation in late-comer economies. Second, regarding the impacts of the IUG cooperation, we strikingly find no significant impact on the innovation probability of firms when we control the possible endogeneity such that already innovative firms might participate more at such cooperation modes. This implies that the IUG cooperation cannot guarantee a firm success in technological innovation; rather, it may have an influence on the selection or direction of the firm's research projects. When we limit the analysis to the innovative firms, we do find positive impacts of the IUG cooperation on patents generated from new product innovation but no impacts in terms of sales increase or labor productivity. These results seem to reflect the still transitional nature of the NIS and knowledge industrialization.

I. Introduction

In the knowledge-based economy, knowledge is essential; thus the role of university as a source of new knowledge has even become more important than in the past (Etzkowitz et al., 2000). Fast-paced global competition and technological change also add significance to the firm's links to university for not only discovery of knowledge but also its industrialization (Bettis and Hitt, 1995; Etzkowitz and Leydesdorff, 1997; Hwang et al., 2003). In other words, the universities and public research institutes have emerged as the key component of the national innovation system (NIS) which was proposed by Freeman (1987) and Lundvall (1992).

Freeman defines the NIS as a "network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies." Lundvall defines it as the "elements and relationships which interact in the production, diffusion, and use of new, and economically useful, knowledge… and are either located within or rooted inside the borders of a nation state." He broadens the concept of Freeman to include economic structure and institutional set-up that affect searching, learning, and adapting. In a book comparing the NIS of 15 countries, Nelson (1993) points out that the performance differences among countries reflect different institutional arrangements. In the NIS literature, one of the roles of universities and research institutes is to channel their knowledge to firms, and universities function as a knowledge diffuser by producing quality students and by interacting with firms through cooperative programs.

Specifically regarding the role of university, there exist two contrasting views, Triple Helix Thesis and the New Economics of Science. Etzkowitz and Leydesdorff (1997) introduce a triple-helix model of industry-university-government relations, emphasizing both social and economic roles of university. Here, the interactions among three are keys to facilitating conditions for innovation. The Triple-Helix thesis argues that university needs to be directly linked to industry in order to maximize the industrialization of knowledge. This emphasizes on the "third mission" of the university to economic development, as well as teaching and research (Etzkowitz and Leydesdorff, 2000). On the other hand, the New Economics of Science (Dasgupta and David, 1994) emphasizes the education as an innate function of university. This view is concerned about the relationships between university and industry becoming too close, arguing that they may be detrimental to the scientific potentials of a nation, and that a proper division of labor between these institutional actors is needed. Criticizing the inappropriateness of the two in its applications to developing countries, Eun et al (2006) suggest a "contingent or contest-specific" perspective on industry-university relationships. Each country has its own NIS, and it is natural that the industry-university linkages of each country take various forms, assuming different functions in a nation. This paper takes the case of Korea to investigate the role of universities and government research institutes (GRIs) in the NIS of a late-comer and fast catching-up economy, with focus on the determinants of the university-academy linkages and their impacts on firm performance.

One of the most important characteristics of the Korean NIS has been the "twin dominance" by the big business and the government, which also meant a relatively weak role by the universities and the SMEs (Kim, 1993; Lim, 2006; Choi et al., 2007). For instance, universities employ around 70 per cent of all doctorates in Korea, yet paradoxically conduct only 10 per cent of Korean research (OECD, 2008). Also, as of 2005, 39.7% of researchers and 52.2% of Ph.D. researchers belong to the top 20 firms (MOST, 2007). While big business groups have dominated the NIS of Korea by huge size of their in-house R&D since the mid 1980, it was the government and GRIs that have led initially the NIS of Korea during its early take-off period in the 1960s and 1970s. In the 1970s, Korea was in transition from light to heavy and chemical industries, but its national R&D base was weak. So, the Korean government tried to promote national R&D capacity by establishing GRIs: a number of GRIs were established, based on the *Special Research Institute Promotion Law* of 1973, in the fields of machinery, shipbuilding, chemical engineering, marine science, and electronics.

Noticeably, from the mid-1970s, *chaebol* firms started to grow rapidly with diversification or entries into heavy and chemical industries. Here, the government played a significant role by selecting to provide a few *chaebol* firms with exclusive advantages. Even in the 1980s and 1990, big business groups or *Chaebols* were helped by the government-led public-private research consortia in achieving key R&D goals, with such examples of TDX (a system of telephone switches), memory chips development and digital TV projects (Lee and Lim, 2001; Lee et al., 2005). According to the OECD's study (2003), Korea is the only country that GRI, rather than university, had a relatively greater role in national R&D.

In the context of the above discussion, one of the possible contribution of this study is that we are examining the role of the government policy in promoting firms' collaboration with universities and GRIs, whereas the existing studies tend to focus more on firm-level and sectoral level characteristics, such as R&D intensity, firm size (Santoro and Chakrabarti. 2002), science-basedness (Meyer-Krahmer and Ulrich Schmoch, 1998) and IPR regimes (Cassiman and Veugelers, 2002). Also, as GRIs have been the key participants in these national R&D projects that involved private firms, it is important to examine the impact of firms' collaboration with GRIs on firm performance. This is one of the distinctive features of this study.

In contrast to the GRIs, the universities have played minor role in boosting R&D performance of the private sector in Korea. Big private firms relied more on foreign knowledge sources than local sources and universities as they hired quality scientists and engineers from abroad or acquiring technology in collaboration with foreign partners. Kim (1993) argues that the lack of interaction between university and industry is one of the greatest weaknesses of Korea's national system, and it was due to the nature of Korean universities as a teaching-oriented university. It is since the 1990s that research has been given increasing priority in universities in Korea. Thus, since the 1990s, the ranking of Korea has been rising in terms of the number of Science Citation Index (SCI) papers to which university has contributed significantly: Korea ranked 19th in 1996 with university accounting for 83.0% of the contributions (Lee, 1998). Then from the late 1990s on ward, policy agenda has finally shifted toward entrepreneurial role of universities.

The enactment of the *Technology transfer Promotion Law* in 2001 symbolizes this transition of interests toward knowledge industrialization. This *Law* prescribes that public universities should establish units or institutions, such as TLOs (Technology Licensing Offices), that are in charge of technology transfer and training of specialists. Promotion of the industry-university cooperation got more momentum as universities started to establish the so-called "industry-university cooperation foundation" from 2004 after the enactment of the *Law on Industrial Education and Industry-University Cooperation* in 2003. Only with this law, the intellectual property rights of research outcomes of university professors began to belong formally to universities, whereas in the past individual professors tended to file patents to have them as their personal ownership. As of 2007, 134 universities have established industry-university cooperation foundations within their campuses, out of which 59.8% (80 universities) have had TLOs. The number of TLOs increased rapidly, especially, in 2004 with 43 being newly established, whereas there was only 32 until 2003 (KRF, 2007). The above discussion indicates that the knowledge industrialization from universities is recent phenomenon and it has not been much progressed. Thus, it is interesting to examine its impact on firm performance and compare the results with those from advanced or mature countries with longer history of the collaboration. Specifically, we find with the data of 2000/01 period that the collaboration with universities is not significantly increasing the probability of innovation success, and has not lead to sales increases but only in the increase of patents, which is in contrast to the results in Europe by Belderbos et al. (2004) or Faems et al. (2005).

While this paper addresses the questions what determines the IUG (industry-university/GRIs) linkages and how the linkages affect firm performances, it also achieves some methodological improvement. Some studies, for instance Monjon and Waelbroeck (2003), examining the impact on firm performance do not control possible endogeneity such that better performing firms might be more inclined to pursue collaboration with universities. We take a two-step approach. We first estimate the determinants of IUG cooperation by Probit model regressions. Second, it estimates the impact of this cooperation on innovation performance where a possible endogeneity of IUG cooperation measure is controlled by using the results of the first-step estimations. We consider the controlling endogeneity is important, because we have obtained contradictory results; when endogeneity is controlled, collaboration with universities is not shown to be significantly increasing the probability of innovation.

Also, when we examine the impact of the IUG cooperation on firms' performance, we control a possible sample selection bias using Heckman's 2SLS method, and the types of innovation are differentiated into product vs. process innovation. The empirical analysis utilizes the data from the *2002 Korean Innovation Survey* (*KIS*) that was conducted by Science and Technology Policy Institute (STEPI). The *KIS* comprises of firm-level data on technological innovation in the manufacturing sector. In order to allow for use of more variables and data credibility, the *Survey* data is merged with the standard financial statements of the firms compiled by a credit rating agency.

This paper is structured as follows. Section II reviews the existing literature on the determinants of IUG cooperation and on the impacts of this cooperation on firm performance, extracting four hypotheses. Section III explains data, variables and methodologies to be used for the empirical analysis. Section V discusses the empirical results with interpretations, and Section VI provides summary and conclusions remarks.

II. Theoretical Framework and Hypotheses

1. What determines the Industry's Relations with University/GRIs: Hypothesis 1

As determinants of firms' relations with universities or GRIs, we can in general consider the firm-level and sector level characteristics, as well as the impact of some government policy initiatives.

The Resource-based theory of the firms states that internal resources play an important role in a firm's growth propensity (Penrose, 1959; Richardson, 1972). If the internal resources are binding, then it makes sense for a firm to engage in cooperation with external partners to get access to additional resources, such as capital, technology, and human capital. Industry-university cooperation has been discussed as one type of R&D cooperation in these contexts. According to Geisler (1995), the more recognized the fact that they are interdependent in terms of resources, the higher the possibility that university and firm establish partnerships. On the other hand, as Santoro (2000) and Freel and Harrison (2006) argue that, in spite of their importance in research, firm often looks for other partners not university in pursuing technological initiatives, due to the mismatch of research interests between them.

