Determinants of Firms Cooperation in Innovation

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November 8, 2009

Abstract

R&D cooperation has received great attention among industrialists, decision makers and researchers as it facilitates research collaboration, information sharing, reduced R&D cost, and affects R&D resource allocation, advancement and competitiveness of the national industry, employment and survival of firms. This paper introduces an econometric approach for identifying the factors that lead firms to cooperative innovation. The determinants of firms cooperation in innovation were defined according to empirical findings on a dataset from the internationally standardized Korean Innovation Survey 2005, captured in a multivariate probit regression model. The model identified the determinants on firms' likelihood to participate in cooperation with other organizations when conducting innovation activities. The aim of this model was to subsidize further research applying agent-based modeling to simulate innovation networks in the Korean manufacturing sector in order to test different policy strategies on fostering cooperation in innovation.

Keywords: Collaborative R&D; multivariate probit models; Korean innovation survey;

JEL Classification Numbers: C35; C71; D20; L20; O31;

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1. Introduction

Innovation networks have been approached and emphasized in many studies, especially in the evolutionary economics literature. Few works have been done, toward modeling the processes by which these networks are formed and the outcomes on innovative products, processes and firm dynamics. The complexity of the dynamics involved and the heterogeneity of the agents make it hard to model this problem using traditional techniques. In recent years, a relatively new technique using computer simulation through the implementation of heterogeneous and autonomous interacting agents has been used by scholars to model the processes of innovation and technological change.

Agent-based Computational Economics (ACE) tries to break the paradigms and limitations of classical economics through applying agent-based simulation to study the economy as an evolving system of autonomous interacting agents. ACE enables social scientists to conduct "laboratory experiments" to test a theory in computational models that can be easily modified in order to observe the effects on economic outcomes (Tesfatsion, 2001). Agent Based (AB) simulation enhances the capability to analyze theoretical models that, despite their simplicity, are not suitable for mathematical modeling and analysis. Moreover, "the modeler is free to try as many variations as he/she wants" (Zhang, 2003). According to (Axelrod, 2003), simulation is a different way of doing scientific research. It doesn't prove theorems but it generates data to be analyzed inductively which may be used to aid intuition and decision making. AB simulation has been used among others on models which allowed scholars to have insights about many issues related to innovation and cooperation.

In this research, we made use of simulation to model cooperative R&D among firms of the manufacturing sector in Korea. Firms are modeled as the agents with heterogeneous behavior. Modeling of firms' cooperative behavior is based on their observable characteristics expressed on questionnaire answers from the Korean Innovation Survey 2005 (Eum et al. 2005). To define firms' behavioral micro- foundations, *i.e.* how firms decide whether to cooperate or not and which kind of partner they would prefer to choose, was the first step of this research and is the main object of this paper.

In recent years, many empirical studies have been conducted based on Innovation Survey Databases. These studies aim to capture impact and agents rationally on the conduction of cooperative R&D (Sung and Carlsson, 2007; Dachs et al., 2008, Heshmati et al., 2006; Sakakibara, 2001; Bayona et al., 2001 and others). Another objective of these studies is to investigate the options and effectiveness of government policies to foster cooperation (examples at Izushi, 1998 and Katz et al., 1990). The definition of the *determinants of cooperation* that would be used on the simulation system, required efforts on collecting appropriate theoretical background as well as conducting our own econometric analysis on the population data.

We have run several regression analyses in order to extract a "reasonable"[2] set of factors

[2] Our meaning of "reasonable" is presented in Session 3 and was the basis for the strategy applied when choosing the appropriate econometrics model. The strategy was to find a model that could explain cooperation through the maximum number of factors for all 4 types of cooperation that were investigated.

that could well differentiate the agents on their likelihood to cooperate and on their choice of partner types.

This study is organized as follow: In Session 2, we present the literature background about cooperation in innovation and its possible determinants and the theory and concepts of cooperation and innovation. Session 3 describes the *Korean Innovation Survey 2005* dataset and some empirical observations. In Session 4 we introduce the model and the independent variables used on the regression analysis. The results, divided into firms characteristics, sector characteristics and constraints for innovation are described in Session 5. In Section 6 we make a brief explanation of the achievements of this research.

2. R&D Cooperation and Innovation Networks

Our literature review describes the theory and concepts about the innovation process and the cooperative behavior of firms when conducting innovation activities. We also present a set of previous studies which aimed to study the factors which lead firms to decide for cooperative innovation.

2.1. Cooperation in Innovation

It is well known that innovation is not generated only in the boundaries of a firm or an organization. Firms are not expected to develop all the relevant technologies without accessing external knowledge sources. It increasingly requires technological, organizational and marketing search involving several players such as firms, customers, suppliers, universities, research institutes, non-profit organizations and so on. Innovation co-operations today are widely considered as an efficient mean of industrial organization of complex R&D processes (Dachs et al., 2008). The sources of valuable knowledge for innovation may be found anywhere on the firm's chain and accessing them may be crucial for firm's competitiveness. The Systems of Innovation approach (Freeman, 1987) shows that this competitiveness is becoming more and more dependent on acquisition of complementary knowledge from other firms and institutions. Besides, inter-firm networking and cooperation's importance are emphasized by the increasing complexity, costs and risks involved in the innovation process inside firms.

Profit-maximization driven firms decide to have cooperation alliance with other organizations whenever it brings positive economical return. A direct economic benefit could be observed, for example, from the reduction of cost of cheaper knowledge acquisition from outside or the reduction on commercialization or time-to-market for new products and processes. Many studies have focused on the analysis whether R&D cooperation affects firms' performance or not. In the literature, we can find studies showing: the positive economic impact of cooperation on competitiveness of firms (Hagedoorn et al., 2000; Powell et al., 1999; Cassiman and Veugelers, 2002; Belderbos et al., 2004b; Doo and Sohn, 2008) and even in welfare (D'Aspremont and Jacquemin, 1988); the positive impact on innovation performance and knowledge spillover (Miotti and Sachwald, 2003, Czarnitzky and Fier, 2003); and, that intra- or inter-firm cooperative competency is a key factor affecting success on the development of new products (Sivadas and Dwyer, 2000).

Venturing in cooperative research, however, should be part of firms' innovation strategy. They should create absorptive capacity in order for firms to be able to benefit from external spillovers and increase the associated profitability of R&D cooperation (Cohen and Levinthal, 1990; Cassiman and Veugelers, 2002). The cooperation activities also help firms to improve their capability through gaining new knowledge and competence, which itself increase capacity to benefit from future cooperative R&D projects (Mark and Graversen, 2004).

In this study, we assumed that it is TRUE that cooperation in innovation activities will benefit firms in a general way, by increasing innovation output and maximizing economic growth in national level. Thus, the objective was centered on the ways to identify and maximize productive cooperation among R&D firms.

