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Technical and Organizational Innovation in South Korea

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Technical & Organizational Innovation in Small and Medium Enterprises

Abstract

This study investigates whether organizational innovation has positive impacts on small and medium enterprises, using three waves of the South Korean innovation survey. We find that the probability of achieving a process or product innovation conditional on organizational innovation increases in a linear fashion from small to large firms. Moreover, the effects of organizational innovation are more pronounced for process innovation relative to product innovation. We show R&D performers who implement an organizational innovation have a greater probability of introducing a new product or process. We also show that larger R&D performing firms benefit more from organizational innovation than smaller firms. Finally, we find evidence that high-tech industries benefit more from organizational innovation, in accordance with one of our hypotheses.

1. Introduction

Many countries have implemented various policies to enhance product and process innovation (hereafter referred to as technical innovation). For instance, Canada has given tax breaks to Research and Development (R&D) performers since the end of WWII through the Scientific Research and Experimental Development Tax Incentive (Canada Revenue Agency, 2015) and the US has done so through the Research and Experimentation Tax Credit since 1981 (Guenther, 2015). However, organizational innovation does not seem to attract the same sort of attention as technical innovation, even though organizational innovation has a role to play in innovation performance. Only recently have governments, such as China, asked self-governing industry groups to put in sector-wide standards as a form of organizational innovation in order to meet market demands (Fanbin, 2017).

In addition, management literature has identified that organizational innovation lags behind technical innovation as the former is usually unwelcomed to management teams (Useem, 2015). Several studies show that small and medium-sized enterprises (SMEs) that conduct R&D and organizational innovation jointly are somehow better equipped to introduce new technical innovations relative to firms without joint R&D and organizational innovation (Battisti & Stoneman, 2010; Laforet, 2013). The purpose of this paper is to investigate whether organizational innovation has in fact imparted positive impacts for SMEs, using three waves of comprehensive national innovation survey from South Korea.

Organizational innovation has become more prevalent as a research topic as firms search for novel ways to become more efficient in R&D investment. In the literature, there is no consensus of what organizational innovation 'is' (Lam, 2005). However, the Harvard Business Review (Staff, 2002) colloquially defined organizational innovation by noting that "organizational innovation…improves the way we do business." To clarify the colloquial definition of organizational innovation, we use the Organisation for Economic Co-operation and Development (OECD) (2005) definition of organizational innovation as: "the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations." Specifically, the OECD Oslo manual defines organizational innovation as the adoption of practices that enhance the firm's internal and external efficiency—training, internal knowledge sharing, external partnerships, job flexibility, supply chain management. This definition is used in our data from the Korean Innovation Survey (KIS).

This paper focuses on the impact of organizational innovation on technical innovation, process and product innovation. Organizational innovation means different things to three distinct streams of literature, as identified by Lam (Lam, 2005). The first stream is organizational design theories, the second organizational cognition and learning, and the third organizational change and adaption. Our work falls into the first stream, organizational design theories, in which researchers explore the link between firm organizational structure and the firm's ability to innovate. To our knowledge, there are no studies that consider the impact of organization innovation on process innovation as a function of firm size. We further compare and contrast our results on process innovation to product innovation. Though we expect our results to be congruent with those found in Camisón-Zornoza et al. (2004), i.e., there is larger impact of technical innovation on larger firms.

Specifically, this study examines: 1) if organization innovation impact varies with firm size and 2) if organizational innovation has a positive or negative impact on a firm's R&D production, again as a function of firm size. In the remainder of this section we formally state the hypotheses of our paper and present the supporting literature for each question. The design of innovation survey does not necessarily include instruments to aid in the determination of causality, so most research relies on correlational methods. Our contribution to the literature is that we account for endogeneity of technical innovation and organizational innovation in the estimations, with an emphasis on SMEs' organizational innovation and R&D.

2. Literature

This paper compares process and product innovation and firm size. Before discussing product and process innovation advances in the literature, we like to note the definitions of product and process innovation. According to OECD (Organisation for Economic Co-operation and Development. & Statistical Office of the European Communities., 2005), *product innovation* "is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics." *Process innovation* "is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software."

As noted in Utterback & Abernathy (1975) and Klepper (1996), firms initially invest efforts in product innovation and later in process innovation. Similarly, larger firms tend to be older than SMEs (Penrose, 2009). Base on these two observations that process innovation follows product innovation and larger firms are older on average than SMEs, one expects larger firms to spend more time on process innovation than product innovation. As noted by Hullova et al. (2016) the interrelationship between process and product innovation is not only a function of firm size, but also a function of a firm's industry sector. Sectors with rapidly evolving products such as (bio)pharmaceuticals have process and product innovation in sync (Feldman & Ronzio, 2001; Pisano & Wheelwright, 1995). Given the fact that sectors with rapidly evolving products do not constitute a large portion of economic output of South Korea (World Bank, 2018), we expect to have larger firms engage in process innovation more than SMEs, i.e., to be in line with the findings of Utterback & Abernathy (Utterback & Abernathy, 1975) and Klepper (Klepper, 1996).

2.1 Organizational innovation and firm size

The positive impact of organizational innovation on technical innovation is well established in empirical literature (Battisti & Stoneman, 2010; Camisón & Villar-López, 2014; Damanpour, 2010) and theoretical work establishing the same relationship also exists (Armbruster et al. 2008). However, besides the work of Camisón & Villar-López (Camisón & Villar-López, 2014) that uses firm size as a control variable, these studies did not consider how the effects of organizational innovation are influenced by firm size. We postulate that the size of a firm will have a positive relationship between organizational innovation and technical innovation. This is because, as noted previously (Camisón-Zornoza et al., 2004), firm size is positively correlated with technical innovation. As such, the first contribution of this research is to determine if firm size has a positive impact on the efficacy of organizational innovation.

Laforet (2013) shows that organizational innovation has a positive impact on small firms' productivity, profit margins, and improvement of product design and process, and Hervas-Oliver et al. (2014) also demonstrate that the combined implementation of both organizational innovation and technical innovation can have a positive effect on firm performance. However, they use data for small firms only and thus the results cannot be compared with the results of larger firms. Sapprasert & Clausen (2012) and Gallego et al. (2012) show that small firms with flexible structures can benefit more from organizational innovation and lead more technical innovations. On the other hand, Cobo-Benita et al. (2016) and Ganter & Hecker (2013) demonstrate that organizational innovation contributes more to technical innovation when the firm size is large. However due to the lack of available data, no empirical research study has formally established the link between organizational innovation and firm size to technical innovation.

Utterback & Abernathy (Utterback & Abernathy, 1975), Klepper (Klepper, 1996) and Penrose (Penrose, 2009) indicate that larger firms spend more time on process innovation than on product innovation. As noted by Hullova et al. (Hullova et al., 2016) the interrelationship between process and product innovation is not only a function of firm size, but also a function of a firm’s industry sector. Sectors with rapidly evolving products such as (bio)pharmaceutical have process and product innovation in sync (Feldman & Ronzio, 2001; Pisano & Wheelwright, 1995). Literature on firm size and innovation, leads us to our first hypothesis.

H_1: Organizational innovation has a greater, i.e., more positive, impact on technical innovation for larger firms than smaller firms.