Firm size is one of the most obvious variables to represent the size of firm-level resources, which affect firm's decision about R&D cooperation with external actors. Large firms can cooperate with partners more effectively than small firms, thereby benefiting from their internal resources (Tether, 2002). On the contrary, there exist a number of studies that argue otherwise: small firms tend to be more eager for external cooperation than large firms as they face lack of internal resources, especially financial, R&D capacity or facility. In empirical analyses, like the theories, the impact of firm size on the firm's decision in cooperation with university or GRI is obscure. We will check this with the Korean data.

As a firm-level variable, we will also consider R&D intensity, as it matters as one possible proxy for the absorptive capacity of a firm that maximizes benefits from R&D cooperation (Fontana et al., 2006). Firms, whose R&D capacities are large enough to easily absorb external knowledge, are willing to obtain benefits from it. However, the opposite can occur: these firms may substitute external cooperation by developing technology independently (Love and Roper, 1999). In this case, the smaller the R&D capacity, the more pursuant the firm is to cooperate with partners. Like the empirical analyses for firm size, those for the impact of R&D intensity show obscure results.

There are also many researches noting the importance of sectoral characteristics in the industry-university cooperation. Pavitt (1984) argues that learning from advancements in technology is crucial for science-based industries, e.g. electronics and chemicals, for which industry-university should be more important. Some literature (Meyer-Krahmer and Ulrich Schmoch, 1998; Santoro and Chakrabati, 2002; Schartinger et al., 2002) underlines the importance of this cooperation, saying that these industries heavily depend on progress in sciences and technology.

Sector characteristics are emphasized in the literature on sectoral systems of innovations (SSI). Marlerba (2005) defines the SSI as a “set of agents carrying out market and non-market interactions for the creation and sale of sectoral products.” He suggests the following four theoretical blocks of the SSI: 1) regimes of knowledge and technology; 2) demand conditions (or marker regimes); 3) actors and networks, and the coordination among them; and 4) surrounding institutions including IPRs, laws, culture, and so on. Literature states that the specific patterns of innovation activities are determined by technological regimes. Breschi et al. (2000**)** define a technological regime as the combination of technological opportunities, appropriability of innovations, cumulativeness of technical advancements, and properties of the knowledge base. Park and Lee (2006) analyze the relationship between technological regime and technological catch-up using U.S. patent data and find that catching-up countries tend to record higher performance in classes/sectors with a shorter cycle time, easier access to knowledge, and higher appropriability.

The Industrial organization literature is interested in how the imperfect appropriability of innovation outcomes affects the incentives for a firm’s innovation: appropriability increases benefits from R&D cooperation when incoming spillovers are high enough, which is on the contrary when there are inducements for a free-rider. There is an argument, like Veugelers and Cassiman, saying that due to the generic characteristics of knowledge, industry-university cooperation tends to be less involved in this issue compared to industry-competitor or supplier cooperation. In this regards, Cassiman and Veugelers (2002) empirically verify that the effective IPR regime facilitates the firm’s propensity of cooperating with universities, while its strategic protection, such as secrecy or lead time, does not. We will consider each sector’s IPR regime as one of the sectoral characteristics that affect the industry-university/GRIs relations.

Finally, the government’s policy for R&D is also emphasized as being crucial for technology transfer from public research organizations to industry. The *Bayh-Dole Act* of the US in the 1980s is often cited as the legislation for facilitating the growth in university patenting; the *Act* allowed the IPR of university research results conducted by public funds to belong to universities. Since then, a number of OECD countries have emulated to adopt similar laws in order to utilize academic research for commercial advantages (OECD, 2003). Government’s supports for R&D are helpful for firms that need external partnerships but face financial or networking problems. The government may provide those firms with capitals for acquiring basic or core technology from university or GRI or with opportunities for collaborating on research projects with them (Mohnen and Hoareau, 2003). Both Mohnen and Hoareau (2003) and Capron and Cinccera (2003) prove that firms, which use the government’s support measures, tend to cooperate with these public research organizations.

2. The Impacts of the Linkages on Firm Performance

(1) Innovation Probability: Hypothesis 2

Knowledge is different from technology in terms of “purpose, degree of codification, type of storage and degree of observability” (Landry et al., 2007): the former is tacit stored in people's head, intangible with the imprecise impact of its use, and concretizing theories and principles; the latter is codified in software or blueprint, tangible with the precise impact of its use, and changing technological environments. Namely, technology transfer is considered as the limited activities of knowledge transfer.

Unlike the technology from private firms, a large part of the knowledge from university is transferred to firms informally,[1] although previous studies have focused mainly on citations (Spencer 2001), patents (Hall and Ziedonis), and spin-offs (Link and Scott, 2005). This is particularly the case in Korea in which education or consulting is more prevalent than others. So, due to their characteristics of knowledge or way of knowledge transfer, industry-university cooperation may not directly influence the firms' success in innovation; rather, it can affect their decision or management of research projects (George et al., 2002; Mowery and Sampat, 2005). Actually, many studies that have tried to conceptualize knowledge transfer from university emphasize its activities of affecting decision-making processes rather than generating tangible products (Knott and Wildasky, 1980; Lester and Wilds, 1990).

The impact of industry-university cooperation is empirically obscure. Based on a CIS data of 1,460 French firms, Monjon and Waelbroeck (2003) find that cooperation with university (foreign rather than domestic) increases the probability of radical innovation, while spillover from university does not.[23] On the other hand, Sung (2005)'s study in Korea finds that this cooperation does not affect the innovation probability of Korean firms in general. We will check, using a more rigorous techniques checking the possible endogeneity, whether the cooperation with universities or GRIs tend to increase firms' innovation probabilities or not.

(2) Tangible Outcomes of Innovation: Sale increase vs. Patents: Hypothesis 3

University's research and development is characterized as being new or creative. Previous literature underlines the fact that industry-university cooperation contributes to radical innovation, which is new not only to the 'firm' but also to the 'market' (Monjon and Waelbroeck, 2003) or to the creation of 'new competencies' (Faems et al., 2005). On the contrary, industry-industry cooperation contributes to incremental innovation, which is new to the 'firm' or to the improvement of 'existing competencies.' This implies that the former has a higher possibility of leading to more patents or generating new products.

This is supported by Belderbos et al.'s study (2004) that is based on the Dutch CIS I and II of 2,056 firms. They empirically prove that both formal cooperation and spillover from university facilitate the growth in innovative sales, concluding that university is important source of knowledge for radical innovation.[4] Using the Belgian CIS II of 221 firms, Faems et al. (2005) examine two types of technological cooperation: the "explorative" partnerships with university and GRI and the "exploitative" partnerships with client and supplier. They find that the presence and number of "explorative" partnerships improve the proportion of turnover generated by product innovation, while that of "exploitative" partnerships enhance product-improving innovation. George et al.'s study (2002), using a data of 2,457 alliances by 147 U.S. publicly traded biotechnology companies, reveal the significant impact of industry-university cooperation on patents. Considering the quality as well as quantity of university linkages, e.g. the number of Research-I university linkages or total federal R&D funding, they claim that firms with links to university perform better in terms of the number of patents as well as products in the market. In contrast to the results on patents or sales, most studies report that university-industry cooperation has no significant impact on labor productivity (Belderbos et al., 2004; Monjon and Waelbroeck, 2003). The interpretation seems to be that labor productivity is affected many other factors.

These studies are from the context of the advanced countries where knowledge industrialization systems have been well developed, and thus industry-university cooperation has been found to be directly linked to the increases in sale from new innovative products. However, the industry-university cooperation has been just being developed in Korea and the forms of knowledge industrialization are not diverse and active. This implies a possibility that the impact of this cooperation is not fully revealed as sales as much as it is in advanced countries; rather, it could be shown more as patents, because patents have a merit of being filed within a short time, regardless of the development of knowledge industrialization systems.

On the basis of the above discussions, we hypothesize that for Korean innovative firms the impact of IUG cooperation is revealed in the form of patents rather than increases in sales or labor productivity.

(3) Product innovation vs. Process Innovation: Hypothesis 4

University is the institution that functions higher education with basic or long-term research interests, which is different from firms with practical or short-term market needs (Hoffman et al., 1998). This implies that industry-university cooperation may be helpful for product innovation, while industry-industry cooperation may for process innovation. Rouvinen (2002) supports this through an empirical analysis of CIS data from Finnish manufacturing firms: that is, industry-university or non-profit research organization contributes only to product innovation, while industry-client or supplier contributes to process innovation as well. He explains it such that process innovation benefits from the “stocks of capital-embodied technology,” while product innovation does from the “disembodied forms of technology.” He also mentions the point that process innovation may constitute a part of product innovation rather than being patented.

On the other hand, there exists the opposite argument: Etzkowitz and Leydesdorff (2000) state that science has been organized in pursuit of practical as well as theoretical interests. Freel and Harrison (2006) empirically prove the positive relationship between product innovation and industry-customer or GRI cooperation, and between process innovation and industry-supplier or university cooperation. They argue that, in spite of their influences on product innovation, universities are significant contributors to just the sort of “industry-relevant” research for manufacturing firms at least.

A few papers point out that the IUG cooperation in Korea focuses on process rather than product innovation. For instance, Samsung Economic Research Institute (SERI, 2006) reports that a large number of Korean firms participate in national R&D programs, focusing on problem-solving rather than new product or technology development. In the case studies of the IUG cooperation system of Po-hang Steel, an affiliate of POSCO, Park et al. (2000) find that this system focuses on problem solving, is centered on short-term projects, and mostly contributes to process and product improvement but partly to product innovation. We will investigate the possibly different impacts of the IUG cooperation on the product vs. process innovation with the Korean data.