2.2. Determinants of Cooperation

The motivation of firms to engage in cooperation with other firms and organizations has been identified within different internal and external perspectives in fields such as economical, production, organizational, marketing and especially in knowledge sharing and product/process development (Child et al., 2005; Sakakibara, 2001; Wognum et al., 2002; Bayona et al., 2001). We are particularly interested about cooperation among firms on these two kinds of cooperation (product and process innovation) which are directly associated with innovation activities. When firms are conducting R&D activities, in fact, they are developing products and processes that are targeted for the market. On this context, other firms are naturally more obvious partners, even than are research oriented institutions such as universities and R&D centers (Mark and Graversen, 2004).

The main reason that drives any firm's decision is, in fact, the profitability of its business. When cooperating, firms may be searching for cost reduction, risk sharing, market access, knowledge acquisition and so on. One of the questions that scholars have been trying to answer and that is important for this research is: What are the motivations and characteristics of firms that determine them to perform cooperative innovation?

Bayona et al. (2001) performed econometrics analysis on a Spanish database with 1,652 firms that have carried out R&D activities. These firms, from the manufacturing sector, answered a Technological Innovation Survey containing questions about firms' characteristics like size and sector of activity; whether they have actively participated in joint projects with other institutions; if their R&D activities are systematic or not; and their perception of motivation or obstacles to conduct innovation activities. From the OECD sector classification, they extracted if the firm belongs to low, medium or high technology intensity sector. The main findings of this study include: firms perceiving difficulty in controlling *cost* for R&D tend not to cooperate while the ones perceiving *risk constraints* tend to cooperate; *large* firms cooperate more than smaller ones; firms looking to conduct innovation in order to achieve better *quality* of their products tend to develop innovation activities internally (not cooperate); and, those firms in higher *technology intensive sectors* tend to cooperate more than others in lower technology intensive sectors.

Other interesting outcomes regarding to propensity to cooperate may be found in the research conducted by Belderbos et al. (2004a) when they applied system probit estimations in data from Dutch Community Innovation Surveys from the years of 1996 and 1998. They tested different equations for each type of partnership: institutional, customer, supplier and competitors. The type of partner chosen by firms for their cooperation activities are positively affected by the types of *sources of information*. Moreover, institutional incoming spillovers affect also both horizontal and vertical cooperation. Better effectiveness would also lead to stimulation of vertical and horizontal cooperation. *R&D intensity* of a firm, impacts positively on institutional and vertical cooperation. Individual *firm size* affects cooperation positively. *Organizational capability constraints* positively impacts cooperation with suppliers and institutions. *Risk constraints* are supposed to affect positively cooperation with suppliers and competitors, while *cost constraints* affects negatively on supplier cooperation. Firms belonging to a *group of enterprise* are more likely to cooperate vertically, but not horizontally or institutionally. *Multinational* firms are less likely to cooperate with competitors. And, finally, *R&D subsidy* from the government has a positive impact in vertical and institutional cooperation.

Dachs et al. (2008) studied innovation cooperative behavior analyzing data from CIS-3 in Finland and Austria. Even though the rates of innovator firms in both countries are similar, the rate of cooperative firms in Finland is considerably higher than in Austria. Their findings, in fact, are not really conclusive, since most of the factors analyzed are significant only in one of the two countries. Basically, only two factors have the same impact on cooperation for both countries: companies that received funds from European Union (framework programs require joint research projects) tend to cooperate, and also the ones considering universities and research institutions as important *sources of information*.

Mark and Graversen (2004) analyzed Danish data containing 592 observations of innovative firms where 63% of them developed some sort of cooperation among domestic and international organizations. In that paper, they showed that: *firm size* affects positively domestic cooperation; if firms employ *foreign* people they tend to cooperate more with international organizations; R&D cooperation is more common to those firms *conducting process innovation*; the existence of an *R&D department* and the presence of *skilled researchers* also affects positively the probability to cooperate; the ratio of *R&D expenditure* in basic research as well as the ratio of *R&D employees* increase the probability of cooperation. For the negative factors, the authors found two sectoral determinants: *market concentration* (with few dominant players) and higher *profitability* (indicating that the industry studied has lower competition), particularly in the private sector.

Miotti and Sachwald (2003) also confirm that firms in *high-tech* sectors tend to cooperate more than the ones in *low-tech* sectors, however, cooperation with rivals are associated mainly with *high-tech* sectors while institutional and vertical cooperation are more concentrated in *low-tech* sectors. Results in Belderbos et al. (2004a) also indicate that belonging to a *group* of enterprises affects positively in vertical cooperation. Other statements are: *Absorptive capacity*, found to improve cooperation with external partners; firms that cooperate horizontally do not identify *lack of market information* as one of the innovation obstacles; and *costs* and *risks constraints* do not influence the propensity to co-operate. For the *cost*, it has negative impact in horizontal and institutional cooperation.

Sakakibara (2001) analyzed government supported R&D cooperative projects in Japan. Among several findings we selected the ones reported below which are related to our model: firms in *R&D-intensive industries* cooperate in order to enter other R&D-intensive industries; firms tend to conduct cooperative R&D projects in *vertically related industries* with forward and backward links; firms in *profitable* or *oligopolistic sectors* tend to cooperate in R&D projects in industries with higher growth rates than their own industries.

3. The Korean Innovation Survey

In this session we describe the dataset used on the econometrics analysis and we also present some preliminary observations. The Korean Innovation Survey is carried out by STEPI (Science & Technology Policy Institute) with the approval of Korean National Statistics Office. The survey has been conducted since 1996 in the manufacturing and service sectors for every three years. Since the 2002 version, each sector has been surveyed in a different year. The 2005 survey version (manufacturing sector) is the one object of this study. The 2005: forth survey for manufacturing sector (2,743 companies).

Similarly to innovation surveys conducted in other OECD countries, the last two Korean surveys used the methodology and definition based on the standardized innovation survey according to the Oslo Manual. From 2005 on, in accordance with the last revision of the Oslo Manual, the KIS started collecting data about non-technological innovation activities such as organizational and marketing innovation. However, the main focus still continued to be on technological innovation.

Questionnaires related to the years from 2002 to 2004 were sent by postal mail to around 4,500 firms from sectors KSIC[3] 15 to 37 with over 10 employees. The response rate was close to 61%. A total of 2,743 firms answered the survey, which represents a work force of about 630 thousand workers and a total turnover of 281 trillion won in 2004 (approximately US$ 280 billion) – about 36% of the total Korean economy.

Innovation activities were conducted by 1,425 firms during the 3-year period, which represent 52% of the sample as one may observe in Figure 1. Almost half (49%) of the firms successfully have conducted innovation in either product or process innovation. The most innovative industry in Korea is sector 24 (Chemicals), in which 67% of the firms have conducted innovation activities.

[3] Korean Standard Industry Classification – which is equivalent to the international Standard Industry Classification (SIC) at two-digit level.