2.2. Organizational innovation and R&D

We expected to find substantial literature pertaining to organizational innovation and R&D. Unfortunately, we only found three such studies. R&D investment to enhance absorptive capacity can affect firm’s innovation and performance. Birasnav (2014) argues that firms make efforts to implement various knowledge enhancing practices to create organizational knowledge, which increases those firms' ability to innovate new products and services. Ali and Park (2016) show that absorptive capacity improve organizational innovation which in turn affects innovation performance. Hurley and Hult (1998) suggest that a firm’s learning orientation indicates a desire to assimilate new ideas. The role of R&D as a source of innovation in services is much lower than in the processes of industrial innovation (Rubalcaba, 2006). Camisón & Villar-López (2014) show that organizational innovation positively affects process innovation, but indirectly affects product innovation. This implies that simply implementing organizational innovation is not sufficient to enhance product innovation. The fact that sectors with rapidly evolving products do not constitute a large portion of economic output of South Korea

(World Bank, 2018), we expect to have larger firms engage in process innovation more than SMEs, i.e., to be in line with the findings of Utterback & Abernathy (Utterback & Abernathy, 1975) and Klepper (Klepper, 1996). Our hypothesis pertaining to organizational innovation and R&D is:

H_2: Organizational innovation should have a more pronounced effect within R&D performing firms.

2.3. Organizational innovation and industry

Evangelista & Vezzani (2010) show that the impact of organizational innovation is more significant in the manufacturing sector than in services, and pure product or process oriented innovation strategies exert a positive and significant impact on firms' performances only in the manufacturing sector. The work of Von Tunzelmann & Acha (2009) argues that low- and medium-tech industries do not innovate. For example, the authors point that in the oil and gas industry "there is little direct correlation between technological performance (say patenting and scientific publications) and business performance (say expansion or profitability)." Using patenting as a measure of innovation, we can restate the claim to say low- and medium-tech industries do not benefit from innovation. The finding is echoed by Jiménez-Jiménez & Sanz-Valle (2011) who find that "the positive relationship between organizational learning and innovation is more intense in the group of firms that are smaller, older, operating in environments that are more turbulent and in the service sector." What the authors label as turbulent environment is one in which "innovation is an obligation the environment imposes," or one which will be labeled as high-tech by Von Tunzelmann & Acha (Von Tunzelmann & Acha, 2009). These overarching findings, that innovation favors high-tech firms, is not universally agreed as some research find that manufacturing firms may still benefit from innovation (Noruzy, Dalfard, Azhdari, Nazari-Shirkouhi, & Rezazadeh, 2013). The discussed research brings us to our third and final hypothesis:

H3. Organizational innovation should have a more pronounced effect on product and process innovation in high-tech industries.

To summarize, the literature shows that organizational innovation has been shown to enhance performance and technical innovation. Organizational innovation and process innovation are complements, while organizational innovation and product innovation may be substitutes. One study inferred that organizational innovation is necessary for the use of technical innovation, which means that the firm adopted a technology and then tried to implement it; those who also implemented a compatible organizational innovation had better outcomes. In terms of R&D and organizational innovation there seems to be little guidance from the literature.

3. Data

Our data are from the national voluntary Korean Innovation Survey (KIS) conducted by the Korea Science and Technology Policy Institute. The survey, performed every 2 – 3 years, is similar in format to the Survey of Innovation and Business Strategy in Canada and to the Community Innovation Survey (CIS) in Europe. Firms with more than ten employees are selected to be in the stratified random sample. We merged three waves of the survey (2005, 2008 and 2010) in the manufacturing sector. In 2005 the sample population of the survey consisted of 6,608 firms, of which 5,386 were 'in scope'.[1] The number of responses to the survey was 2,743 with a response rate of 61%. For 2008 the sample population was 6,314 of which 5,381 where in scope, and the number of responses was 3,081 for a response rate of 67%. For 2010 the sample population was 8,792 with 7,692 in scope, and the response rate for this survey was lower at 51% (3,925 responses).

Like CIS, KIS asks questions about four types of innovation: product innovation, process innovation, organizational innovation and marketing innovation. Product innovation is defined as the goods or services that are either new or significantly improved with its fundamental characteristics or technical specification. Examples of product innovation include digital cameras, smartphones, GPS in automobiles, electronic payment system, etc. Process innovation includes new or significantly improved producing technology, supplying services and delivering products. Examples include just-in-time system, automated production facilities, barcode system, and new software. While the 2005 survey asks the number of product or process innovations achieved during the past 3 years, the 2008 and 2010 ask the binary questions of yes/no on these innovations.

Organizational innovation is defined as the introduction of new or significantly improved methods, in terms of how to work, how to organization and how to make external cooperation networks. The survey asks if any of the following four organizational innovations were implemented within the past three years with responses as yes/no: job training or internal knowledge sharing; supply management or production management

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[1] Firms that were out of scope went bankrupt, were duplicates, had merged or had been acquired.

(lean production system, supply chain management, etc.); job flexibility or inter-divisional cooperation (team-system, horizontal communication increase, etc.); management of external relationship with suppliers, clients or public authorities. For R&D, this analysis combines two measures of R&D to arrive at total R&D expenditure—intramural (conducted within the firm) and extramural (conducted by universities, government institutes, or other companies).[2]

In Table 1, we split the sample into three classes of firm size: small (less than 25 employees), medium (between 25 and 150 employees) and large (greater than 150 employees). The sample size for each category is 3259, 4012 and 2470, respectively. Average employment across each category is 16 for small, 69 for medium and 700 for large firms. Thus, the surveys are heavily composed of small and medium enterprises not so much by design, but because of the structure of the Korean manufacturing sector. Consequently, large firms are typically very large, due to the chaebol (conglomerate) ecosystem. Only 12% of small firms conduct R&D, while 31% of medium firms, and 62% of large firms do so. The last three rows of the table indicate that 11% of small firms undertake R&D and organizational innovation jointly, while 88% of small firms that undertake organizational innovation also do R&D, and of small firms that engage in R&D 66% also undertake organizational innovation.

Here we consider R&D as a distinct activity from product and process innovation (we do not use it as a proxy for innovation for instance). Firms that undertake R&D are searching for new knowledge that may/may not lead to innovation. There seems to be modest support for the notion that small firms that undertake R&D and/or organizational innovation are different from others (as only 54% of medium firms that undertake R&D also do organizational innovation). Variable construction and relevant statistics can be found in Appendix A.

[2] Marketing innovation is to introduce new or significantly improved methods as a way to increase in the attractiveness of products or the recognition of clients in terms of marketing or selling products. Examples include creating e-marketplaces, improvement displays in shop windows, etc.

4. Method[3]

The survey does not ask direct questions as to *why* organizational innovation occurred. Thus, we do not know if organizational innovation is the result of external or internal forces. We also do not know if the organizational structure of the firm has changed in response to the adoption of organizational innovation. It could be that without changing the structure of the firm, say from J-form to M-form, an organizational innovation's impact is curtailed. This is a limitation of the research that we have to live with. From the foregoing discussion, one might ask whether organizational innovation is causally related to product and process innovation. Causation is hard to disentangle and thus the potential endogeneity of organizational innovation with technical innovation is a concern.

We therefore need to use an estimation procedure that explicitly takes this into account. Two avenues of estimation could be explored: product and process innovation and organizational innovation are binary, while R&D expenditure is continuous. A single estimator that accommodates this data is not feasible, but we discuss our proposed method below. A second avenue of estimation, is to simply treat R&D expenditure as a binary variable, and then use a trivariate probit estimator. It was felt that 'throwing out' the R&D expenditure data was unnecessary, as a two-stage estimator could be used.[4]

Thus we propose to use a bivariate probit estimator for product and process innovation. In the survey, R&D information is gathered in terms of investment per employee. Since, all firms in the survey are required to answer the R&D question, selection bias is not problematic. We therefore use a Tobit Type I specification to estimate R&D expenditure. We estimate a system of two equations with R&D as the first stage and technical innovation as the second stage. We instrument for R&D expenditure by using its predicted values in the innovation equation. Equation (1) represents the R&D equation, which uses the log of R&D expenditure per employee for firm i (subscripts are omitted for clarity), where β_1 are coefficients on the covariates, and e_1 is the error term.