III. Data, Variables, and Methodologies

1. Data

The 2002 *KIS* (Korea Innovation Survey) is the third innovation survey conducted in Korea. The *KIS*, following the definitions in the *Oslo Manual*[5] from the OECD, covers the innovation-related activities of firms for 2000-2001. Out of the 6,233 target firms, 60.6% or 3,776 firms have responded. After matching with the database providing the standard financial statement (the Korean Investor Service *VALUE database which is most widely used in academic research)*, a total of 538 firms are found to have their matching financial statement data available and thus only these firms are used for econometric analysis. Technological innovation here includes three types – new product innovation, product-improving innovation and process innovation: the first two is called as product innovation.

The composition of the sample firms used in analysis below is as follows (Figure A1). Out of the total 538 firms, 388 (72.1%) are innovative firms, while 150 (27.9%) are non-innovative firms. The innovative firms are divided into three, with overlapping among them, namely, 269 (50%), 324 (60.2%) and 250 (46.5%) firms that succeeded in product innovation, product-improving innovation and process innovation, respectively. Specifically, the innovative firms are defined as those who conduct technological innovations (one of the three types) during 2000-2001 and produce at least one of innovative outcomes in 2001. And, they are asked how many patents they file from each type of innovation, and what percentage of their sales is related to the product innovation.

Regarding the cooperation with outsiders, the survey asks firms the following question, “Does your firm cooperate with partners for technological innovation? If yes, how important is the cooperation (with each partner) for your innovation (on a five-point scale)?” Out of the total 538 firms, 40.1% or 216 firms had a positive answer regarding cooperation with at least one partner. According to the type of partner, university, and GRI ranks fourth (139, 25.8%) and fifth (129, 24.0%), respectively, in terms of number and percentage, and both rank third (3.32 point) in terms of the degree of importance (Table 1). These figures are a bit lower than those of client firms (161, 29.9% / 3.66 point) and suppliers (161, 29.9% / 3.32 point).

For empirical analysis below, we focus on those firms that answered doing the ‘technological cooperation’ with either university or GRIs.

<Table 1> Technological cooperation by types of partners (n=538)

Partners	No. of firms (%)	Degree of importance [1] (point)
Affiliated firms	113 (21.0)	3.42
Clients	161 (29.9)	3.66
Suppliers (raw materials)	161 (29.9)	3.32
Suppliers (components/SW)	142 (26.4)	3.03
Competitors	122 (22.7)	2.88
Joint venture	94 (17.5)	2.84
Business service firms	101 (18.8)	2.74
Universities	139 (25.8)	3.32
Public research institutes	129 (24.0)	3.32
Public research laboratories [2]	116 (21.6)	3.06
Research associations	99 (18.4)	2.45
Research cooperatives	92 (17.1)	1.00
Private research institutes	95 (17.7)	2.53

Note: 1) The average value of the firms that cooperate with corresponding partners.
2) Public research laboratories conduct testing and certification service, which is far from research. Accordingly, this study considers only public research institutes as the variable of GRIs for empirical analysis.

2. Variables

(1) Firm Characteristics

Firm size: In this study, firm size (*SIZE*) is measured as a log value of the average number of employees during 2000~2001. The survey results show that the mean firm size is larger for firms that cooperate with university and GRI (5.27 and 5.30), respectively, rather than otherwise (5.02 and 5.01). The t-ratio is 2.23 (p=0.03) for university and 2.56 (p=0.01) for GRI, implying the significant difference in firm size between cooperators and non-cooperators (<Table 2>). Therefore, based on the above discussions, we will test if firm size affects the firm's propensity of cooperating with them.

R&D intensity: In this study, R&D intensity (*RD_INT*) is measured as a ratio of average R&D expenditure during 2000~2001 to sales in 2001. The mean of R&D intensity is only slightly higher for firms in cooperation with university (5.47%) and GRI (5.94%), respectively, than otherwise (2.99% and 2.91%). The difference is not significant as seen from the t-ratios of each (1.12 (p=0.26) and 1.28 (p=0.20)) (<Table 2>). Using regression analysis, we will test if R&D intensity affects the firm's propensity of cooperating with them.

Reasons for Cooperation: Firms cooperate with others for a variety of reasons, and sharing of costs or risk would be one of the reasons. This makes sense because R&D projects often involve high costs and uncertainty (Jensen and Thursby, 2003). In the empirical analyses, both Belderbos et al. (2004) and Veugelers et al. (2005) reveal that the cost-sharing objective is one of the key factor affecting firm's decision in cooperating with university. However, regarding the risk-sharing objective, they obtain a negative correlation. In this study, the cost-sharing objective (*COST*) and risk-sharing objective (*RISK*) are measured based on the answers to the following question: "What is the weight of the following as a barrier to technological innovation (on a five-point scale)?" Among 23 hindrance factors to innovation, the weight of excessive risk or uncertainty is used for the *RISK* variable and that of excessively high cost for innovation or industrialization, for the *COST* variable. The reasoning is that those firms that felt such barriers would have a higher motivation to seek collaboration with universities or GRIs.

Actually, the mean score of these two cooperation objectives is much higher for firms that are engaged in this cooperation than otherwise (<Table 2>): university (3.14 vs. 2.08) and GRI (3.22 vs. 2.09) for cost-sharing objectives, and university (3.17 vs. 2.20) and GRI (3.26 vs. 2.19) for risk-sharing objectives. The t-ratio is statistically significant for the both objectives. Therefore, we hypothesize that the more important are these cooperation objectives, the higher the firm's propensity to cooperate with universities or GRIs.

Affiliation to Business Groups: Business groups refer to a collection of legally independent firms bound together by equity ties. Given the predominance of such styles of firms in developing countries, the literature attributes the origin of business groups to underdeveloped market institutions and high transaction costs in developing countries (Leff, 1978; Goto, 1982). There exists a large volume of empirical research finding several advantages of business groups, associated with internal capital and products markets as well as resource sharing among affiliates (Chang and Hong, 2000). On the one hand, if an affiliate can obtain technology from other sister affiliates within the same group, it would feel less need for cooperating with universities or GRIs. On the other hand, it may take advantage of the brand names, resources, and networks of the affiliated group, thus making IUG cooperation arrangement easier and effective than otherwise (Tether, 2002). Belderbos et al. (2004) empirically prove that firms belonging to a group tend to cooperate with university. On the other hand, Mohnen and Hoareau (2003) reveal the opposite result, that is, the negative impact of this affiliation, interpreting it such that affiliates cooperate with university only through their headquarters while headquarters do directly. Given the importance of the business groups in Korean economic growth, it is important to examine their role in IUG.

In this study, affiliation to business groups (*GROUP*) is measured in two ways. One is based on the answer to the following question in the survey: "Of which type is your firm among an independent company, an affiliate to domestic business groups, or an affiliates to foreign firms?" *GROUP* is measured as a dummy, 1 if it is either a domestic or a foreign affiliate, or 0 otherwise. The mean percentage of firms affiliated to business groups is lower for firms that cooperate with university or GRI (11.51 and 10.08), compared to the ratio among the non-cooperators (13.79 and 14.18). However, the t-ratio of each is -0.68 (p=0.50) and -1.29 (p=0.20), and the difference is not statistically significant (<Table 2>). The other measurement is *chaebol*. *CHAEBOL10* and *CHAEBOL11-30* refer to the top 10 and the top 11th to 30th business groups as designated by the Fair Trade Commission (FTC) of the Korean government. The mean percentage of firms affiliated to top 10 or below *Chaebols* is almost similar for firms that cooperate with university or GRI as the ratio among the non-cooperators, and the difference between cooperators and non-cooperators is not statistically significant. Anyway, we will add these variables to test if affiliation to groups or *chaebol* decreases the firm's propensity to cooperate with universities or GRIs.

Firm Location: In spite of developments in communication means and reduced transaction costs in general, the factor of firm location or geographic proximity is still an issue in industry-university cooperation. It is expected that the firms in the same region as universities can have easy access to technology or employ quality scientists from the universities. Audretsch and Stephan (1996) emphasize the geographic proximity in terms of specific roles played by scientists, e.g. technology transfers. This is particularly important if knowledge is tacit, such that its transfer can be facilitated by face-to-face communication. Jaffe (1986) suggests that the closer the proximity of university research to corporate laboratories, the more probable the potency of spillovers from university. Acs et al. (1994) also argue that firms receive R&D spillovers from the knowledge of university or large counterpart. Mowery and Ziedonis (2001) underline "regional agglomeration effects" − geographical proximity between firms and public research institutes - in the growth of high-technology clusters in the U.S.

Due to data limitation, we use region dummies, instead of direct measure of geographic proximity, to reflect firm location. The KIS Survey data allow sixteen regions across South Korea, and this analysis re-groups them into seven dummies. Firm locations are thereby measured as dummies with value of 1 if a firm is located in a specific region and 0 otherwise. It is found that 56.5% of all firms are located in the Seoul Metropolitan area, followed by *South Kyungsang province* (16.7%), *North Kyungsang province* (9.5%), *South Choongchung province* (5.8%), *North Choongchung province* (4.8%), and so on. Based on the above, we will test if firm location affects the firm's propensity of cooperating with them

(2) Sector Characteristics

As noted by Cassiman and Veugelers (2002), the nature of IPR regime affect the firm's propensity of cooperate universities. We take the IPR regime as a sector variable in our regression. In our study, the IPR regime variable (*IN_IPR*) is measured based on the answers to the following question in the survey: "How important are the following methods as means to protect IPRs of your innovation outcomes (on a five-point scale)?" Among four answered methods, patent is used for this variable. *IN_IPR* is measured as the industry average, following the idea of Veugelers and Cassiman (2005). In the case of Korea, the mean score of the IPR regime is higher for firms that cooperate with universities (2.09) than otherwise (1.99), with a t-ratio of 3.01 (*p*=0.0) (<Table 2>). This implies that firms cooperating with universities tend to use patent filing to protect their innovation outcomes than other means of protection. However, the mean score is only slightly higher for cooperators with GRIs (2.07) than non-cooperators (2.00), and the difference is not statistically significant as evident in the t-ratio of 2.16 (*p*=0.03). We will find out by regressions whether the IPR regime matters for the firm's propensity of IUG cooperation will be done.