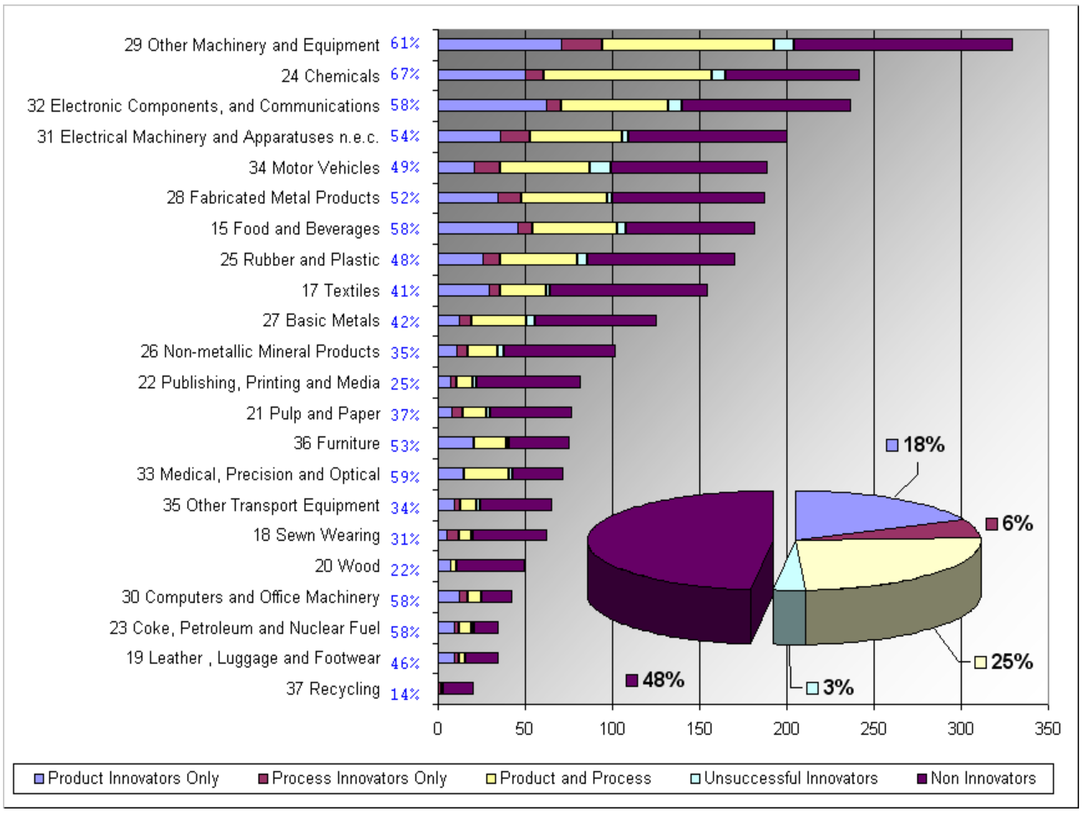

Figure 1. Number of firms per each industry and types of innovation[4]

From the point of view of cooperation, which is the object of this research, firms have answered about the percentage of contribution of internal, cooperative or outsourcing to their product or process innovation activities. Figure 2 shows the number of firms grouped by type of external partners. From the 1,345 successful innovator firms, 475 (or 35%) have had cooperation with external partners (including the ones with both cooperation and outsourcing), while 11% have not had cooperation, but received some outsourcing type of external contribution. More than half of the firms (54%) conducted product or process innovation activities with no external contribution (only internal R&D).

[4] percentages near vertical axis represent share of innovative firms in the industry

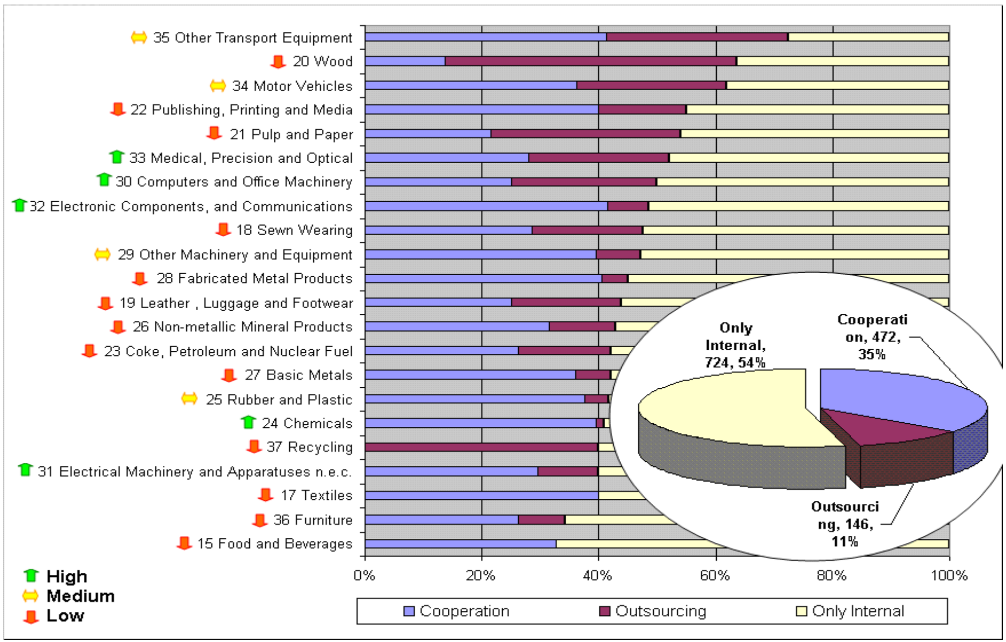

Figure 2. Number of firms per type of external partner

The percentage of contribution of these external partners, however, was much lower. The ratio of internal development for product innovation was about 86%, while collaborative and outsourcing development contributed with 12% and 5% respectively. For process innovation, the share of internal contribution for innovation was 69%, while collaborative and outsourcing development represented 15% and 16%. Even though the contribution of external partners was still low, a significant part of the companies (46%) have already experienced cooperation products. It means that there has been a growing trend since the previous innovation survey (KIS 2002), in which 42% of the companies answered positively whether or not they had cooperated in innovation activities.

An unexpected preliminary observation is that the share of contribution of external patterns was higher in low and middle-tech sectors than in high-tech sectors, which is not in accordance with the theoretical background. Further econometric tests, however, have to be done in order to confirm whether this determinant is valid or not for Korean firms.

As to the location of the selected firms, more than half of them (54%) were located either in Seoul, the province of Gyeonggi-do or in the city of Incheon – the capital and surrounding areas.

This survey was a unique source of indicators for part of the innovation process, such as cooperative activities among firms. It can be very useful concerning the definition and evaluation of governmental innovation policies. Raw data of KIS in firm level are made available to policy makers and researchers throughout Korean universities and research institutes.

3.1 Previous Empirical Observations

Eum et al. (2005), researchers from STEPI, reported general preliminary statistics on the survey data – usually showing the results distributed by industry, firm size and/or regional location. They analyzed firms conducting successful innovation; the main driven objectives when conducting innovation; the output of technological innovation generated in the period, including number of new products in the market and the contribution of these new products to firms' turnover; the actors conducting R&D, either internal, outsourced or in cooperation; the main sources of information which were found to be clients, suppliers and competitors; the barriers that firms face to conduct innovation; and, policy measures and their importance to firms.