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[3] The Oslo Manual defines organizational innovation as: 'An organizational innovation is the implementation of a new organizational method in the firm's business practices, workplace organization or external relations' (OECD, 2005). The implementation of organizational innovation in KIS follows the Oslo Manual definition.

[4] In fact, trivariate probit estimation using the GHK simulator was done. We will discuss this later in the paper.

$$\ln(RD\ \ ) = \beta_1 x_1 + e_1\ , \tag{1}$$

In the second stage, the innovation equation is expressed in equation (2), in which the term *INNO* is technical innovation and *ORG* is organizational innovation. Since there are two types of technical innovation—process and product, we will have two sets of equations to estimate. The dependent variables in these equations are dichotomous.

$$INNO\ \ = \phi(\ \delta_1\ RD^*\ + \delta_2\ ORG\ \ + \beta_2\ x_2 + e_2\ \ > 0) \tag{2}$$

$$ORG\ \ = \phi(\beta_3\ instrument + e_3\ \ > 0)\ , \tag{3}$$

where ϕ is an indicator function for the binary response variable. If *INNO* and/or *ORG* are equal to one then the inequality is true otherwise it is false (equal to zero). Equations (2) and (3) follow a bivariate normal distribution and can be estimated simultaneously using maximum likelihood. The term RD* is the predicted value from the Type I Tobit equation given in (1), while the term *instrument* is one of a set of chosen instruments for *ORG* that will be estimated in the bivariate probit regression.

In a typical innovation survey, it is unlikely to find instruments readily. For instance, the best sort of instrument for an innovation setting would be the random assignment of firms into a program that receives government funding (treatment group) and the random assignment of firms that do not receive funding (control group). However, such assignments are rarely (if ever) made and certainly such 'obvious' instruments elude us in the KIS data. Because endogeneity must be addressed, we are forced to empirically search for instruments. From the KIS survey, we tested 12 potential instruments using a linear probability model. Four of them were standardized variables constructed from multiple items in the survey, and the remaining eight variables were non-forced Likert items. [5]

Ten instruments (delay, fund, info, lackinfo, policy, protection, risk, secrecy, skill, subsidy, turnover) passed the following tests at 0.01 level of significance—underidentification test (Kleibergen-Paap LM statistic), weak identification test (Cragg-Donald Wald F statistic and Kleibergen-Paap Wald F statistic), the

[5] The initial set of potential instruments from the survey was quite large. We narrowed the set down by checking whether the potential candidate was correlated with organizational innovation but not correlated with the residuals from regressing product (process) innovation on organizational innovation and the other covariates. From this first test, only 12 candidates were retained. Subsequent to the first test, the 12 were subjected to the underidentification test, weak identification test, overidentification test, and endogeneity test.

overidentification test of all instruments (Hansen J statistic), and finally a test for endogeneity (Wu-Hausman F statistic). We present the results from the ten tested and validated instruments rather than simply presenting the 'best' one. All regressions are corrected for heteroskedasticity using Huber-White clustered standard errors (clustering is done by industry), and for finite sample bias by bootstrapping (50 replications)[6].

5. Results

The results for the R&D equation are in Table 2. The table shows the first stage estimation via Tobit Type I for R&D expenditure per employee for small, medium and large firms. The final column shows the estimation for the entire sample. The chi-squared statistics are all significant, and sigma is highly significant. The results for the second stage bivariate probit model are shown in Tables 3 to 8. The tables are grouped by process and product innovation, with Tables 3-5 showing results for process innovation from large to small firms. Tables 6-8 show results for product innovation from large to small firms. We refrain from presenting the results from the whole sample, and instead these are in Appendix B.[7]

Depending on firm size and innovation type, two to four of the instruments failed to converge. When looking at the tables, we can see that those instruments are omitted from the results. The bulk of the regressions that achieved convergence performed reasonably well. In 93 percent of the regressions (55 out of 59), organizational innovation is significant.

Table 9 contains the overall results by firm size as motivation for Hypothesis one. The table shows the probabilities for a new product or process innovation dependent on organizational innovation. The probability of having a process or product innovation increases in a nearly linear fashion from small firms to large firms. For example, the average probability for a process innovation within a small firm (that has an organizational innovation) is 5.7 percent, while for a large firm the probability is 38.7 percent (the effect is 6.8 times larger on average in a large firm). For product innovation the conditional probabilities are lower: only a 4.4 percent of a product innovation conditional on an organizational innovation in a small firm, and 24.2 percent for a large firm (a large firm is 5.5 times more likely to have a product innovation than a small firm). These results offer support

[6] It is feasible to do more replications but at considerable computational cost due to the nature of the algorithm that maximizes the likelihood function. The full set of regressions takes one day running on a 24-core server with 64GB of RAM.
[7] For brevity we omit the trivariate probit specification.

for Hypothesis one. Clearly, the effects of organizational innovation are more pronounced for process innovation relative to product innovation.

For Hypothesis two, Table 10 shows the probabilities of new product or process innovation conditional on organizational innovation and whether the firm conducts R&D. Since R&D is a continuous variable, we set it at the sample mean which is 7.18 million South Korean won, or approximately $7,180 USD. On average the probability for a new process innovation increases by 18.5% (column 5 of Table 10) when the firm undertakes R&D and has an organizational innovation. On the other hand, the probability of a new product innovation for an R&D doer who has an organizational innovation increase by 12.3%. The foregoing is support for hypothesis two—that R&D doers should experience a greater impact of organizational innovation than non-R&D firms. Another finding worth mentioning is that large firms experience roughly eight times the benefit than small firms in terms of increased probabilities of innovation. For instance, a large R&D firm has on average, a 48.4% probability of introducing a process innovation relative to a 5.6% probability for a small firm.

To address hypothesis three, we conducted industry-level regressions for the 20 manufacturing sectors in KSIC version 8 (please note that the 2010 survey used version 9 or KSIC, so we used a concordance table to convert version 9 industries back to version 8) For brevity the 200 regressions (5 instruments by 20 industries by 2 innovation types) are omitted. The sample sizes for each industry are included in Table 10 for reference. All estimated probabilities for organizational innovation (200 probabilities in total) have a p-value less than 0.01. We present the average predicted probabilities for each industry in Table 10. In all industries, except one (wearing apparel, clothing accessories & fur articles), the conditional probability of a process innovation exceeds that of a product innovation. For the furniture industry (#36), both probabilities are 10 percent.

From the table, we can see that three industries consistently rank the lowest in terms of one standard deviation less than the mean for both process and product innovation. These industries are: #19-tanning & dressing of leather, #20-wood products, #22-printing. There are also three high performing industries in terms of one standard deviation above the mean: #24-chemicals & pharmaceuticals, #31-electrical equipment, #32-electronic components & computers.

For process innovation there are two more industries that are outside the groups above: #18-wearing apparel & clothing is one standard deviation below the mean, while #34-motor vehicles is one standard deviation above the mean. Although some might consider motor vehicles to be a medium-tech sector, lately the industry has become quick to adopt high technology and the lines between the motor vehicle sector and high-tech have been blurred (Durbin, 2015). For product innovation, #33-medical, precision & optical instruments also falls within one standard deviation above the mean. It is interesting that this industry does not perform as well on the process side, since the probability is 18 percent for a new process, which falls substantially short of 24 percent, which is the mean plus one standard deviation. This is evidence that high-tech industries benefit more from organizational innovation, in accordance with Hypothesis 3.

6. Conclusion

This paper uses three waves of Korea's national innovation survey to explore the effect of organizational innovation on technical (product and process) innovation. Tabular data reveals that organizational innovation occurs more frequently in large firms relative to SMEs (62 percent, versus 31 percent for medium firms and 12 percent for small firms).