(3) Government's Policy Initiatives

Government's support: The variable representing the government's support (*G_SUP*) is constructed based on the answers to the following question in the survey: "Which government's support measure does your firm use/participate?" Among the possible answers, whether a firm participates with national R&D projects or not is used for this variable. This variable take the value of 1 if a firm participates at the national R&D projects, and 0 otherwise. If a firm participates at the national R&D programs, a firm is entitled to get grant for R&D expenditure in Korea, and some of them are conducted in joint projects with universities and/or GRIs. For example, in 2005, out of the total national R&D projects (25,877) with the budget of 6,339 trillion won, joint research projects, conducted through industry-university or industry-GRI cooperation, accounted for 61.2% (15,829) in numbers or 58.9% (3,737 trillion won) of total budget (NSTC, 2006). In terms of the type of cooperation, the tripartite cooperation involving industry, university, and GRIs was the majority, accounting for 1,069 trillion won of the R&D expenditure. It was followed by bilateral types of either industry-university (748 trillion won) or industry-GRI cooperation (452 trillion won). In these projects, the number of patents generated out of these projects is counted as one of the evaluation criteria.

Thus, the participation at the national projects means higher likelihood of firms' cooperative arrangement with universities and/or GRIs. As seen from <Table 2>, the mean percentage of firms that use government support is higher among firms that cooperate with universities and GRIs (66.17 and 73.13), respectively, rather than otherwise (30.53 and 29.67). The t-ratio of each is 7.95 (*p*=0.00) and 9.43 (*p*=0.00), and thus, the difference is statistically significant. Therefore, it is hypothesized that government's supports for R&D facilitate the firm's propensity of IUG cooperation.

<Table 2> Statistics on the possible determinants of IUG cooperation

	Industry-university cooperation			Industry-GRI cooperation		
	Cooperation	Non-cooperation	t-test	Cooperation	Non-cooperation	t-test
	(*n*=139)	(*n*=399)		(*n*=129)	(*n*=409)	
Firm size (log of employees)	5.27	5.02	2.23 (0.03)**	5.3	5.01	2.56 (0.01)**
R&D intensity (%)	5.47	2.99	1.12 (0.26)	5.94	2.91	1.28 (0.20)
% of firms belonging to business groups	11.51	13.78	-0.68 (0.50)	10.08	14.18	-1.29 (0.20)

% of firms belonging to the top 10 business groups	4.32	2.06	1.09 (0.28)	3.88	2.44	0.99 (0.45)
% of firms belonging to the top 11-30 business groups	1.44	3.26	-1.35 (0.18)	1.55	3.18	-1.17 (0.24)
Cost-sharing objective (point)	3.14	2.08	8.58 (0.00)***	3.22	2.09	9.27 (0.00)***
Risk-sharing objective (point)	3.17	2.2	7.72 (0.00)***	3.26	2.19	8.66 (0.00)***
% of firms participating in national R&D projects	66.17	30.53	7.95 (0.00)***	73.13	29.67	9.43 (0.00)***
IPR regime (point)	2.09	1.99	3.01 (0.00)***	2.07	2	2.16 (0.03)**

Note: The numbers in parenthesis present *p*-value.
***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

(4) Measuring innovation probability

In this study, innovation probability is measured as 1 if a firm does technological innovation and 0 otherwise. In Korea, 25.8% or 139 out of a total of 538 firms cooperate with university, of which 94.2% or 131 firms do technological innovation (Table 3). However, 64.4% or 260 out of 399 firms, which have no cooperation with it, do technological innovation. With regard to the industry-GRI cooperation, a 24.0% or 129 firms out of the total have cooperation with GRIs, and among them 95.4% or 123 firms do technological innovation. However, 64.8% or 268 of 409 firms, which have no cooperation with them, do technological innovation.

On the basis of the above discussions, the second hypothesis of this paper is that IUG cooperation may not directly increase the innovation probability of Korean firms.

<Table 3> IUG cooperation and technological innovation

(unit: no. of firms)

	Universities			GRIs		
	Cooperators (n=139)	Non-cooperators (n=399)	t-statistics	Cooperators (n=129)	Non-cooperators (n=409)	t-statistics
No. (%) of innovative firms	131 (94.24%)	260 (64.41%)	9.58 (0.00)***	123 (95.35%)	268 (64.79%)	10.15 (0.00)***

Note: The numbers in parenthesis present *p*-value.
***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

(5) Variables of Innovation outcomes: Sales, Patents, and labor productivity

In this study, innovation performance is measured in three ways: 1) the number of patents filed from the three finds of innovation together as well as from each type of innovation, 2) share of sales revenue associated with product innovation, and 3) labor productivity. The first two variables are from the innovation survey, while the last one is from the financial statement of the firm database.

In terms of the average number of patents filed from technological innovation, overall, it is higher for cooperators (7.22) than non-cooperators (5.31) with universities, but the difference is not significant (Table 4A). In the case of industry-GRI cooperation, cooperating firms have produced on average 10.36 patents from their innovations more than non-cooperators have produced, 3.91, but the differences are not statistically significant either. As to the means of percentage in the sales of innovation outcomes and labor productivity, no significant differences are found between cooperators and non-cooperators.

According to <Figure A1>, more Korean firms are engaged in product (342) rather than process innovation (239). Looking at the former in detail, more firms do product improvement (303) rather than new product development (251). In terms of the number of patents filed as outcomes of new product development, firms cooperating with universities or GRIs tend to generate more patents than non-cooperating firms: 4.54 vs. 1.29 in industry-university cooperation comparison, and 4.62 vs. 1.35 in industry-GRI cooperation comparison. The difference measured by t-statistics is significant with 2.23 (p=0.03) for cooperation with university and 2.11 (p=0.04) for cooperation with GRIs (table 4B).

However, in spite of a larger number of firms engaged in process innovation than product innovation, much less number of patents are generated by both cooperating and non-cooperation firms. It might make sense when we consider the different nature of process innovation compared to product innovation. Also, no significant difference is found between the cooperating and non-cooperating firms.

The above simple comparison seems consistent with the fourth hypothesis that IUG cooperation contributes more to product rather than process innovation. We will verify this by regressions below.

<Table 4A> IUG cooperation and firm performance

	Universities			GRIs		
	Cooperators	Non-cooperators	t-test	Cooperators	Non-cooperators	t-test
Patent (no,)	7.22	5.31	0.67 (0.50)	10.36	3.91	1.68 (0.10)
Sale (%)	48.62	44..90	1.08 (0.28)	49.38	44.70	1.28 (0.20)
Labor productivity (trillion won)	71,234.68	70,394.18	0.12 (0.90)	66,113.04	72,811.18	-0.97 (0.33)

Note: The numbers in parenthesis present *p*-value.
***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

<Table 4B> IUG cooperation and firm performance (no. of patents filed)

	Universities			GRIs		
	Cooperators	Non-cooperators	t-test	Cooperators	Non-cooperators	t-test
New product innovation	4.54	1.29	2.23 (0.03)**	4.62	1.35	2.11 (0.04)**
Product improving Innovation	2.12	2.77	-0.41 (0.68)	3.77	1.99	1.11 (0.27)
Process innovation	0.65	1.26	-0.59 (0.56)	2.09	0.58	1.01 (0.32)

Note: The numbers in parenthesis present *p*-value.
***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

3. Regression Methodology

This section sets up empirical models for analysis. First, we analyze what determines a firm's propensity of IUG cooperation, using the Probit model.

$$\boldsymbol{IUG_i = \alpha_0 + \alpha_1 X_i + u} \quad (1)$$

$\boldsymbol{X}$ = {*SIZE, RD_INT, COST, RISK, GROUP* (*CAHEBOL10/CAHEBOL11-30*),
regional dummies (*r_*) *IN_IPR, G_SUP*}

IUG indicates whether a firm cooperates with university and GRI, respectively: 1 if the firm cooperates with them and 0 otherwise. The model is specified by firm size (*SIZE*), R&D intensity (*RD_INT*), cooperation objective (*COST* and *RISK*), affiliation to business groups (*GROUP*), firm location (*r_*), IPR regime (*IN_IPR*), and government's support measure (*G_SUP*). It also includes the top 10 *chaebols* (*CHAEBOL10*) and the top 11-30 *chaebols* (*CHAEBOL11-30*) as a variable of affiliation to business groups. Here, marginal effects are estimated at the mean point.

Second, we test whether IUG cooperation affects the innovation probability of firms, using the Probit model.

$$\boldsymbol{IUG_i = \beta_0 + \beta_1 Z_i + \beta_2 X_i + u_1} \quad (2\text{-}1)$$

$$\boldsymbol{P\_INNO_i = \gamma_0 + \gamma_1 IUG_i\hat{} + \gamma_2 X_i + u_2} \quad (2\text{-}2)$$

$\boldsymbol{Z}$ = {regional dummies (*r_*)}
$\boldsymbol{X}$ = {*SIZE, RD_INT, COST, RISK, GROUP, G_SUP,
Demand-pull, Cost-push, AGE, EXPORT, FOREIGN,* industry dummies}

The innovation probability of firms is estimated by the eq. 2-2. *P_INNO* is 1 if a firm does technological innovation and 0 otherwise. The model is specified by the estimated *IUG^*, instead of *IUG*, and explanatory variables, *X*.