Among the main findings on this report, we would like to highlight:

- 36% of the firms were successful product innovators, while 23% conducted successfully innovation processes within the period investigated (2002~2004);
- The ratio of products developed that were first introduced in the market was 37% of product innovations;
- The contribution of innovative products on firms' turnover for the year of 2004 was about 54% on average;
- In the case of external process innovation, SMEs tend to outsource, while large firms tend to collaborate;
- On average, 49% of product innovations were conducted through R&D facilities, while 26% and 25% were conducted on the headquarters and production facilities respectively;
- As the size of firm increased, R&D facilities became more important for product innovation;
- The most important source of information, independent on firm size, was the customer;
- Firms with an outcome on innovation (on-going or unsuccessful innovations) had less tendency to cooperate with external partners;
- The most common barriers to innovation were pointed to be: cost, lack of skilled personnel, lack of knowledge, and the easiness of copying innovations by competitors.

Doo and Sohn (2008) conducted a study using KIS 2005 data, analyzing SMEs productivity growth as a proxy for innovation. They found out, among other things, that technological cooperation, technology acquisition, government support and patenting may be used as positive explanatory variables for innovation. For technology acquisition one should understand a company simply buying existing technology, knowledge, equipment or software (without any further information resources). Regarding to technological cooperation, the analysis showed enterprise partnership as positively influencing SMEs innovation while institutional partnership may not significantly be considered as a source for innovation. Government support (in form of technology, education and marketing) are also evaluated as acceptable as positive explanatory variables for innovation by the method of factor analysis.

They also conducted cluster analysis for these three factors and concluded that:

- Most of the firms are lacking awareness about information resources and are depending mainly on existing knowledge;
- Most SMEs do not attempt technology acquisition;
- Technology acquisition from an institution (university, etc) is more effective than from enterprises;
- Contradictorily to technology acquisition, technological cooperation with an enterprise contributes more to productivity growth than cooperation with an institutional partner.

4. Model Specification and Estimation

Table 1 presents all the variables used on our econometrics model introduced in this session. One may refer to the English version of the questionnaire (Eum et al. 2005) to understand more deeply how the values were captured and the meaning of each variable. For the information used in the econometrics model we have direct variables, where data represents exactly the information we want to use, as well as inferred variables deducted from answers. For example, to determine if a firm collaborated or not with suppliers, customers, competitors or institutions, we consider the degree of contribution the firm attributes to external partners. Some inferences may lead to small differences from the real world; however, we believe we have chosen the best approximations from the available information.

Table 1. KIS 2005 Variables used in the Econometrics Model

Variable	Questionnaire	Explanation
COOP-C	Q.8.2	Dummy variable indicating if a firm had cooperated with Customers. This is inferred according to the degree of importance of this type of partnership. For values from 2 to 5, we will consider that a firm had some sort of cooperation.
COOP-S	Q.8.2	Dummy variable indicating if a firm had cooperated with Suppliers. The value is established according to the same strategy used in COOPC.
COOP-H	Q.8.2	Dummy variable indicating if a firm had cooperated horizontally – *i.e.* – with competitors on the same industry. (same way of calculating from other type of cooperation)
COOP-I	Q.8.2	Dummy variable indicating if a firm had cooperated with institutions. (same way of calculating from other type of cooperation)
WORKERSLOG	Q.0.1.2	Number of Workers in the year of 2004 in the logarithmic form.

Variable	Questionnaire	Explanation
CHAEBOL	Q.0.1.1	Dummy variable indicating if a Firm is part of a Korean conglomerate.
FOREIGN	Q.0.1.1	Dummy variable with value 1 or 0 indicating if the Firm belongs to a Foreign conglomerate.
HITECH	KSIC	Dummy variable indicating if the firm belongs to a hi-tech industry according to OECD classification.
Constraints for Innovation		
COSTCNST	Q.12.2 (2)	Degree of importance a firm attributes for high cost as a barrier to Innovation. (adjusted to a scale from 0 to 1)
RISKCNST	Q.12.2 (1)	Degree of importance a firm attributes for perceived risk as a barrier to Innovation (adjusted to a scale from 0 to 1)
ORGCAPCNST	Q.12.2 (9..19)	Average degree of importance of perceived lack of internal capability as a barrier to Innovation (adjusted to a scale from 0 to 1). This is a little bit different than the one analyzed in Belderbos et al. (2004a), since the information available is different.
Sectoral Variables		
RDINTTY	Q.0.1.2 & Q.0.3.2	R&D intensity – is measured as the proportion of employees involved in innovation activities. (Belderbos et al. 2004a).
INDPROFIT	Q.0.1.3	**Industry Profitability** – the average profitability of all firms in each two-digit sector.
INDTURNOVER	Q.0.1.3	**Industry Average Turnover** – average turnover (divided by 1000) of all firms in each two-digit sector.
INDINNSIZE	Q.0.3.2	**Industry Average Innovative Size** – average number of R&D employees of all firms in each two-digit sector.
SPDTECCHG	Q.1.1 & Q.0.1.1	**Speed of Technological Change** – similarly but not exactly equal to the calculation method in (Belderbos et al. 2004a), we will proxy this by the average percentage of participation of new products in the market compared to non-new products weighted by the firm size (weights are 1, 2 and 3 for Small, Medium and Large enterprises). Larger firms with greater percentage of new products have a higher impact on this index than smaller firms. This value is industry specific and doesn't differentiate from firm to firm on the same sector.

4.1 Data Selection

The whole dataset is filled with 2,743 firms but we have selected only 1,839, mostly due to missing information. Firms were eliminated from the model according with the following rules: no information about the size variables, number of workers and/or firm's turnover; no information about innovation activity, innovation workers or R&D facilities which indicates that such firm cannot cooperate at all; firms from industry 37 – with only 4 firms was excluded from the data set.

4.2 The Model

In session 0, we reviewed the previous literature about determinants of cooperation. We were mainly inspired by Belderbos et al. (2004a) to define our model as a 4-equations multi-variate probit model with a dependent variable for each kind of cooperation. The 4 equations on Belderbos et al. (2004a)'s model use exactly the same independent variables on each of the four equations. In our model we consider that determinants for each kind of cooperation are not necessarily the same, thus, the defined four equations may be different from each other. This allows identification of the effects which were neglected in Belderbos et al. (2004a). And in fact, we performed tests which resulted in better cooperative model specification and determination of the factors that impact on firm's cooperation when we applied different equations.

The model consists of four different binary choice equations representing the likelihood of firms to cooperate with customers, suppliers, competitors (horizontal cooperation) and institutions respectively. There are four binary dependent variables y_C, y_S, y_H, and y_I, where:

$$y_{im} = \begin{cases} 1 \text{ if } \beta_m X_{im} + \varepsilon_{im} > 0 \\ 0 \text{ otherwise} \qquad\qquad m = C, S, ..., H, I; i = 1, 2, ..., N \end{cases}$$

ε_{im} are error terms distributed as multivariate normal, each with a mean of zero, and variance-covariance matrix, with 1 on the main diagonal values and correlations $\rho_{jk} = \rho_{kj}$ in off-diagonal values. The set of X in each equation partially overlap however they are different from each other to satisfy identification of the effects and a correct specification of the relationship. We will further describe each set of independent variables and interdependence relationship between equations representing the types of cooperation.