We acknowledge that organizational innovation and technical innovation are endogenous and we correct for this. We also acknowledge that R&D is potentially endogenous. Since our R&D variable is coded as expenditure, we used a Type I Tobit estimator and used the predicted values in a bivariate probit model. In general, the regressions by firm size performed well with organizational innovation. The probability of a process or product innovation conditional on organizational innovation increases in a nearly linear fashion from small firms to large firms which is in concordance with Hypothesis one as well as Gallego, Rubalcaba, and Hipp (2012) and Cobo-Benita et al. (2016). Moreover, the effects of organizational innovation are more pronounced for process innovation relative to product innovation. This result agrees with Camison and Villar-Lopez (2014) who found that organizational innovation enhances process innovation.

Our second hypothesis stated that R&D performers should experience a greater impact on product and process innovation from implementing organizational innovation. Our findings support this hypothesis, and is concordant with Ali & Park (2016), however, in contrast to Camison & Villar-Lopez (2014) we find that organizational innovation has a direct effect on product innovation. Our results also demonstrate that larger R&D performing firms reap the greatest benefits of organizational innovation.

We also investigate the effect of organizational innovation by industry to address Hypothesis three. We can say that organizational innovation has a greater impact on process innovation than on product innovation. However, there are substantial differences by industry. For example, we find evidence that affirms Von Tunzelmann & Acha (2009) who assert that high-tech industries will innovate more frequently. Furthermore, we find that the probability of a new product innovation is contingent on organizational innovation in chemicals and pharmaceuticals, electrical equipment, electronic components and computers, as well as medical and optical instruments. We find that the probability of a new process innovation is contingent on organizational innovation in chemicals and pharmaceuticals, electrical equipment, electronic components and computers, as well as motor vehicles.

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Table 1. Employment, R&D and organizational innovation (KIS 2005, 2008, 2010)

Employees	Small (25 or fewer)	Medium (greater than 25 less than 150)	Large (150 or more)
Number observations	3259	4012	2470
		Mean (Std Dev)	
Employment	16.08	69.30	699.50
	(4.62)	(34.42)	(1936.69)
R&D expenditure per employee (millions of South Korean Won)*	5.14	6.14	9.60
	(17.85)	(23.10)	(39.28)
R&D (dummy)	0.32	0.49	0.73
	(0.47)	(0.50)	(0.44)
Organizational innovation (dummy)	0.12	0.31	0.62
	(0.33)	(0.46)	(0.49)
		Percent	
Those who do org inno and R&D jointly	11	26	54
Those who do org inno who also do R&D	88	85	87
Those who do R&D who also do org inno	66	54	74

*Approximately $1000USD equals one million South Korean Won
For 2005 and 2008, KSIC version 8 (15 - 37) is used for manufacturing.
For 2010, KSIC version 9 (10 - 33) is used for manufacturing.

Table 2. R&D expenditure per employee, Tobit Type I

	Firm Size			
	Small	Medium	Large	Whole Sample
lemp1	-2.531	-0.152	0.698	0.178
	(5.226)	(1.453)	(0.454)	(0.130)
lemp_lemp	0.501	0.00405	-0.0543	-0.0286^{**}
	(0.955)	(0.174)	(0.0341)	(0.0136)
enterprise=2	-0.487	-0.0134	0.197^{**}	0.117
	(0.641)	(0.196)	(0.0909)	(0.0907)
enterprise=3	-1.145	0.505^{**}	0.0831	0.280^{*}
	(1.816)	(0.218)	(0.218)	(0.156)
prod_ktime	0.0225^{***}	0.0158^{***}	0.00327	0.0139^{***}
	(0.00345)	(0.00359)	(0.00335)	(0.00192)
proc_ktime	0.0120^{**}	0.00598^{*}	0.000527	0.00565^{***}
	(0.00558)	(0.00308)	(0.00243)	(0.00179)
protection	0.876^{***}	0.494^{***}	0.338^{***}	0.471^{***}
	(0.115)	(0.0565)	(0.0405)	(0.0360)
info	1.151^{***}	0.804^{***}	0.337^{***}	0.768^{***}
	(0.0799)	(0.0431)	(0.0476)	(0.0346)
policy	0.616^{***}	0.325^{***}	0.239^{***}	0.337^{***}
	(0.0743)	(0.0435)	(0.0434)	(0.0335)
constant	2.610	0.0632	-2.280	-0.761^{**}
	(7.078)	(3.050)	(1.477)	(0.352)
Sigma	2.405^{***}	2.004^{***}	1.905^{***}	2.111^{***}
	(0.0546)	(0.0491)	(0.0499)	(0.0448)
N	3259	4012	2470	9741
Left censored	2348	2403	1055	5806
Uncensored	911	1609	1415	3935
Log likelihood	-2968.2	-4554.9	-3674.4	-11388.7
Chi square	760.5	1051.8	421.2	920.4

Huber-White-Sandwich standard errors in parentheses: clustered by industry, bootstrapped 100 replications.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3. New process bivariate probit results for large firms under selected instruments#

	Subsidy	*Secrecy*	*Protection*	*Policy*	*Info*	*Fund*	*Delay*
Org_inno	1.651***	1.907***	2.077***	1.082**	1.513***	1.739***	2.065***
	(0.254)	(0.102)	(0.0548)	(0.434)	(0.158)	(0.0893)	(0.610)
R&D (predicted)	0.108***	0.087***	0.0367**	0.123***	0.099***	0.102***	0.107***
	(0.0232)	(0.0189)	(0.0159)	(0.0338)	(0.0230)	(0.0223)	(0.0208)
Employment	0.120	0.0940	0.0663	0.0888	0.0333	0.0842	0.0110
	(0.260)	(0.253)	(0.256)	(0.268)	(0.264)	(0.266)	(0.226)
Emp squared	-0.00273	-0.00207	-0.00227	0.000192	0.00331	-0.00003	0.00393
	(0.0208)	(0.0202)	(0.0206)	(0.0213)	(0.0213)	(0.0212)	(0.0181)
Enterprise	0.0355	0.0232	0.0345	0.0294	0.0346	0.0406	0.0214
	(0.0444)	(0.0403)	(0.0360)	(0.0491)	(0.0462)	(0.0443)	(0.0381)
Education	-0.594	-0.610	-0.668*	-0.569	-0.624	-0.677	-0.448
	(0.476)	(0.435)	(0.376)	(0.503)	(0.469)	(0.465)	(0.375)
Year	0.079***	0.066***	0.0619***	0.081***	0.079***	0.062***	0.057***
	(0.0115)	(0.0105)	(0.00811)	(0.0113)	(0.0106)	(0.0104)	(0.00967)
Constant	-160.2***	-133.4***	-126.1***	-163.8***	-159.6***	-126.9***	-116.7***
	(22.70)	(21.03)	(16.11)	(22.47)	(20.86)	(20.56)	(19.08)
Org_inno							
instrument	0.167***	0.244***	0.587***	0.375***	0.634***	0.663***	-0.0560
	(0.0182)	(0.0173)	(0.0292)	(0.0320)	(0.0282)	(0.0456)	(0.0344)
Constant	0.0411	-0.117***	0.0557**	0.207***	-0.0185	0.0549	0.366***
	(0.0539)	(0.0434)	(0.0259)	(0.0374)	(0.0339)	(0.0349)	(0.0611)
athrho							
Constant	-0.450	-0.777***	-1.167***	-0.0263	-0.354***	-0.591***	-1.472
	(0.296)	(0.152)	(0.106)	(0.285)	(0.113)	(0.0727)	(2.613)
N	2470	2470	2470	2470	2470	2470	2470
Log likelihood	-2924.4	-2817.7	-2659.8	-2879.6	-2698.5	-2753.4	-2997.6
rho	-0.422	-0.651	-0.823	-0.0263	-0.340	-0.531	-0.900
chi2	4.914	32.10	87.21	0.0227	14.04	34.57	18.37

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Huber-White-Sandwich standard errors in parentheses: clustered by industry, bootstrapped 100 replications.
#Regressions using instruments that failed to converge are omitted: cost, lackinfo, risk, skill, turnover.