Previous studies deal with this issue without considering the endogeneity of IUG cooperation measure. In contrast, bearing in mind that certain factors specific to IUG cooperation, e.g. technological capability of firms, indirectly affect firm performance, we try to control this endogeneity. If *IUG* is used instead of *IUG^*, this variable may be correlated with disturbance *u2*, and thus it is endogenous. The zero-covariance condition Cov[*Xi, u2*] = 0 is violated, and thereby, the zero-conditional-mean assumption E[*u2*| *Xi*] = 0 does not hold anymore (Baum, 2006). As a result, OLS estimates become biased and inconsistent. Accordingly, we control the endogeneity by trying an instrument variable for *IUG* that is uncorrelated with *u2* but is highly correlated with *IUG*. We use *regional dummies* (*r_*) as instruments; IUG cooperation is active in the regions that universities and firms tend to cluster, e.g., *Seoul* or *Daejon*, but the firms there do not necessarily perform better than otherwise.

In the first stage, we regress IUG cooperation (*IUG*) on instrumental variables (*Z*) and exogenous variables (*X*) (eq. 2-1). In the second stage, we then regress the innovation probability of Korean firms (*P_INNO*) on the estimated or endogenous variable (*IUG^*) and exogenous variable (*X*) (eq. 2-2). The explanatory variables in eq. 2-

2 include those of eq.1, except for region dummies, and additional variables—innovation objectives (*Demand-pull* and *Cost-push*), firm age (*AGE*), export (*EXPORT*), and foreign capital (*FOREIGN*). In order to control industry effect, industry dummies are used instead of *IN_IPR*, the sector variable in eq. 1.

Innovation objective is based on the answers to the following question in the survey: "What are the objectives of your firm to do technological innovation (on a five-point scale)?" *Demand-Pull* is measured as the average degree of importance of such answers as product substitutions, market share increases and improvements in quality, and *Cost-Push*, as the average degree of importance of such factors as enhanced flexibility, material costs reductions, and labor cost reductions. *AGE* is measured as a log value of firm age. The export of a firm, *EXPORT*, is measured as a dummy variable, 1 if the firm exports in either 2000 or 2001 and 0 otherwise. Foreign capital, *FOREIGN*, is measured as the average ratio of foreign capitals to total capitals, and indicates the share of foreign ownership of a company.

Third, we analyze how IUG cooperation affects firm performance, with a sample selection model.

$$P\_INNO_i = \delta_0 + \delta_1 IUG_i + \delta_2 X_i + u_1 \qquad (3\text{-}1)$$

$$INNO_i = \varepsilon_0 + \varepsilon_1 IUG_i + \varepsilon_2 X_i + u_2 \qquad (3\text{-}2)$$

$\boldsymbol{X}$ = {*SIZE, RD_INT, GROUP, Demand-Pull, Cost-Push, AGE, EXPORT, FOREIGN, industry dummies*}

Firm performance (*INNO*) is estimated by the eq. 3-2. For *INNO,* three types of variables are used, namely, the number of patents filed from each type of innovation, the percentage in sales of innovative outcomes produced from product innovation and the value added per worker. The model is specified by *IUG* and explanatory variables, *X*. Additionally, another industry dummies are considered here - high, medium-high, medium-low, and low-technology, following the OECD classification (OECD, 2006) based on the levels of R&D intensity.

This analysis deals with only innovative firms. In the KIS, only firms that do technological innovation are asked questions regarding how many patents or sales they make from each type of innovation. This means that performance variables, *INNO*, are censored based on whether they do technological innovation or not. Accordingly, a selection bias based on the unobserved characteristics of firms with the potential of doing technological innovation needs to be checked, and if any, it should be corrected. If OLS is applied without considering this sample selection bias, this selectivity may make the coefficients biased because the sample of firms is not a random one. In order to deal with this problem, we use *Heckman's 2SLS* (1979), a two-step sample selection procedure. In the first stage, the corrective term, the inverse Mill's ratio (*IMILLS*), is estimated as a prediction of the Probit model (eq. 3-1). Using these estimates, the inverse Miller's ratio is calculated as a function of the standard normal density divided by the cumulative distribution function. The ratio is then used as an additional regressor in the second stage, using the OLS, to correct the sample selection bias, if any (equation 3-2).

IV. Results and Interpretations

1. The Determinants of IUG Cooperation

This part analyzes the determinants of IUG cooperation, using the Probit model. The dependent variable measures whether a firm cooperates with universities or GRIs, respectively, for its innovation effort: the variable is 1 if it does and 0 otherwise.

<Table 5> presents the results for both industry-university and industry-GRI cooperation. Across two different channels of linkages, one robust and striking result is that traditional firm characteristics variables of *SIZE* and R&D intensity (*RD_INT*) are not statistically significant at all, while the government support variable (*G_SUP*) is significant in both cooperation modes. This is in quite contrast to the results from the cases of European countries, and reflects importantly the heavy weight of government policies in promoting the IUG cooperation in late-comer economies.

Another common result across two cooperation modes is the results with dummies for business groups or affiliates. First, the coefficient of *GROUP* (*affiliates to either local or foreign groups*) is negative, but not statistically significant (Model 1). When we narrowly focus on local business groups or *Chaebols*, the results change. The coefficient of middle-sized *chaebols* (*CHAEBOL11-30*) is significantly negative (Model 3), while that of large-sized *chaebols* (*CHAEBOL10*) is insignificantly positive (Model 2). This implies that middle-sized local business groups tend not to cooperate with universities or GRIs, while this might not be the case with large-sized business groups. Our original interest is to find out whether firms affiliated to business groups are less inclined to seek cooperation with external partners as they might find such partners within the group (internal market than external markets) as mentioned in the literature mentions (Mohnen and Hoareau, 2003; Capron and Cincera, 2003). Our results show that this might be the case as shown by negative sign of the *GROUP* dummy, and that the case should be stronger with regard to middle-sized business groups as shown by significantly negative sign of the top 11 to 30 *chaebols.*

Now let us turn to some differences between the two cooperation modes. First, we notice that cost-sharing motives are more important and significant for linkages with universities, whereas risk-sharing motives, for linkages with GRIs. This might reflect the situation in Korea that GRIs in general have more financial resources than universities with more direct and regular support from the government budget. In contrast, firms seem to cooperate with universities to get help from knowledge of professors and student and thereby save the cost of man power.

Another difference between the two modes is found with regard to the importance of IPR regimes with this sector variable (*IN_IPR)* significant and positive only for the university-cooperation mode. This results are consistent with the literature, like (Veugelers and Cassiman, 2005), suggesting that firms consider the IPR issue seriously when they cooperate with universities. This might have to do with the fact that cooperation with universities are often carried out with money from the firm side, whereas cooperation with GRIs are often led financially by GRIs.

Finally, firm location variable or regional dummies are in general significant, although different locations are shown to be strong either of the two modes. The two regions containing two largest cities in Korea, namely The *Seoul metropolitan area* (*r_S*) and *Busan city* (*r_KN*) are shown to be strong in both modes as expected, in addition to the *South Chungcheong* and *Daejon* area with the famous Daejon science park (*r_CN*).

<Table 5> Determinants of IUG cooperation (Probit model)

	Industry-university cooperation			Industry-GRI cooperation		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
SIZE	0.06 (1.01)	0.03 (0.52)	0.08 (1.21)	0.08 (1.19)	0.05 (0.79)	0.08 (1.27)
RD_INT	0.66 (1.13)	0.68 (1.15)	0.68 (1.17)	0.81 (1.32)	0.84 (1.37)	0.84 (1.37)
GROUP	-0.23 (-1.17)			-0.31 (-1.52)		
CHAEBOL10		0.26 (0.68)			0.08 (0.19)	
CHAEBOL11-30			-0.93 (-2.02)**			-0.84 (-1.79)*
COST	0.11 (1.68)*	0.11 (1.68)*	0.12 (1.71)*	0.10 (1.45)	0.10 (1.46)	0.10 (1.49)
RISK	0.10 (1.46)	0.10 (1.48)	0.10 (1.49)	0.12 (1.83)*	0.12 (1.79)*	0.12 (1.83)*
r_S	0.98 (1.84)*	1.05 (1.95)*	1.02 (1.92)*	1.03 (1.86)*	1.07 (1.93)*	1.07 (1.96)*
r_CB	1.00 (1.65)	1.04 (1.70)*	1.04 (1.72)*	0.75 (1.18)	0.75 (1.17)	0.77 (1.22)
r_CN	1.32 (2.29)**	1.36 (2.33)**	1.31 (2.28)**	1.32 (2.20)**	1.32 (2.20)**	1.30 (2.19)**
r_JB	1.66 (2.53)**	1.72 (2.59)**	1.72 (2.61)**	1.10 (1.55)	1.12 (1.57)	1.13 (1.60)
r_KB	1.07 (1.88)*	1.13 (1.97)*	1.08 (1.92)*	0.92 (1.56)	0.96 (1.62)	0.94 (1.61)
r_KN	1.25 (2.26)**	1.31 (2.35)**	1.28 (2.34)**	1.05 (1.84)*	1.08 (1.89)*	1.09 (1.93)*
G_SUP	0.62 (4.54)***	0.62 (4.57)***	0.62 (4.57)*	0.80 (5.68)***	0.81 (5.76)**	0.81 (5.74)***
IN_IPR	0.33 (1.86)*	0.31 (1.73)*	0.35 (1.93)*	0.16 (0.87)	0.13 (0.73)	0.16 (0.88)
No. of obs	538	538	538	538	538	538
McFadden R^2	0.15	0.15	0.16	0.18	0.18	0.19
Log likelihood	-260.29	-260.77	-258.64	-241.15	-243.32	-240.5
Pro(LR stat)	0.00	0.00	0.00	0.00	0.00	0.00

Note: 1) Variables starting with r's are regional dummies: *r_S* (*Seoul Metropolitan area*), *r_CB* (*North Choongchung province*), *r_CN* (*South Choongchung province*), *r_JB* (*North Junra province*), *r_KB* (*North Kyungsnag province*) and *r_KN* (*South Kyungsang province*).