The estimation method used to capture the possible interdependence between the choices of partners a firm makes is a multivariate limited dependent variable (multivariate probit) model. The dependent variables in the dataset are COOP-C, COOP-S, COOP-I and COOP-H (see definitions on Table 1). These are dummy variables with value 0 meaning no cooperation or value 1 meaning that a firm engaged in cooperation with Customers, Suppliers, Institutions and Competitors (horizontal cooperation), respectively. The distribution of the values for each of these variables in the dataset is presented on Table 2.

The model includes a number of independent variables as presented on Table 1. Some of them are firm specific and some are industry specific. The definition of these variables has the basis on the literature background, but the inclusion of one or other in the four different equations remains "*rather explorative given the lack of straightforward theoretical predictions available*" (Belderbos et al., 2004a). In fact, numerous combinations of equations in order to reach the best set of explanatory variables that explains the variations in firms' cooperation and would be sufficient to account for the heterogeneity of the agents (firms) in our simulation model.

Some information like the "*external sources of information*" used in the previous literature could not be used here. Firm's sources of information in one survey were identified to impact positively on cooperation choices along the following years – which could only be captured in the following survey. We are analyzing only one instance of the innovation survey – *i.e.* 2005 – and we don't have any information about the following years that could be checked. We still tried to verify these independent variables against the dependent variables on the same survey but, as expected, the correlation was strait forward: it is quite obvious that a firm with cooperation with suppliers or competitors would consider them as an important external source of information. KIS 2002, with information regarding the years of 1999-2001, unfortunately could also not be used due to the absence of a unique ID that could link firms in one dataset to the other. Mostly we only included in our model the independent variables that were available in the dataset. Using data on cross section of firms observed over time (panel data) would have the advantage to allow analysis of dynamics of network and cooperative innovation activities. Our data is cross section and subsequently allows only a static analysis, but accounts for heterogeneity in firms' cooperative behavior.

Table 2. Distribution of firms by type of cooperation[5]

H	C	S	I	Description	Firms	%
0	0	0	0	No Cooperation	1,320	72%
			1	Institutions Only	160	8.7%
		1	0	Suppliers Only	25	1.2%
			1	Suppliers + Institutions	22	2.6%
	1	0	0	Customers Only	40	1.8%
			1	Customers + Institutions	33	4.0%
		1	0	Customers + Suppliers	20	2.0%
			1	Customers + Suppliers + Institutions	37	3.1%
1	0	0	0	Horizontal Only	25	0.8%
			1	Horizontal + Institutions	14	2.1%
		1	0	Horizontal + Suppliers	7	0.7%
			1	Horizontal + Suppliers + Institutions	12	1.0%
	1	0	0	Horizontal + Customers	12	0.5%
			1	Horizontal + Customers + Institutions	9	1.1%
		1	0	Horizontal + Customers + Suppliers	15	4.8%
			1	All Four	88	5.6%
Grand Total					**1,839**	**100%**

Firm's size, in terms of number of employees (in line with previous studies) has been added as an explanatory variable (WORKERSLOG) in all four equations. It is expected that larger firms are more likely to cooperate –*i.e.* – size affects positively all four types of cooperation. In line with previous studies we used the logarithm form since it is natural that this effect is attenuated when the number of employees grow –i.e.– it is likely that number of employees affects the likelihood to cooperate but in a diminished way. RDINTTY (R&D Intensity), which is defined by the share of employees engaged in R&D activities, is expected to create absorptive capacity to benefit from external spillovers, leading to likelihood to cooperate in general. We are not exactly convinced by the attenuation theory that would require squaring the value like observed in Belderbos et al. (2004a) but tests will be made anyway, specially because they mention (but do not explain) some linear relationship for this variable. More R&D personnel would increase not only

[5] H = Horizontal Cooperation; C = Cooperation with Customers; S = Cooperation with Suppliers; I = Cooperation with Research Institutions.

the company's absorptive capacity but also expand the external network increasing the chances of R&D partnerships.

As regards to the firm's origin, we have included two variables that may affect cooperation: FOREIGN is a dummy variable that indicates if the firm is part of a foreign conglomerate and CHAEBOL which assumes value 1 for firms belonging to one of the well-known Korean conglomerates. Foreign companies in Korea usually face difficulties on market penetration which lead us to think that there is no significant impact on cooperation with customers. In addition, it must not have any interest to share knowledge with local competitors or even institutions – they must do it in their host countries. It is maybe expected that they cooperate with suppliers in order to develop their local supply chain. Then we expect negative effect from this variable in cooperation with competitors and institutions and a positive but weak effect on cooperation with suppliers. Korean *chaebols* are very strong institutions and they must usually rely more on internal capabilities rather than external partners, especially competitors. On the other hand, they may look very attractive for suppliers who want to be part of their supply chain. They are also constantly targeted by government policies which frequently include research institutes and universities on technology development. It is expected then that firms belonging to a domestic conglomerate are likely to cooperate with suppliers and institutions but not with competitors. We don't expect, however, a significant impact of this variable in cooperation with customers.

From the hampering factors which negatively affect firms' likelihood to develop innovation activities, we have chosen three: RISKCNST, COSTCNST and ORGCAPCNST. Whenever firms face constraints on Risk and Cost of innovation activities, they must look for partners in order to share them. And whenever they lack capabilities, they must also find partners who are able to complement the missing points. Risk constraints must be highly related to horizontal cooperation – sharing profits are acceptable when one shares the risk involved. Bayona et al. (2001a)'s argue that cooperative R&D leads to higher degree of difficulty to control costs leading to a general negative impact. In Belderbos et al. (2004a), cost constraints affects negatively supplier cooperation and positively in institutional cooperation. Miotti and Sachwald (2003), on the other hand, found negative impact for cooperation with competitors and institutions. We believe that cost constraints are more likely to influence positively institutional and suppliers cooperation since cooperation with institutions in Korea is usually supported by the government. Risk and cost constraint are not likely to influence cooperation with customers since usually the objective of this type of cooperation is to better understand market issues and not to reduce these factors. However, customers' capability may be an important source of information and may fulfill needed knowledge that is not available internally. So, we understand that organizational capability constraint may be a reason for a firm to search R&D partnership with customers in the same way with institutions and suppliers. Risk and Cost constraints have a strongly correlation with each other, according to what is presented on Appendix I. In order to avoid risk of multicollinearity and difficulties in separation of risk and cost constraint effects, we will not include both variables in specification of the same model. So, we will not use both variables in one equation.

As supported by previous literature, the industry to which the firm belongs also plays a major role on the likelihood of firms to collaborate. From the OECD sector classification used by Bayona et al. (2001) on the determination of cooperation behavior, we generated a KSIC 2-digit level standardized table with technology intensity of sectors. This is also in accordance with general findings of Miotti and Sachwald (2003) when analyzing French CIS-2 data and Sakakibara (2001) when analyzing Japanese government sponsored R&D consortiums. Miotti and Sachwald (2003) also state that vertical cooperation prevails in lower-tech sectors and horizontal cooperation are more common in high-tech industries.