Table 4. New process bivariate probit results for medium firms under selected instruments[#]

	Subsidy	*Secrecy*	*Risk*	*Protection*	*Policy*	*Info*	*Fund*	*Delay*
Org_inno	1.831***	1.812***	1.326***	1.972***	1.669***	1.637***	1.890***	0.197
	(0.0986)	(0.0940)	(0.336)	(0.0608)	(0.128)	(0.0697)	(0.0676)	(0.822)
R&D (predicted)	0.0182***	0.0161**	0.0266***	0.00333	0.0170**	0.0140**	0.0156**	0.0239**
	(0.00694)	(0.00647)	(0.00817)	(0.00440)	(0.00789)	(0.00593)	(0.00625)	(0.00947)
Employment	0.165	0.425	0.245	0.439	0.312	0.237	0.143	0.224
	(0.744)	(0.690)	(0.738)	(0.622)	(0.739)	(0.729)	(0.662)	(0.629)
Emp squared	-0.00471	-0.0345	-0.0107	-0.0380	-0.0214	-0.0127	-0.00394	-0.00976
	(0.0884)	(0.0826)	(0.0882)	(0.0748)	(0.0882)	(0.0871)	(0.0789)	(0.0740)
Enterprise	-0.0331	-0.0569	-0.0545	-0.0417	-0.0359	-0.0554	-0.00849	-0.0508
	(0.0370)	(0.0407)	(0.0418)	(0.0420)	(0.0384)	(0.0395)	(0.0372)	(0.0350)
Education	0.509**	0.606***	0.670***	0.430*	0.523**	0.550**	0.353	0.616**
	(0.227)	(0.231)	(0.246)	(0.241)	(0.245)	(0.235)	(0.224)	(0.280)
Year	0.0835***	0.0738***	0.0855***	0.0723***	0.0829***	0.0776***	0.0599***	0.0733**
	(0.0138)	(0.0130)	(0.0146)	(0.0121)	(0.0144)	(0.0144)	(0.0125)	(0.0288)
Constant	-169.6***	-150.7***	-173.8***	-147.6***	-168.7***	-157.9***	-122.1***	-148.7**
	(28.22)	(26.53)	(29.85)	(24.48)	(29.42)	(29.34)	(25.65)	(58.59)
Org_inno								
instrument	0.239***	0.322***	0.0747***	0.740***	0.476***	0.738***	0.830***	0.0381***
	(0.0154)	(0.0177)	(0.0137)	(0.0422)	(0.0284)	(0.0222)	(0.0333)	(0.0134)
Constant	-0.786***	-0.831***	-0.590***	-0.451***	-0.528***	-0.533***	-0.624***	-0.535***
	(0.0556)	(0.0519)	(0.0612)	(0.0393)	(0.0434)	(0.0440)	(0.0391)	(0.0533)
athrho								
Constant	-0.532***	-0.542***	-0.123	-0.723***	-0.381***	-0.396***	-0.754***	0.573
	(0.0749)	(0.0703)	(0.210)	(0.0747)	(0.0812)	(0.0437)	(0.0523)	(3.110)
N	4012	4012	4012	4012	4012	4012	4012	4012
Log likelihood	-4079.7	-3951.9	-4299.2	-3836.5	-4038.5	-3754.9	-3598.1	-4310.2
rho	-0.487	-0.495	-0.123	-0.619	-0.364	-0.377	-0.638	0.517
chi2	36.89	58.97	0.183	92.07	18.80	38.79	134.3	0.0910

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Huber-White-Sandwich standard errors in parentheses: clustered by industry, bootstrapped 100 replications.
[#]Regressions using instruments that failed to converge are omitted: cost, lackinfo, skill, turnover.

Table 5. New process bivariate probit results for small firms under selected instruments[#]

	Subsidy	*Secrecy*	*Protection*	*Policy*	*Info*	*Fund*
Org_inno	1.998***	2.209***	2.372***	1.878***	2.039***	2.124***
	(0.101)	(0.112)	(0.101)	(0.196)	(0.0967)	(0.0803)
R&D (predicted)	0.00142	0.00111	0.0000936	0.00131	0.000912	0.00127
	(0.00361)	(0.00306)	(0.00178)	(0.00385)	(0.00286)	(0.00307)
Employment	3.757	3.726	3.499	3.981	3.641	2.929
	(2.435)	(2.344)	(2.204)	(2.506)	(2.429)	(2.176)
Emp squared	-0.662	-0.656	-0.612	-0.703	-0.640	-0.515
	(0.441)	(0.424)	(0.401)	(0.454)	(0.440)	(0.394)
Enterprise	0.0635	0.0305	0.0888	0.0488	0.0237	0.0285
	(0.122)	(0.131)	(0.126)	(0.121)	(0.129)	(0.124)
Education	0.805*	0.869**	0.613	0.815*	0.799**	0.666*
	(0.418)	(0.391)	(0.407)	(0.472)	(0.405)	(0.401)
Year	0.0644***	0.0636***	0.0627***	0.0641***	0.0631***	0.0455**
	(0.0207)	(0.0204)	(0.0194)	(0.0215)	(0.0215)	(0.0190)
Constant	-136.2***	-134.7***	-132.7***	-136.1***	-133.6***	-97.13**
	(42.32)	(41.66)	(40.02)	(44.19)	(43.93)	(39.06)
Org_inno						
instrument	0.339***	0.358***	0.957***	0.643***	0.840***	0.927***
	(0.0217)	(0.0108)	(0.0387)	(0.0384)	(0.0293)	(0.0264)
Constant	-1.409***	-1.433***	-0.950***	-1.037***	-0.989***	-1.155***
	(0.0403)	(0.0319)	(0.0271)	(0.0297)	(0.0347)	(0.0208)
athrho						
Constant	-0.397***	-0.580***	-0.793***	-0.306***	-0.487***	-0.650***
	(0.0802)	(0.0650)	(0.0833)	(0.111)	(0.0424)	(0.0548)
N	3259	3259	3259	3259	3259	3259
Log likelihood	-1975.5	-1946.2	-1836.5	-1981.3	-1832.3	-1720.8
rho	-0.377	-0.523	-0.660	-0.297	-0.452	-0.572
chi2	18.44	43.88	73.49	8.612	40.49	60.18

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Huber-White-Sandwich standard errors in parentheses: clustered by industry, bootstrapped 100 replications.
#Regressions using instruments that failed to converge are omitted: cost, lackinfo, skill, turnover.