2) Numbers in parentheses indicate z-values.

***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

Next, we estimate the marginal effects of the determinants at the mean point (Table 6). The marginal effect of an additional point in the participation at the government-supported R&D program is to increase the firms' probability of cooperating with university by 19.0% and with GRI by 23.0%, respectively. An additional point in the effectiveness of the IPR regime significantly increases the firms' propensity for cooperation with the former by 10.0%. Moreover, an additional point in the importance of cost-sharing objective increases the firms' likelihood by 3.0%. Regarding cooperation with GRI, an additional point in the importance of risk-sharing objective increases the firms' likelihood by 3.0%.

<Table 6> Marginal effects

	Industry-university cooperation	Industry-GRI cooperation
SIZE	0.02(1.01)	0.02(1.19)
RD_INT	0.19(1.13)	0.22(1.32)
GROUP	-0.06(-1.27)	-0.07(-1.49)
COST	0.03(1.68)*	0.03(1.45)
RISK	0.02(1.47)	0.03(1.85)*
r_S	0.27(2.02)**	0.26(2.04)**
R_CB	0.36(1.55)	0.25(1.03)
R_CN	0.48(2.36)**	0.47(2.15)**
R_JB	0.59(3.20)**	0.39(1.43)
R_KB	0.38(1.78)*	0.31(1.39)
R_KN	0.44(2.21)**	0.35(1.67)*
G_SUP	0.19(4.42)***	0.23(5.47)***
IN_IPR	0.10(1.87)*	0.04(0.87)

Note: Numbers in parentheses indicate z-values.
***, ** and * represent 1%, 5% and 10% levels of significance, respectively.

2. The Impacts of IUG Cooperation on Firm Performance

(1) Innovation Probability

This part analyzes the impact of IUG cooperation on the innovation probability of firms, using the Probit model. The dependent variable measures whether a firm does (and succeeds in) technological innovation: the value of this variable is 1 if it does and 0 otherwise. IUG cooperation variable, *IUG*, is measured as 1 if a firm cooperates with university, and GRI, respectively, and 0 otherwise. Different from the previous studies, this analysis controls the endogeneity. <Table A1> reveals the regression result of the 1st stage, *IUG^* (eq. 2-1). The coefficients of the regional dummies are statistically significant, revealing the strong relevance of the instruments. Then, *IUG^*, instead of *IUG*, is used at the 2nd stage (eq. 2-2) to see its impact. Both results are presented in <Table 7>.

IUG reveals a significantly positive sign (2nd and 3rd columns), implying a significant impact of the IUG cooperation on innovation possibility. But, this result change when endogeneity is controlled, using *IUG^*: the coefficient of the latter is not statistically significant (4th and 5th columns). Based on the result, we can say that the significance of *IUG* in the first step reflects the endogeneity such that more innovative firms tend to pursue collaboration with universities or GRIs, not the other way around. This is different from previous studies in advanced countries (Monjon and Waelbroeck, 2003): the latter reports the positive impact, without controlling the endogeneity of IUG cooperation measure.

Regarding the other variables, the variable of the government support (*G_SUP*) indicating participation at the national R&D programs is shown to be positive and significant, which again underscores the importance of the government initiatives to promote innovation in private firms. Besides this, the *demand-pull* and *cost-push* factors are shown to be statistically significant, which implies that firms tend to innovate either to increase market shares and improve product quality (demand pull) or to reduce the costs of material or labor inputs (cost-push). *EXPORT* is also statistically positive, implying that export-oriented firms tend to do technological innovation. Somewhat surprisingly, the impact of R&D intensity (*RD_INT)* is shown to be obscure. This result may be related to the possibility that due to contemporaneous nature of regressions now allowing for lagged impacts the impact of today's R&D might not show up affecting today's innovation success possibility.

<Table 7> Impact of IUG cooperation on the innovation probability

	Probit model		Probit model (endogeneity controlled)	
	Industry-university cooperation	Industry-GRI cooperation	Industry-university cooperation	Industry-GRI cooperation
	Model 1	Model 2	Model 3	Model 4
SIZE	0.03(0.28)	0.04(0.35)	0.04(0.40)	0.04(0.39)
RD_INT	-1.56(-2.37)**	-1.61(-2.36)**	-1.05(-1.63)	-1.03(-1.76)*
GROUP	0.00(0.02)	0.01 (0.03)	-0.10(-0.36)	-0.15(-0.52)
COST	0.12(1.24)	0.11(1.21)	0.17(1.51)	0.11(1.30)
RISK	0.08(0.83)	0.08(0.82)	0.10(1.20)	0.11(1.37)
G_SUP	0.21(1.05)	0.19(0.95)	0.61(2.19)**	0.62(2.08)**
Demand-Pull	0.42(4.85)***	0.42(4.83)***	0.42(5.02)***	0.42(5.05)***
Cost-Push	0.17(2.11)**	0.17(2.13)**	0.25(2.88)**	0.22(2.65)**
AGE	-0.01(-0.11)	-0.01(-0.17)	0.00(0.01)	0.01(0.05)
EXPORT	0.23(1.18)	0.21(1.07)	0.41(1.87)*	0.43(1.86)*
FOREIGN	0.55(1.10)	0.51(1.03)	0.19(0.46)	0.39(0.97)
Industry dummies	Included	Included	Included	Included
IUG	0.51(2.19)**	0.58(2.24)**		
IUG^			-1.69(-1.65)	-1.40(-1.40)
No. of obs	538	538	538	538
Pseudo R^2	0.56	0.56	0.57	0.57
Log likelihood	-140.63	-140.43	-135.02	-135.33
Pro(LR stat)	0.00	0.00	0.00	0.00

Note: Numbers in parentheses indicate z-values
***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

Based on this result, regarding the hypothesis two, we conclude that the IUG cooperation does not seem to be the triggering factor for the probability of innovation success. Rather, successful innovation seems to be affected by direct government support program, as well as traditional factors like cost-push and demand-pull factors.

(2) Sale vs. Patent and Product Innovation vs. Process Innovation

Now in this part, we deal with only the innovative firms, and analyze the impact of their IUG cooperation on firm performance. For this reason, we do not have to worry about the possible endogeneity of IUG cooperation but should be instead concerned about the possible sample selection bias as discussed above. Thus, using the Heckman's 2SLS, we checks the data for sample selection bias associated with firms' innovation propensity. As seen from the following results, *IMILLS*, the inverse Miller's ratio, is statistically significant in some cases, proving the existence of sample selection bias. The bias is corrected then by adding this term, *IMILLS*. For dependent variables, three alternatives are tried: the number of patents filed from innovation, share of sales associated with product innovation, and labor productivity.

Table 8A and 8B present the results examining the impact of the IUG cooperation on different indicators of firm performance. The coefficient of *IUG* is not statistically significant at all for all the three indicators of the number of patents, sale, and labor productivity, either in the industry-university case or in industry-GRI cooperation case. This implies that this cooperation has no significant impact on firm performance overall, which is consistent with the preceding results on the impact of the IUG cooperation on innovation probability. The result is different from the case of advanced countries where industry-university cooperation contributes to the sales of innovation outcomes as well as the number of patents filed.

<Table 8A> Impact of industry-university cooperation on firm performance (OLS with selection bias checks)

	Model 1			Model 2		
	Patent	Sale	Labor productivity	Patent	Sale	Labor productivity
SIZE	0.10(4.88)***	0.01(0.44)	0.01(1.28)	0.11(6.76)***	0.01(0.48)	0.01(0.11)
RD_INT	0.25(0.85)	0.35(1.06)	-0.08(-1.28)	0.22(1.00)	0.57(2.24)**	-0.09(-1.51)
GROUP	-0.05(-0.84)	-0.12(-1.75)*	0.03(2.10)**	-0.05(-1.13)	-0.08(-1.51)	0.03(2.21)**
Demand-Pull	0.08(1.50)	0.10(1.50)	0.01(0.61)	0.06(1.55)	0.02(0.84)	0.01(0.64)
Cost-Push	0.00(0.18)	0.08(3.39)***	0.01(2.22)**	-0.00(-0.12)	0.07(3.87)***	0.01(2.13)**
AGE	-0.06(-2.29)**	-0.06(-2.14)**	0.01(0.84)	-0.06(-2.80)**	-0.04(-1.77)*	0.00(0.61)
EXPORT	0.05(1.02)	0.03(0.53)	0.01(0.81)	0.04(1.09)	-0.01(-0.23)	0.01(1.08)
FOREIGN	-0.05(-0.43)	-0.08(-0.67)	0.04(1.50)**	-0.04(-0.44)	-0.02(-0.23)	0.03(1.39)*
IUG(UNIV)	0.05(0.90)	0.07(1.10)	0.01(1.17)	0.04(0.99)	0.01(0.16)	0.01(0.94)
OECD industry dummies	Included	Included	Included			
Industry dummies				Included	Included	Included
IMILLS	0.40(1.85)*	0.40(1.70)*	0.13(2.44)**	0.29(1.99)**		0.12(2.69)**
No. of obs	382	330	310	382	330	310
R^2	0.15	0.12	0.20	0.24	0.17	0.29
Adjusted R^2	0.13	0.09	0.17	0.19	0.12	0.25
Prob(F-stat)	0.00	0.00	0.00	0.00	0.00	0.00