We have also calculated a number of other variables such as Speed of Technological Change (SPDTECCHG), Industry Innovation Size (INDINNSIZE), Industry Profit (INDPROFIT) and Industry Turnover (INDTURNOVER), which explanation of calculation is on Table 1 and the values for each industry on Table 3. Other literature also supports the use of these as a possible explanatory factor (Miotti and Sachwald, 2003 and Sakakibara 2001). "*The availability of large innovating potential partners (nearby) appears to stimulate horizontal cooperative R&D*" (Belderbos et al. 2004a). We interpret the authors' statement as: the higher average innovation capacity of firms in the industry level, the higher likelihood to cooperate with competitors. In fact, they used the average turnover of firms on industry level. We will use the average size of the firms in terms of number of R&D workers (INDINNSIZE) as a more appropriate proxy to represent the innovative potential of the industry while we use industry turnover as a proxy for concentration (see below).

Table 3. Sector specific variables

Industry	Tech	InnSize	TecChg	Profit	TurnOver
15 Food	Low	14.2	28.6	7.7%	180,182
17 Textiles	Low	13.7	40.2	3.0%	93,742
18 Sewn Wearing	Low	19.2	62.5	7.5%	70,565
19 Leather	Low	9.3	17.1	5.1%	45,488
20 Wood	Low	5.8	85.3	10.0%	56,171
21 Pulp and Paper	Low	6.1	28.8	6.8%	131,982
22 Media	Low	29.4	32.3	11.2%	98,743
23 Fuels	Low	21.3	13.9	7.7%	1,314,257
24 Chemicals	High	27.7	31.4	7.2%	159,611
25 Rubber & Plastic	Mid	17.2	43.2	5.0%	70,391
26 Non-metallic	Low	10.0	40.1	8.2%	81,999
27 Basic Metals	Low	17.9	29.9	7.5%	633,944
28 Metal Products	Low	9.4	31.2	6.5%	30,106
29 Machinery	Mid	15.9	37.2	5.3%	67,502
30 Computers	High	26.9	55.6	7.3%	74,988
31 Electrical	High	15.6	32.8	7.4%	49,104
32 Electronics & ICT	High	29.8	40.4	3.7%	115,679
33 Precision	High	11.6	42.3	6.9%	18,707
34 Motor Vehicles	Mid	24.4	46.6	5.4%	78,123
35 Other Transport	Mid	44.8	40.6	1.7%	818,869
36 Furniture	Low	16.0	54.8	-23.5%	248,608

For the speed of technological change (SPDTECCHG) in the sector, Belderbos et al. (2004a) found that it affects positively cooperation with competitors, customers and institutions. The speed of technological change is proxied by the rate of firms reporting new products over the number of firms that didn't, weighted by the firm size. It is expected that firms have more incentive to cooperate if they operate in an industry with more dynamics on the introduction of new products to the market. Since we are not analyzing the service sector, we don't need to worry about any bias caused but unfitness of the proxy definition to services.

If a sector is highly competitive, it means that companies do not have a high level of profit. If average turnover of firms in the industry is high, it means high concentration. According to Mark and Graversen (2004), low competition and high concentration leads to lower level of cooperation. We will than test if industry average turnover (INDTURNOVER) and industry profitability (INDPROFIT) affect some of the types of cooperation. It is expected that high profitability or concentration in the industry decreases the likelihood to cooperate.

We have not considered government subsidies in this model due to the strong correlation between this variable and cooperation. Since government policies strongly support cooperative R&D or their provision is conditioned to cooperation in innovation activities, it is likely that firms must cooperate in order to receive these benefits – *i.e.* – there is no causal effect from this variable but just a straight forward relationship.

5. Estimation Results

We run our model using MVPROBIT implementation of GHK simulator (Geweke et al., 1997), available on-line as an STATA module[6]. It estimates multiple equation probit models by the method of simulated maximum likelihood. For a description of the GHK simulator and further literature, see Greene (2003). By using this method, we are able to verify not only the factors and significance of explanatory variations but also the cross-equation error terms variance-covariance matrix which (in case of positiveness and significance) would support the idea of interdependence between the four cooperation equations. In addition to accounting for simultaneity bias we used the *robust* option which is usually available in STATA commands to indicate the use of Huber/White/sandwich estimates of variance (Huber 1967, White 1980). "*Robust estimation of variances gives more accurate assessments of the sample-to-sample variability of the parameter estimates even when the model is misspecified*" (Gutierrez and Drukker 2003).

The final system of four equations resulted in a set where more than 50% of the explanatory variables are statistically significant at 10% level of significance with at least four characteristics for each type of cooperation. Anyhow, the systematic approach with inter-related heterogeneous equations (not the same independent variables) got us with better results than any other system, including individual simple probit model (one-equation system for each of the dependent variables). The final results for the multivariate system with identified explanatory variables are presented on Table 4.

[6] http://ideas.repec.org/c/boc/bocode/s432601.html

Table 2. Explanatory variables for cooperation (multivariate Probit model)

Multivariate probit (SML, # draws = 5)				Number of obs	=	1784
				Wald chi2(34)	=	156.87
Log pseudolikelihood = -2183.3308				Prob > chi2	=	0.0000

	Coef.	Std.Err	z	P>z	[95% Conf.	Interval]
coop-i						
workerslog	0.1292	0.0216	5.97	0.000	0.0868	0.1716
rdintty	0.7092	0.2314	3.06	0.002	0.2557	1.1627
chaebol	0.1250	0.1038	1.2	0.229	-0.0785	0.3286
foreign	-0.3751	0.1694	-2.21	0.027	-0.7072	-0.0430
hitech	0.0500	0.0764	0.65	0.513	-0.0998	0.1998
indinnsize	0.0048	0.0048	1	0.318	-0.0046	0.0142
indprofit	1.9350	0.9766	1.98	0.048	0.0209	3.8492
spdtecchg	-0.0069	0.0038	-1.84	0.066	-0.0143	0.0005
costcnst	0.0203	0.1026	0.2	0.843	-0.1807	0.2213
orgcapcnst	0.8275	0.1992	4.15	0.000	0.4369	1.2180
_cons	-2.2099	0.2473	-8.94	0.000	-2.6945	-1.7252
coop-s						
workerslog	0.1259	0.0249	5.06	0.000	0.0771	0.1747
rdintty	0.9866	0.2762	3.57	0.000	0.4452	1.5280
chaebol	0.1906	0.1041	1.83	0.067	-0.0133	0.3945
foreign	-0.0523	0.1741	-0.3	0.764	-0.3936	0.2889
indturnover	0.0003	0.0002	1.76	0.078	0.0000	0.0006
costcnst	0.0514	0.1031	0.5	0.618	-0.1507	0.2534
orgcapcnst	0.3470	0.2042	1.7	0.089	-0.0532	0.7472
_cons	-2.4078	0.2243	-10.74	0.000	-2.8474	-1.9682
coop-c						
workerslog	0.1520	0.0248	6.13	0.000	0.1034	0.2006
rdintty	0.7293	0.2776	2.63	0.009	0.1851	1.2734
chaebol	-0.0342	0.1087	-0.31	0.753	-0.2473	0.1788
foreign	-0.1514	0.1678	-0.9	0.367	-0.4803	0.1776
hitech	0.0922	0.0675	1.37	0.172	-0.0400	0.2244
indturnover	0.0001	0.0002	0.48	0.635	-0.0003	0.0005
spdtecchg	0.0061	0.0036	1.72	0.086	-0.0009	0.0131
orgcapcnst	0.8401	0.2039	4.12	0.000	0.4405	1.2397
_cons	-2.9254	0.2618	-11.17	0.000	-3.4385	-2.4123
coop-h						
workerslog	0.1626	0.0259	6.28	0.000	0.1118	0.2134
rdintty	1.0415	0.3157	3.3	0.001	0.4226	1.6603
foreign	-0.6421	0.2656	-2.42	0.016	-1.1626	-0.1215
hitech	0.1950	0.0940	2.07	0.038	0.0107	0.3793
indinnsize	-0.0114	0.0056	-2.02	0.044	-0.0224	-0.0003
indprofit	-1.1401	0.6591	-1.73	0.084	-2.4320	0.1517
indturnover	0.0004	0.0002	1.82	0.069	0.0000	0.0008
spdtecchg	0.0036	0.0041	0.87	0.386	-0.0045	0.0117
riskcnst	0.2198	0.1059	2.08	0.038	0.0123	0.4274
_cons	-2.6122	0.2714	-9.62	0.000	-3.1441	-2.0802