Table 6. New product bivariate probit results for large firms under selected instruments#

	Subsidy	*Secrecy*	*Risk*	*Protection*	*Policy*	*Info*	*Fund*	*Delay*
Org_inno	1.026***	1.707***	1.672	1.570***	0.356	1.175***	1.138***	1.670*

	(0.321)	(0.0695)	(1.297)	(0.0709)	(0.454)	(0.0885)	(0.117)	(0.883)
R&D (predicted)	0.0894***	0.0386***	0.0757***	0.0162	0.106***	0.0646***	0.0837***	0.0765***
	(0.0169)	(0.00982)	(0.0157)	(0.0152)	(0.0233)	(0.0145)	(0.0149)	(0.0130)
Employment	-0.382	-0.268	-0.329	-0.275	-0.451	-0.505*	-0.387	-0.344
	(0.313)	(0.221)	(0.230)	(0.285)	(0.323)	(0.287)	(0.304)	(0.225)
Emp squared	0.0383*	0.0257*	0.0313**	0.0262	0.0440**	0.0461**	0.0386*	0.0322**
	(0.0215)	(0.0152)	(0.0158)	(0.0199)	(0.0220)	(0.0197)	(0.0210)	(0.0154)
Enterprise	-0.0471	-0.0446**	-0.0396*	-0.0310	-0.0595	-0.0430	-0.0382	-0.0401*
	(0.0342)	(0.0190)	(0.0240)	(0.0228)	(0.0363)	(0.0304)	(0.0327)	(0.0235)
Education	0.800***	0.515**	0.613**	0.566***	0.895***	0.773***	0.665**	0.618***
	(0.307)	(0.201)	(0.245)	(0.210)	(0.309)	(0.269)	(0.295)	(0.196)
Year	-0.0205	-0.0322***	-0.0185	-0.0264**	-0.0229	-0.0220	-0.0357**	-0.0212
	(0.0180)	(0.0121)	(0.0166)	(0.0134)	(0.0183)	(0.0166)	(0.0178)	(0.0147)
Constant	40.66	63.87***	36.34	52.32**	46.07	44.20	71.15**	41.87
	(35.92)	(24.16)	(32.96)	(26.62)	(36.36)	(33.08)	(35.50)	(29.19)
Org_inno								
instrument	0.168***	0.256***	-0.00399	0.584***	0.374***	0.636***	0.668***	-0.0367
	(0.0173)	(0.0159)	(0.0207)	(0.0297)	(0.0323)	(0.0282)	(0.0471)	(0.0240)
Constant	0.0407	-0.120***	0.316***	0.0766***	0.206***	-0.0137	0.0587*	0.347***
	(0.0510)	(0.0422)	(0.0585)	(0.0281)	(0.0368)	(0.0339)	(0.0348)	(0.0549)
athrho								
Constant	-0.402*	-1.614	-2.065	-1.120***	0.0537	-0.582***	-0.549***	-2.034
	(0.236)	(2.229)	(2.345)	(0.123)	(0.273)	(0.0764)	(0.0911)	(1.927)
N	2470	2470	2470	2470	2470	2470	2470	2470
Log likelihood	-2964.8	-2783.3	-3041.8	-2703.8	-2920.3	-2723.2	-2795.2	-3040.3
rho	-0.382	-0.924	-0.968	-0.808	0.0536	-0.524	-0.499	-0.966
chi2	6.307	48.61	9.709	88.75	0.119	43.81	34.82	9.259

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Huber-White-Sandwich standard errors in parentheses: clustered by industry, bootstrapped 100 replications.
#Regressions using instruments that failed to converge are omitted: cost, lackinfo, skill, turnover.

Table 7. New product bivariate probit results for medium firms under selected instruments#

	Subsidy	*Secrecy*	*Risk*	*Protection*	*Policy*	*Info*	*Fund*	*Delay*
Org_inno	1.285***	1.735***	1.055**	1.763***	1.194***	1.435***	1.394***	0.879***
	(0.108)	(0.0470)	(0.427)	(0.0666)	(0.126)	(0.0690)	(0.0559)	(0.213)

R&D (predicted)	0.0373***	0.0243***	0.0437***	0.0111***	0.0354***	0.0241***	0.0338***	0.0444***
	(0.00621)	(0.00440)	(0.00680)	(0.00334)	(0.00695)	(0.00542)	(0.00529)	(0.00606)
Employment	1.208	1.466**	1.291*	1.433**	1.331*	1.233*	1.117	1.299*
	(0.789)	(0.644)	(0.776)	(0.598)	(0.773)	(0.701)	(0.738)	(0.779)
Emp squared	-0.138	-0.170**	-0.146	-0.167**	-0.153	-0.143*	-0.128	-0.147
	(0.0950)	(0.0781)	(0.0936)	(0.0718)	(0.0933)	(0.0845)	(0.0888)	(0.0940)
Enterprise	0.00659	-0.0187	-0.00757	-0.00322	0.00666	-0.0151	0.0259	-0.00798
	(0.0665)	(0.0569)	(0.0674)	(0.0624)	(0.0682)	(0.0635)	(0.0678)	(0.0686)
Education	0.800***	0.769***	0.894***	0.582**	0.797***	0.750***	0.685***	0.907***
	(0.254)	(0.231)	(0.292)	(0.243)	(0.281)	(0.242)	(0.253)	(0.280)
Year	0.0114	-0.00192	0.0111	0.00157	0.00930	0.00276	-0.00597	0.00867
	(0.0160)	(0.0128)	(0.0175)	(0.0139)	(0.0163)	(0.0150)	(0.0154)	(0.0166)
Constant	-26.95	-0.769	-26.56	-7.703	-23.01	-9.658	8.053	-21.64
	(32.46)	(25.79)	(35.39)	(27.97)	(33.04)	(30.27)	(31.14)	(33.42)
Org_inno								
instrument	0.237***	0.342***	0.0752***	0.760***	0.475***	0.744***	0.816***	0.0322**
	(0.0152)	(0.0175)	(0.0146)	(0.0477)	(0.0278)	(0.0205)	(0.0321)	(0.0127)
Constant	-0.786***	-0.834***	-0.590***	-0.444***	-0.529***	-0.529***	-0.637***	-0.529***
	(0.0556)	(0.0513)	(0.0594)	(0.0389)	(0.0438)	(0.0443)	(0.0404)	(0.0538)
athrho								
Constant	-0.368***	-0.859***	-0.195	-0.871***	-0.298***	-0.543***	-0.552***	-0.0833
	(0.0684)	(0.0421)	(1.310)	(0.0597)	(0.0867)	(0.0498)	(0.0335)	(0.130)
N	4012	4012	4012	4012	4012	4012	4012	4012
Log likelihood	-3905.4	-3704.4	-4114.4	-3621.7	-3857.6	-3552.2	-3456.1	-4125.7
rho	-0.353	-0.696	-0.192	-0.702	-0.290	-0.495	-0.502	-0.0831
chi2	18.63	165.9	0.517	138.5	12.26	73.50	84.74	0.0567

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Huber-White-Sandwich standard errors in parentheses: clustered by industry, bootstrapped 100 replications.
#Regressions using instruments that failed to converge are omitted: cost, lackinfo, skill, turnover.

Table 8. New product bivariate probit results for small firms under selected instruments[#]