Note: Numbers in parentheses indicate t-values
***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

<Table 8B> Impact of industry-GRI cooperation on firm performance (OLS with selection bias checks)

	Model 1			Model 2		
	Patent	Sale	Labor productivity	Patent	Sale	Labor productivity
SIZE	0.10(7.44)***	0.01(0.46)	0.01(1.41)	0.11(7.48)***	0.01(0.47)	0.01(1.23)
RD_INT	0.40(1.92)*	0.40(1.42)	-0.07(-1.11)	0.36(1.72)*	0.56(2.18)**	-0.08(-1.28)
GROUP	-0.05(-1.36)	-0.11(-1.93)*	0.03(2.21)**	-0.05(-1.35)	-0.08(-1.49)	0.03(2.30)**
Demand-Pull	0.00(0.04)	0.08(1.54)	0.01(0.49)	-0.00(-0.01)	0.02(0.84)	0.01(0.54)
Cost-Push	-0.02(-1.39)	0.08(3.91)***	0.01(2.27)**	-0.02(-1.32)	0.07(3.86)***	0.01(2.18)**
AGE	-0.06(-3.27)**	-0.06(-2.45)**	0.01(0.99)	-0.06(-3.13)***	-0.04(-1.78)*	0.00(0.71)
EXPORT	0.02(0.49)	0.02(0.48)	0.01(0.84)	0.01(0.34)	-0.01(-0.26)	0.01(1.16)
FOREIGN	-0.07(-1.01)	-0.08(-0.82)	0.03(1.54)**	-0.07(-0.95)	-0.02(-0.24)	0.03(1.40)
IUG(GRI)	0.04(1.34)	0.07(1.15)	0.01(0.71)	0.04(1.52)	0.01(0.37)	0.00(0.29)
OECD industry dummies	Included	Included	Included			
Industry dummies				Included	Included	Included
IMILLS		0.33(1.72)*	0.03(2.21)**			0.11(2.66)***
No. of obs	382	330	310	382	330	310
R^2	0.16	0.12	0.20	0.16	0.17	0.29
Adjusted R^2	0.13	0.09	0.17	0.12	0.12	0.25
Prob(F-stat)	0.00	0.00	0.00	0.00	0.00	0.00

Note: Numbers in parentheses indicate t-values
***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

Next, in results in presented in tables 9A and 9B, we have divided the patents into types of the associated innovations, namely patents filed as outcomes of new product development, product improvement, and process innovation. Now it is confirmed that the IUG cooperation affects positively the number of patents filed not from process innovation but from product innovation to develop new products but not to improve existing products. The correlation is more robust in the industry-university cooperation than in the industry-GRI cooperation. This result is consistent with the finding by Rouvinen (2002) that in the Finnish manufacturing firms the industry-university research cooperation contribute only to product innovation, while industry-client or supplier contributes to process innovation as well. This result is also consistent with the finding by Belderbos et al (2004) that university is important source of knowledge for radical innovation.

It is also interesting to note that now the R&D intensity (*RD_INT)* turns out to be significant for patents filed from new product and process innovation, whereas it was not significant in the regressions on innovation probability in the whole sample regressions. This R&D intensity variable is also significant for the sales associated with innovation in regressions with industry dummies. These results together implies that while more R&D intensity cannot guarantee the success of innovation effort but it is positively associated with certain types of patents or sales when there is successful innovations.

Among other variables, the *SIZE* variable is significantly positive for patents, suggesting that larger firms tend to be more innovative than smaller ones. This is consistent with Schumpeter's original observation on the role of big firms (Schumpeter, 1949; Kamien and Schwartz, 1975). Besides, older firms (*AGE variable*) are shown to perform worse than younger ones, in terms of both patents and sales.

Another interesting finding is about the FOREIGN (foreign ownership) variable. The insignificance of this variable in innovation probability first implies that foreign-ownership does not guarantee innovation success. Then, the insignificance of this variable in innovation performance equation with sales or patents but high significance in labor productivity equation implies that any superior performance of foreign firms tend not to come from their innovation efforts in the host country (Korea) but from higher productivity possibly associated with knowledge and skills transplanted directly from abroad. In contrast to the foreign ownership variable, export-orientation variable is shown to be positively linked not only to innovation probability but also to the IUG cooperation possibility.

In sum, the results with regard to R&D intensity, size and age are not surprising and consistent with the literature. An interesting finding from this study should be the limited impact of the IUG cooperation, showing up only in the form of more patents related to new product development. This feature deserves more discussion.

<Table 9A> Impact of industry-university cooperation on patents by innovation-types

	Model 1			Model 2		
	New product innovation	Product improvement	Process innovation	New product innovation	Product improvement	Process innovation
SIZE	0.05(6.06)***	0.06(7.15)***	0.02(2.50)**	0.05(5.76)***	0.07(7.27)***	0.02(2.51)**
RD_INT	0.28(1.83)*	0.15(1.09)	0.38(2.39)**	0.31(1.91)*	0.12(0.90)	0.36(2.23)**
GROUP	-0.04(-1.78)*	-0.04(-1.56)	-0.00(-0.00)	-0.04(-1.59)	-0.04(-1.69)*	0.00(0.04)
Demand-Pull	0.01(0.53)	-0.01(-0.49)	-0.01(-0.86)	0.01(0.76)	-0.01(-0.62)	-0.01(-0.86)
Cost-Push	-0.00(-0.28)	-0.01(-0.62)	-0.02(-2.25)**	-0.00(-0.27)	-0.01(-0.58)	-0.02(-2.28)**
AGE	-0.02(-1.79)*	-0.05(-4.11)***	-0.00(-0.14)	-0.02(-1.85)*	-0.05(-4.10)***	-0.00(-0.03)
EXPORT	-0.00(-0.23)	0.02(0.82)	0.02(0.67)	-0.00(-0.18)	0.01(0.59)	0.01(0.56)
FOREIGN	-0.00(-0.12)	-0.05(-1.03)	-0.04(-1.12)	-0.01(-0.17)	-0.05(-0.99)	-0.04(-1.05)
IUG(UNIV)	0.03(2.03)**	-0.02(-1.06)	-0.02(-0.93)	0.03(1.91)*	-0.02(-1.13)	-0.01(-0.87)
OECD industry dummies	Included	Included	Included			
Industry dummies				Included	Included	Included
No. of obs	266	322	246	266	322	246
R^2	0.17	0.17	0.09	0.17	0.17	0.09
Adjusted R^2	0.13	0.13	0.04	0.11	0.12	0.02
Prob(F-stat)	0.00	0.00	0.04	0.00	0.00	0.23

Note: Numbers in parentheses indicate t-values
***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

<Table 9B> Impact of industry-GRI cooperation on patents by innovation types

	Model 1			Model 2		
	New product innovation	Product improvement	Process innovation	New product innovation	Product improvement	Process innovation
SIZE	0.05(5.98)***	0.06(7.07)***	0.02(2.42)**	0.05(5.71)***	0.06(7.19)***	0.02(2.49)**
RD_INT	0.28(1.76)*	0.13(0.96)	0.34(2.13)**	0.30(1.85)*	0.10(0.73)	0.31(1.89)*
GROUP	-0.04(-1.73)*	-0.04(-1.54)	0.00(0.09)	-0.04(-1.58)	-0.04(-1.65)	0.00(0.13)
Demand-Pull	0.00(0.42)	-0.01(-0.41)	-0.01(-0.87)	0.01(0.64)	-0.01(-0.52)	-0.01(-0.89)
Cost-Push	-0.00(-0.15)	-0.01(-0.74)	-0.02(-2.38)**	-0.00(-0.13)	-0.01(-0.72)	-0.02(-2.37)**
AGE	-0.02(-1.77)*	-0.05(-4.13)***	-0.00(-0.20)	-0.02(-1.85)*	-0.05(-4.10)***	-0.00(-0.05)
EXPORT	-0.01(-0.26)	0.01(0.68)	0.01(0.52)	-0.00(-0.18)	0.01(0.40)	0.01(0.33)
FOREIGN	-0.01(-0.27)	-0.04(-0.93)	-0.04(-1.04)	-0.01(-0.30)	-0.04(-0.86)	-0.04(-0.92)
IUG(GRI)	0.02(1.68)*	0.00(0.27)	0.01(0.85)	0.02(1.45)	0.01(0.45)	0.02(1.11)
OECD industry dummies	Included	Included	Included			
Industry dummies				Included	Included	Included
No. of obs	266	322	246	266	322	246
R^2	0.16	0.16	0.09	0.17	0.17	0.1
Adjusted R^2	0.12	0.13	0.04	0.10	0.10	0.02
Prob(F-stat)	0.00	0.00	0.04	0.00	0.00	0.21

Note: Numbers in parentheses indicate t-values
***, **, and * represent 1%, 5%, and 10% levels of significance, respectively.