First, and a very important finding, the cross-equation terms variance-covariance matrix is composed by only positive and statistically highly significant coefficients. It supports the view that the equations are interdependent and the decision to estimate the model as a system was correct. The presence of one or other insignificant variable in the equations slightly changed the results but not impacting significantly in the final objective of this analysis. Moreover, no other independent variable would get a better statically significant coefficients set when included in the system of equations.

An important finding in this analysis is that estimated coefficients and their levels of significance differ among the equations, showing the heterogeneity of behavior of firms when deciding about one or other type of cooperation.

Horizontal cooperation showed to be the type of cooperation with more significant determinants among the types investigated. There are eight characteristics of firms that are statistically significant (2 at 10%, 4 at 5% and 2 at 1% levels of significance) associated to their likelihood to cooperate with competitors. The two types of vertical cooperation (with suppliers and customers) have five and four determinants respectively in the final system. However, the equation for cooperation with customers showed to be more unstable and in many preliminary calculations, the number of statistically significant determinants was limited to only two variables.

Cooperation with customers has three independent variables with highly significant coefficients (at 1%), and one at 10%. Cooperation with suppliers has two determinants significant at 1% and three others at 10%. Cooperation with institutions has a total of six determinants: 3 of which are statistically significant at 1% and 2 at 5% and 1 at 10% level of significance.

We also compared the results between the simultaneous multivariate model and individual probit models (available on request) and we observed that coefficients remain somewhat equivalent for the factors which are significant in both system and single equation models. One may observe changes in the signal (positive or negative) and big differences in the estimated coefficients but, in fact, they are not statistically significant in both systems or in the single equation probit models.[7]

5.2 Firms' characteristics

As expected, firms' size (defined in this model as the logarithm of number of employees – WORKERSLOG) affects positively in all four types of cooperation. This variable is significant at 1% level for the four equations and the estimated coefficient is a bit higher for horizontal cooperation and not for institutional cooperation like was found in the previous literature. Investigating the system with non logarithmic workers variable generated no different results for this variable but impacted on the significance of other determinants and generated worse models according to our strategy. Firms with a larger number of employees are supposed not only to have the required absorptive capacity to engage in cooperation but also benefits from the larger network from the employees. Larger firms are also more attractive and it is natural that they are regularly considered when other firms are looking for partners.

R&D Intensity is also included in all four equations and the estimated coefficients are highly significant (and positive at 1% level) for the four types of cooperation. From the

[7] The final results for multivariate system and simple equation probit models are not presented here. These are available from the authors upon request.

value of the coefficients, it is evidenced that it seems to affect more the cooperation with suppliers and competitors. This is not in line with the findings on the previous literature (Belderbos et al. 2004a; Miotti and Sachwald 2003) which didn't find significant coefficient for horizontal cooperation and found it to be significantly positive to cooperation with institutions. Investigating, the squared value didn't make substantive improvements on the model and the linear relation showed to be suitable to the system.

If a company belongs to a domestic corporate group (CHAEBOL), it affects its likelihood to collaborate with suppliers (significant at 10%). In few systems of equations we found significance on this factor affecting cooperation with institutions. For customer and competitor cooperation, the estimated coefficients were not found to be significant in any of the investigated cooperation forms.

In our previous expectations, the Korean *chaebols* are likely to be often targeted by suppliers and institutions who want to collaborate in R&D. Our final system shows that to be true for suppliers but not for institutions. The findings are also inconclusive about *chaebols* having incentives or disincentives to cooperate with competitors. For companies belonging to foreign groups of enterprises (FOREIN dummy variable), the effect is negative and significant to cooperate with institutions and competitors. The coefficients for suppliers' and customers' cooperation are also negative in the final system however not statistically significant. Thus, foreign companies in Korea are not likely to cooperate with institutions and competitors but nothing can be said about suppliers or customers. These findings are supported by all of the specified equation systems.

5.3 Sectoral determinants

Belonging to high-tech sector influences firms to cooperate with competitors but it doesn't affect significantly the other three types of cooperation, according to the final system. The positive effect in horizontal cooperation is highly expectable according to the previous literature as well as the insignificant coefficient for institutional cooperation. These two facts were found in all combinations of equations. For customers' cooperation, even though in the final system this variable is not significant, it was found to impact significantly in some systems of equations. The same happened for suppliers but we had to eliminate this variable from the final system due to our strategy to increase the frequency and to utilize the number of significant determinants. This deserves further investigation and may be a limitation of our model. Previous studies didn't find this variable to impact in these two types of cooperation. The findings help to understand the preliminary analysis about the chart on Figure 2. In fact the information on the chart also takes into account the number of firms using outsourcing external partners, which was not targeted on the econometrics analysis and the failure on determining its significance for vertical cooperation leaves room for other interpretations.

For the industry average innovation size (INDINNSIZE), defined as the average number of R&D employees, it affects negatively horizontal cooperation. This independent variable was extracted for vertical cooperation equations because its inclusion on the final system did not generate significant results and other significant variables turned into insignificant ones. Similarly to HITECH, this variable was found to be significant in many equations for institutional and suppliers' cooperation. Industry average turnover (INDTURNOVER) impacts positively on horizontal cooperation and cooperation with suppliers but doesn't impact significantly in cooperation with customer. In fact, very few systems of equations (including the final one) found this to be true. Common findings were that it doesn't affect any type of cooperation. According to our raised hypothesis when describing the independent variables, these two variables (INDINNSIZE and INDTURNOVER) were supposed to impact positively cooperation with competitors and cooperation in general according to the previous literature, which was confirmed in current study partially.