	Subsidy	*Secrecy*	*Risk*	*Protection*	*Policy*	*Info*	*Fund*	*Delay*
Org_inno	1.940***	2.137***	0.810**	2.026***	1.960***	1.820***	1.925***	0.901
	(0.106)	(0.0904)	(0.324)	(0.120)	(0.153)	(0.0995)	(0.0863)	(0.560)
R&D (predicted)	0.00145	0.00103	0.00201	0.000352	0.00114	0.000985	0.00144	0.00201
	(0.00269)	(0.00199)	(0.00325)	(0.00145)	(0.00252)	(0.00219)	(0.00233)	(0.00334)
Employment	0.879	0.518	1.018	0.669	1.063	0.692	0.310	1.018
	(2.301)	(2.238)	(2.444)	(2.161)	(2.347)	(2.280)	(2.045)	(2.399)
Emp squared	-0.151	-0.0829	-0.174	-0.106	-0.187	-0.114	-0.0504	-0.174
	(0.417)	(0.408)	(0.444)	(0.391)	(0.426)	(0.414)	(0.372)	(0.436)
Enterprise	0.196	0.154	0.191	0.199	0.178	0.150	0.152	0.190
	(0.136)	(0.150)	(0.141)	(0.123)	(0.138)	(0.139)	(0.128)	(0.140)
Education	1.073**	1.161***	1.564***	1.122**	0.927*	1.190***	1.011**	1.569***
	(0.490)	(0.441)	(0.488)	(0.477)	(0.507)	(0.436)	(0.439)	(0.551)
Year	0.0121	0.0107	0.0123	0.0135	0.00855	0.0120	-0.00700	0.0134
	(0.0255)	(0.0238)	(0.0288)	(0.0258)	(0.0262)	(0.0266)	(0.0239)	(0.0283)
Constant	-27.31	-24.07	-27.99	-29.95	-20.46	-26.95	11.82	-30.08
	(51.79)	(48.12)	(58.51)	(52.16)	(53.36)	(54.10)	(48.37)	(57.50)
Org_inno								
instrument	0.343***	0.387***	0.0797***	0.947***	0.658***	0.850***	0.919***	0.0145
	(0.0223)	(0.0131)	(0.0135)	(0.0395)	(0.0421)	(0.0321)	(0.0241)	(0.0184)
Constant	-1.411***	-1.436***	-1.240***	-0.951***	-1.030***	-0.982***	-1.161***	-1.181***
	(0.0401)	(0.0322)	(0.0450)	(0.0244)	(0.0291)	(0.0352)	(0.0213)	(0.0429)
athrho								
Constant	-0.602***	-0.825***	0.122	-0.759***	-0.602***	-0.582***	-0.781***	0.0738
	(0.0725)	(0.0551)	(0.184)	(0.0839)	(0.0934)	(0.0709)	(0.0667)	(3.342)
N	3259	3259	3259	3259	3259	3259	3259	3259
Log likelihood	-1961.3	-1908.5	-2129.4	-1834.2	-1965.2	-1819.5	-1707.1	-2136.2
rho	-0.539	-0.678	0.122	-0.640	-0.538	-0.524	-0.653	0.0737
chi2	37.37	100.5	0.112	73.44	28.94	56.74	68.45	0.0233

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Huber-White-Sandwich standard errors in parentheses: clustered by industry, bootstrapped 100 replications.
[#]Regressions using instruments that failed to converge are omitted: cost, lackinfo, skill, turnover.

Table 9. Probability of New Innovation by Firm Size (bivariate probit)
(Hypothesis 1: organizational innovation has a greater impact on large firms)

Process Innovation

Instrument	Large (N=2470)	Medium (N=4012)	Small (N=3259)	Whole Sample (N=9741)
delay		0.151	0.053	0.159
fund	0.383	0.163	0.062	0.175
info	0.392	0.163	0.059	0.181
policy	0.386	0.159	0.056	0.171
protection	0.390	0.161	0.057	0.178
risk		0.150		
secrecy	0.389	0.161	0.058	0.176
subsidy	0.383	0.158	0.057	0.170
Average	0.387	0.158	0.057	0.173

All probabilities significant at 0.1%

Product Innovation

Instrument	Large (N=2470)	Medium (N=4012)	Small (N=3259)	Whole Sample (N=9741)
delay		0.096		0.100
fund	0.236	0.108	0.047	0.114
info	0.247	0.113	0.046	0.122
policy	0.239	0.107	0.043	0.113
protection	0.248	0.111	0.044	0.121
risk			0.039	0.100
secrecy	0.248	0.113	0.047	0.122
subsidy	0.237	0.104	0.043	0.112
Average	0.242	0.107	0.044	0.113

All probabilities at 0.1%
"   " = not significant

Table 10. Probability of New Innovation Conditional on an Organizational Innovation and Conducting R&D (bivariate probit, R&D expenditure per employee set at mean of 7.18 million won)*

(Hypothesis 2: organizational innovation has a more pronounced effect on R&D performing firms)

Process Innovation

Instrument	Large (N=2470)	Medium (N=4012)	Small (N=3259)	Whole Sample (N=9741)
delay	0.509	0.168	0.054	0.181
fund	0.487	0.170	0.061	0.187
info	0.485	0.167	0.058	0.188
policy	0.501	0.166	0.055	0.183
protection	0.432	0.162	0.053	0.180
risk		0.167	0.053	
secrecy	0.483	0.187	0.058	0.187
subsidy	0.495	0.167	0.056	0.185
Average	0.484	0.169	0.056	0.185

All probabilities significant at 0.1%

Product Innovation

Instrument	Large (N=2470)	Medium (N=4012)	Small (N=3259)	Whole Sample (N=9741)
delay	0.378	0.121	0.039	0.121
fund	0.329	0.121	0.046	0.124
info	0.315	0.119	0.045	0.126
policy	0.305	0.120	0.042	0.123
protection	0.266	0.115	0.043	0.121
risk	0.357	0.121	0.039	0.121
secrecy	0.302	0.123	0.047	0.127
subsidy	0.338	0.121	0.043	0.124
Average	0.324	0.120	0.043	0.123

All probabilities at 0.1%

"   " = not significant

*Probabilities of innovation when organizational innovation (=0) + R&D performer (=7.18) are rarely zero, but are still negligent when compared to organizational innovation (=1) + R&D performer (=7.18)

Table 11. Probability of New Process or Product Innovation by Industry (conditional on an organizational innovation)

(Hypothesis 3: organizational innovation has a more pronounced effect within high-tech industries)

			Process	Product
KSIC8	Industry	N	Mean Probability†	
15	Food & beverage products	631	0.20	0.14
17	Textiles, except apparel	496	0.12	0.07
18	Wearing apparel, clothing accessories & fur articles	348	0.05	0.06
19	Tanning & dressing of leather, manufacture of luggage & footwear	233	0.07	0.03
20	Wood products of wood & cork; except furniture	320	0.05	0.03
21	Pulp, paper & paper products	375	0.11	0.06
22	Printing & reproduction of recorded media	381	0.07	0.04
23	Coke, hard-coal & lignite fuel briquettes & refined petroleum products	119	0.13	0.10
24	Chemicals, chemical products, pharmaceuticals, medicinal compounds, botanical products	725	0.31	0.24
25	Rubber & plastic products	548	0.18	0.13
26	Other non-metallic mineral products	609	0.10	0.08
27	Basic metal products	500	0.16	0.07
28	Fabricated metal products, except machinery & furniture	601	0.17	0.10
29	Other machinery & equipment	798	0.22	0.14
31	Electrical equipment	578	0.24	0.16
32	Electronic components, computer, radio, television & communication equipment & apparatuses	725	0.27	0.19
33	Medical, precision & optical instruments, watches & clocks	371	0.18	0.17
34	Motor vehicles, trailers & semitrailers	595	0.30	0.13
35	Other transport equipment	288	0.12	0.09
36	Furniture, other manufacturing	500	0.10	0.10
	Mean		*0.16*	*0.11*
	Std Dev		*0.08*	*0.06*
	Mean + 1(Std Dev)*		*0.24*	*0.16*
	Mean - 1(Std Dev)*		*0.08*	*0.05*

†Mean probability is calculated as mean of the probability of an innovation conditional on an organizational innovation for each of the five instruments (fund, info, protection, secrecy, subsidy)

Appendix A: Variable definitions from merged Korean Innovation Survey (waves 2005, 2008, 2010)