This pattern seems to reflect the level of development in knowledge industrialization in Korea. Knowledge industrialization goes through several stages. It starts from R&D effort, and then effort can lead to some R&D outcomes captured in either patents and other IPR forms or tacit knowledge. These new knowledge can then be commercially and practically utilized to lead to increase in sale or productivity. As this scheme indicates, patent generation correspond to prior stage to the stage of actual utilization. In this light, our results indicate the Korean practices have just reached the stage before actual industrialization. A caution is needed in this interpretation because patents in the current are possible to lead to the increase of sale or productivity in the next period. This study cannot capture this time-lag effect due to data limitation, that is, cross-sectional data. However, we would like put emphasis on the former interpretation because it is more consistent with reality in Korea where the policy agenda has only recently been shifted from generation of more patents to their industrialization (Lim 2006). So far, the number of patents generated from the national R&D projects has been one of the most important and easy to impose criteria from the point of view of bureaucrats.

Next, producing more patents related to product innovation than from process innovation also require two interpretations. It might first indicate the nature of the IUG cooperation such that it target not just technical consultation or short-term projects but more radical or basic R&D goals, as noted in the Korean literature mentions (SERI, 2006; Park et al., 2000). In the past, university and GRI may have contributed more to process innovation, as firms themselves are pre-occupied with reverse engineering or problem-solving type minor innovations. However, now the level of technological capability of the Korean has been upgraded to a certain extent, and they feel more need in R&D collaboration to generate product innovation. Second, this result also seems to reflect to a certain degree the fact that outcomes of process innovation tends to be less readily protected via patents; rather, it is often exploited internally or it constitutes a part of product innovation (Rouvinen, 2002). Thus our position is not to say that the successful IUG cooperation does not take the form of process innovation but only to say that it tend to show up more in product innovation and related patents.

V. Summary and Concluding Remarks

Given the increasing importance of knowledge and universities as the source of new knowledge, this paper has investigated the role of firms' cooperation with universities and GRIs in the NIS of an emerging economy of Korea. As a fast catching-up economy, the NIS of Korea has been unbalanced or immature with strong dominance by the government and a few big firms called *Chaebols* and the accompanied weaker roles by universities and the SMEs. These unique characteristics of the Korea NIS have left its knowledge industrialization systems underdeveloped, compared to those in the advanced countries. It is only recently or since mid 1990s that Korea has realized the significance of knowledge industrialization and started to promote it again by the government initiatives. Thus, the focus of the paper has been on sorting out the differences of Korea as a late-comer from the situation in more mature and advanced economies.

This utilizes the 2001/02 Korea Innovation Survey data to find out the determinants of industry-university and industry-GRI (IUG) cooperation and its impact on firm performance. Regarding the latter, it has focused on innovation probability and on sale vs. patent (by the type of performance) and product innovation vs. process innovation (by the type of innovation). The main findings are as follows.

First, among determinants of IUG cooperation, traditional firm characteristics variables of sizes and R&D intensity are not significant at all, while the participation at the national R&D project turns out be most significant and robust in both cooperation modes. This is in quite contrast to the results from the cases of European countries, and reflects importantly the heavy weight of government policies in promoting the IUG cooperation in late-comer economies. As difference between the two modes of cooperation, we find that cost-sharing motives are more important for the industry-university mode, whereas risk-sharing motives, for the industry-GRI mode. The importance of IPR regimes is shown more clearly in the industry-university cooperation mode.

Second, regarding the impacts of the IUG cooperation, we strikingly find no significant impact on the innovation probability of firms when we control the possible endogeneity such that already innovative firms might participate more at such cooperation modes. This implies that the IUG cooperation cannot guarantee a firm success in technological innovation; rather, it may have an influence on the selection or direction of the firm's research projects.

When we limit the analysis to the innovative firms, we do find positive impacts of the IUG cooperation on patents generated from new product innovation but no impacts in terms of sales increase or labor productivity. This is again quite different from the results from the advanced countries. These results seem to reflect the still transitional nature of the NIS and knowledge industrialization such that knowledge industrialization (innovation leading to sales or productivity) has not been fully progressed, and also reflect the nature of government-sponsored IUG program where the number of generated patents was given high priority as evaluation criteria. Also, significant increase of patents from new product innovation rather than product-improving or process innovation seems to reflect the characteristics of the research by Korean universities as being oriented toward more radical innovation.

It is also interesting to note that the R&D intensity is positively related to the number of patents and sales associated with new product and process innovation, whereas it was not significant in the regressions on innovation probability or as determinants of the IUG cooperation. These results together implies that while more R&D intensity cannot guarantee the success of innovation effort but it is positively associated with certain types of patents or sales when there is successful innovations.

Synthesizing the above findings, an emerging picture about the nature of the IUG cooperation in Korea is as follows: Given the low priority of universities or GRIs as the partners for innovation efforts (lower than those of client or supplier firms), some firms are exposed to the opportunity to cooperate with them more when they participate at the national R&D projects. But, this cooperation arrangement does not increase the probability of innovation success, while the participation at the national R&D itself counts significantly as a determinant of the cooperation. Then, in the cases of successful innovations, the cooperation with universities or GRIs tend to be associated more with product innovation, than process innovation, that generate patents rather than new sales. This story is consistent with observation in the literature (George et al., 2002; Mowery and Sampat, 2005) that due to their characteristics of knowledge or way of knowledge transfer, industry-university cooperation may not directly influence the firms' success in innovation; rather, it can affect their decision-making or management of research projects.

Contribution of the paper lies in that it adopts more rigorous method to show the different motivations and impacts of the IUG cooperation between a late-comer economy and the advanced countries, and interprets them in terms of the different stages of development in knowledge industrialization systems. One limitation of this study is that it refers to only the particular point of time of 2001 and 2002 whereas the knowledge industrialization in Korea is in constant change, with more roles played by universities and diverse evaluation criteria being adopted.[6] It should be thus interesting to try with newer data set to see if there is any sign of improvement or maturing.

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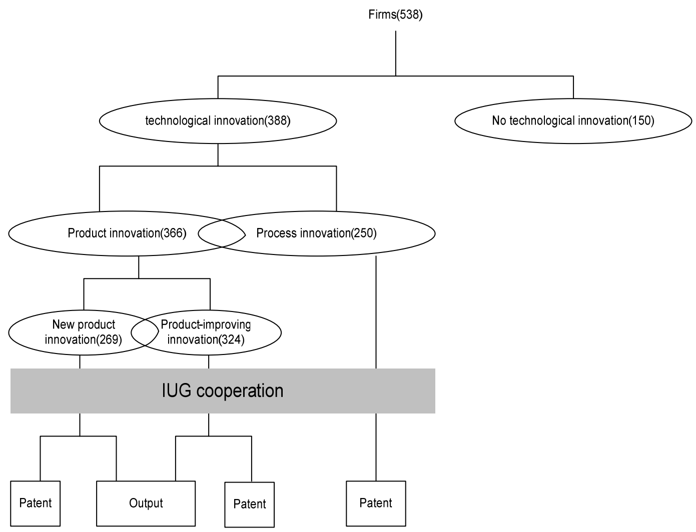
≪ Appendix ≫

Figure A1 The structure of firms in the KIS



<Table A1> Endogeneity: first stage

	Industry-university cooperation	Industry-GRI cooperation
SIZE	0.01(0.09)	-0.00(-0.05)
RD_INT	0.92(1.49)	1.27(1.96)**
GROUP	-0.15(-0.73)	-0.28(-1.27)
COST	0.05(0.73)	0.02(0.27)
RISK	0.05(0.74)	0.11(1.46)
G_SUP	0.55(3.91)***	0.76(5.12)**
Demand-Pull	0.10(1.17)	0.14(1.6)
Cost-Push	0.13(1.83)*	0.12(1.62)
AGE	0.02(0.22)	0.01(0.08)
EXPORT	0.40(2.20)**	0.59(2.94)***
FOREIGN	-0.78(-1.83)*	-0.30(-0.73)
r_S	0.98(1.70)*	1.12(1.86)*
r_CHB	1.01(1.54)	0.90(1.29)
r_CHN	1.41(2.25)**	1.49(2.25)**
r_JNB	1.66(2.39)**	1.10(1.45)
r_KNB	1.08(1.78)*	0.88(1.38)
r_KNN	1.18(1.99)**	0.99(1.59)
Industry dummies	Included	Included

No. of obs	538	538
Pseudo R^2	0.20	0.25
Log likelihood	-244.73	-220.30
Pro(LR stat)	0.00	0.00

[1] For example, Landry et al. (2007), based on a data of 1,554 researchers, find that Canadian researchers are more actively involved in non-commercial knowledge transfer rather than commercial one, less involved in intellectual property right.

[2] Technological spillovers are often defined as “non-appropriable amounts of knowledge” transmitted voluntarily or involuntarily (Monjon and Waelbroeck, 2003). Regarding industry-university cooperation, the literature refers to indirect or informal interactions between them: Monjon and Waelbroeck (2003) regard publications and discussions at conferences as channels of knowledge transmission from universities to industries; Gibbons and Johnston (2000) treat scientific papers and contacts with scientists as the most important sources of academic knowledge.

[3] They measure spillover as the degree of the importance of university as a source of information.

[4] They measure spillover as residuals from the auxiliary regression of spillover variables by partner.

[5] This is a standardized manual that provides the criteria on innovation surveys. The Manual was firstly published by OECD countries in 1992, based on which several Community Innovation Survey (CIS) projects were conducted. In Korea, three Surveys have been done for last 10 years.

[6] According to the more recent 2005 *KIS* that refer to the period of 2002-2004, university (18%) is now shown as the most important partner of firms in technological innovation, out of 10 alternatives. The second preference was client firms (15%), followed by supplier (14%), competitor (11%), and GRI (11%). Even in terms of degree of importance, university receives the highest score. This result partly reflects a change in the status of university as compared to that in the 2002 *KIS* (2000-2001).