Industry average profitability (INDPROFIT) appears to influence negatively on cooperation with competitors (confirmed by most of the systems) and positively with institutions (confirmed by all systems). This rejects the hypothesis that higher profitability in the industry decreases the likelihood to cooperate in general but confirms the negative influence in horizontal cooperation. No significant impact on vertical cooperation was found for this variable in any combination of cooperation equations.

The findings also include the speed of technological change (SPDTECCHG) as a positive and significant factor affecting cooperation with customers, which is in line with previous studies. An unexpected result from the final system of equations (and confirmed in most of systems) is that it affects negatively on cooperation with institutions. It seems that Korean companies from dynamic sectors prefer to develop their innovation activities internally. Nothing can be said about horizontal cooperation since 100% of the systems pointed this variable to be statistically insignificant. For cooperation with suppliers, it is generally insignificant but few systems found the factor to be statistically significant and negative.

5.4 Constraints for Innovation

From the three types of constraints that firms answered as hampering factors to avoid innovation activities, we found in all systems of equations that cooperation with institutions and customers are affected positively by organizational capability constraints (ORGCAPCNST). In the final system and also in the majority of the models, it also affects positively cooperation with suppliers. Horizontal cooperation is not affected significantly by this determinant (according to all systems). This is in line with our previous expectations. Risk constraints (RISKCNST) affect positively horizontal cooperation (in the final system and in most of the other tested models) and do not affect any other types of cooperation (in any combination of equations), which is completely in line with our expectations. Cost constraints (COSTCNST) has no significant influence on vertical and institutional cooperation (even though the variable is not included in supplier equation, it never had any significant effect when included in the specification of the model). It is not included in Horizontal cooperation due to correlation with the variable RISKCNST. It seems not be a factor to determine Korean firms' likelihood to cooperate on innovation activities.

6. Final Remarks

Clusters and network policies, on national and regional level, have been conducted by a number of governments worldwide in both industrialized and developing countries in order to increase economic development and industry competitiveness. Micro-level studies of R&D cooperation among firms and other types of organizations has received great emphasis from policy makers as it facilitates knowledge transmission, reduced R&D cost, increased innovative capacity and generates useful information for targeted public intervention.

The aim of this research was to develop an agent-based simulation model that could be used to show how this technique may be useful on the design of policy tools toward cooperation in innovation activities. Then, we have introduced an agent-based model representing the dynamic processes of cooperative R&D in the manufacturing sector of South Korea. The main dataset utilized in the simulation game came from the Korean Innovation Survey 2005 (KIS 2005) conducted by STEPI (Science & Technology Policy Institute) which covered innovation activities from 2002 to 2004 developed by firms with at least 10 employees.

This paper focused on one of the four steps conducted in this research as described below. We have conducted research and survey of previous studies about the determinants of firms' behavior when conducting R&D activities, whether alone or in cooperation, whether partnering vertically, horizontally or with institutions. We also have surveyed existing studies conducting agent-based simulation games about firms cooperation in innovation. From this step, we extracted the theoretical background to be applied in the following steps, and the common practices on running agent-based simulation models.

As described in this paper, we have conducted regression analysis, directly using the target data (the KIS 2005), to find out the significant determinants of cooperation in R&D in South Korea. The regression model was defined as a system of four different binary choice equations which aimed to identify firms' (and sectors') characteristics defining their likelihood to cooperate with customers, suppliers, competitors and private/public research institutions. We carried out a multivariate probit regression analysis with one dependent variable for each kind of cooperation. The results from this analysis allowed us to define a more accurate view of South Korean firm's rationale regarding to their choice whether to cooperate or not and with which kind of partners they could find in the market.

In the third phase, we have defined our simulation model of firms' cooperation in innovation. Agents are 1839 firms from manufacturing industries SIC (Standard Industry Classification) 15 through 36. The agents are heterogeneous in their characteristics and behaviors; and the outcomes accrue from their interactions in an artificial gravitational landscape. The attraction forces and probabilities to establish cooperative links with other firms' were defined by a set of determinants and rules extracted from theoretical assumptions and empirical evidences. The simulation model was then validated by finding, in the artificial world, equivalent industry distribution of cooperative firms, with a maximum error of 5%, when compared to the real world (for the 8 larger industries – industries with more than 100 firms). The model accomplished partnerships between firms, including inter-sectoral alliances, whose determinant was a minimal level of commercial transaction obtained from the Korean input/output table. From the model validation, in the last step we conducted simulations with different policy scenarios in order to analyze sector responses to different government strategies.

We would suggest improvements in Korean Innovation Surveys to better capture network formation and cooperative behavior of firms. Questionnaires could be extended to accomplish information such as region and industry classification of partner organizations, number of projects and researchers involved in collaborative R&D, and direct reasons leading companies to decide for their engagements in joint projects. Moreover, some information of very simple implementation could be of great improvement of data quality, such as SIC 3-digit level classification, city of location, and a unique identifier number that could link firms from one version of the innovation survey to the other one three years later.

One other interesting use of the current system would be to test it in different countries with similar innovation and network survey data, such as Austria, Germany, Sweden or, why not, the whole European Community or preferably at the OECD level. On the case of an entire continent or a large country, the regional aspect would play a major role and the analysis only on industry level would not be the best option.

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Appendix I. Correlation matrix of dependent and independent variables

	coop-i	coop-s	coop-c	coop-h	workers	rdintty	chaebol	foreign	hitech	indinn~e	indtur~r	indpro~t	spdtec~g	riskcnst	costcnst
coop-i	1.00														
coop-s	0.47	1.00													
coop-c	0.45	0.62	1.00												
coop-h	0.39	0.55	0.52	1.00											
workers	0.11	0.12	0.11	0.13	1.00										
rdintty	0.02	0.04	0.02	0.04	-0.10	1.00									
chaebol	0.09	0.10	0.06	0.06	0.18	-0.06	1.00								
foreign	-0.04	0.00	-0.01	-0.05	0.02	-0.03	-0.08	1.00							
hitech	0.03	-0.02	0.02	0.01	-0.03	0.16	-0.01	0.04	1.00						
indinnsize	0.06	0.04	0.04	0.02	0.09	0.14	0.04	0.04	0.48	1.00					
indturnover	0.02	0.05	0.01	0.04	0.14	-0.05	0.10	-0.02	-0.15	0.29	1.00				
indprofit	0.06	0.02	0.01	-0.01	0.02	-0.01	0.04	0.00	0.13	-0.05	-0.06	1.00			
spdtecchg	-0.06	-0.03	0.01	-0.01	-0.04	0.08	-0.04	-0.01	-0.07	0.09	-0.30	-0.34	1.00		
riskcnst	0.07	0.05	0.07	0.06	0.00	-0.01	0.05	-0.05	0.00	0.03	0.02	0.00	0.00	1.00	
costcnst	0.06	0.04	0.06	0.05	-0.03	0.02	0.02	-0.03	0.05	0.06	0.04	0.01	-0.01	0.58	1.00
orgcapcnst	0.11	0.05	0.10	0.05	-0.03	0.01	0.04	-0.08	0.02	0.03	0.00	-0.01	0.04	0.46	0.45