Variable	Description	Mean	Std. Dev.	Min	Max
cost_rd	Logarithm of R&D expenditure per employee	0.727	1.382	-5.838	7.365
edu	Percentage of employees with masters degree or above	0.029	0.072	0.000	1.000
enterprise	1=independent company, 2=affiliated company of Korean conglomerate, 3=affiliated company of foreign conglomerate	1.149	0.444	1.000	3.000
ksic2	Korean Standard Industrial Classification system - manufacturing industries	24.928	6.571	10.000	37.000
lemp_lemp	Logarithm of employment squared	18.837	12.695	0.000	119.543
lemp1	Logarithm of employment	4.124	1.352	0.000	10.934
org_inno	Organizational innovation (binary)	0.327	0.469	0.000	1.000
pc_new	New process innovation (binary)	0.259	0.438	0.000	1.000
pd_new	New product innovation (binary)	0.189	0.392	0.000	1.000
proc_ktime	Length in years that process knowledge is useful (max is 99)	3.294	13.119	0.000	99.000
prod_ktime	Length in years that product knowledge is useful (max is 99)	3.570	12.697	0.000	99.000
year	Year of the survey (2005, 2008, 2010)	2008	2.034	2005	2010
cost	Innovation and commercialization costs are too prohibitive (Likert)	1.136	1.372	0.000	5.000
delay	Delay of payments from clients (Likert)	1.061	1.227	0.000	5.000
fund	Standardized. Firms can check that they use any or all of the following sources of funding: internal capital stock, parent or affiliated companies, government, bank loans, equity financing, corporate bonds.	0.000	1.000	-0.963	5.405
info	Standardized variable from three items. Information sources from conferences, fairs and exhibitions, journal and magazines.	0.000	1.000	-0.733	2.639
lackinfo	Lack of market information (Likert)	0.823	1.349	0.000	5.000
policy	Standardized variable from five items. Types of policies used to support innovation: financial support, government R&D program, public program for technology, technology information provision, training program.	0.000	1.000	-0.531	3.972
protection	Standardized variable from 12 modes of IP protection for product and process innovation (excluding secrecy).	0.000	1.000	-0.593	4.392
risk	Excessive key risks (Likert)	1.140	1.380	0.000	5.000
secrecy	Used secrecy as a method of IP protection for product innovation (Likert)	1.039	1.737	0.000	5.000
skill	Lack of skilled personnel in your firm (Likert)	1.247	1.451	0.000	5.000
subsidy	Use of R&D tax reductions and/or use of government financial support (Likert)	1.048	1.745	0.000	5.000
turnover	Frequent turnover of R&D personnel (Likert)	0.850	1.395	0.000	5.000

Note: Number of observations is 9,741

Appendix B1. New process bivariate probit results for whole sample under selected instruments[#]

	Subsidy	*Secrecy*	*Protection*	*Policy*	*Info*	*Fund*
Org_inno	1.755***	1.872***	2.073***	1.599***	1.671***	1.881***
	(0.0656)	(0.0693)	(0.0516)	(0.0904)	(0.0580)	(0.0477)
R&D (predicted)	0.0260***	0.0212***	0.00489	0.0251***	0.0199***	0.0233***
	(0.00723)	(0.00658)	(0.00439)	(0.00818)	(0.00611)	(0.00647)
Employment	0.279***	0.298***	0.338***	0.288***	0.284***	0.218***
	(0.0749)	(0.0732)	(0.0700)	(0.0794)	(0.0756)	(0.0697)
Emp squared	-0.0131*	-0.0165**	-0.0237***	-0.0133	-0.0149*	-0.00789
	(0.00779)	(0.00769)	(0.00750)	(0.00818)	(0.00805)	(0.00736)
Enterprise	0.0185	-0.00295	0.0130	0.0170	0.00432	0.0325
	(0.0325)	(0.0295)	(0.0292)	(0.0335)	(0.0349)	(0.0311)
Education	0.294	0.330*	0.134	0.319	0.307	0.0997
	(0.199)	(0.188)	(0.188)	(0.213)	(0.197)	(0.189)
Year	0.0806***	0.0698***	0.0667***	0.0792***	0.0759***	0.0567***
	(0.00969)	(0.00917)	(0.00844)	(0.0103)	(0.00979)	(0.00915)
Constant	-164.3***	-142.6***	-136.3***	-161.3***	-154.6***	-116.1***
	(19.53)	(18.48)	(16.99)	(20.68)	(19.72)	(18.44)
Org_inno						
instrument	0.282***	0.354***	0.818***	0.553***	0.824***	0.872***
	(0.0130)	(0.00905)	(0.0269)	(0.0236)	(0.0144)	(0.0236)
Constant	-0.776***	-0.853***	-0.463***	-0.470***	-0.534***	-0.566***
	(0.0510)	(0.0444)	(0.0369)	(0.0396)	(0.0414)	(0.0350)
athrho						
Constant	-0.433***	-0.567***	-0.820***	-0.302***	-0.399***	-0.688***
	(0.0392)	(0.0423)	(0.0469)	(0.0492)	(0.0365)	(0.0282)
N	9741	9741	9741	9741	9741	9741
Log likelihood	-9569.7	-9183.7	-8684.5	-9471.2	-8566.0	-8478.5
rho	-0.408	-0.513	-0.675	-0.293	-0.379	-0.597
chi2	69.96	163.0	292.1	32.70	105.2	276.2

[*] $p < 0.1$, [**] $p < 0.05$, [***] $p < 0.01$ Huber-White-Sandwich standard errors in parentheses: clustered by industry, bootstrapped 100 replications.
[#]Regressions using instruments that failed to converge are omitted: cost, delay, lackinfo, risk, skill, turnover.

Appendix B2. New product bivariate probit results for whole sample under selected instruments[#]	*Subsidy*	*Secrecy*	*Risk*	*Protection*	*Policy*	*Info*	*Fund*	*Delay*
Org_inno	1.266***	1.736***	0.864***	1.670***	1.119***	1.380***	1.391***	0.702***
	(0.0709)	(0.0266)	(0.239)	(0.0337)	(0.0934)	(0.0400)	(0.0437)	(0.0631)
R&D (predicted)	0.0328***	0.0195***	0.0405***	0.00932***	0.0319***	0.0214***	0.0302***	0.0407***
	(0.00442)	(0.00294)	(0.00477)	(0.00281)	(0.00518)	(0.00377)	(0.00379)	(0.00473)
Employment	0.0338	0.0518	0.0519	0.103*	0.0388	0.0265	-0.00767	0.0531
	(0.0627)	(0.0535)	(0.0630)	(0.0545)	(0.0641)	(0.0592)	(0.0594)	(0.0638)
Emp squared	0.00647	0.000940	0.00612	-0.00519	0.00652	0.00480	0.0102*	0.00602
	(0.00632)	(0.00528)	(0.00641)	(0.00526)	(0.00649)	(0.00583)	(0.00583)	(0.00648)
Enterprise	-0.0236	-0.0452*	-0.0405	-0.0257	-0.0256	-0.0379	-0.00858	-0.0409
	(0.0344)	(0.0257)	(0.0355)	(0.0301)	(0.0355)	(0.0333)	(0.0355)	(0.0359)
Education	0.964***	0.854***	1.127***	0.777***	0.994***	0.926***	0.791***	1.132***
	(0.218)	(0.191)	(0.243)	(0.203)	(0.236)	(0.198)	(0.207)	(0.237)
Year	0.000294	-0.0142	-0.000787	-0.00959	-0.00262	-0.00556	-0.0192	-0.00242
	(0.0147)	(0.0113)	(0.0166)	(0.0130)	(0.0150)	(0.0132)	(0.0141)	(0.0153)
Constant	-2.312	26.74	-0.103	17.43	3.553	9.519	36.96	3.216
	(29.59)	(22.74)	(33.49)	(26.03)	(30.08)	(26.61)	(28.30)	(30.82)
Org_inno								
instrument	0.282***	0.372***	0.0887***	0.831***	0.554***	0.829***	0.866***	0.00357
	(0.0128)	(0.00914)	(0.00915)	(0.0278)	(0.0232)	(0.0152)	(0.0231)	(0.00873)
Constant	-0.776***	-0.854***	-0.554***	-0.455***	-0.470***	-0.528***	-0.571***	-0.453***
	(0.0511)	(0.0444)	(0.0590)	(0.0380)	(0.0399)	(0.0418)	(0.0363)	(0.0534)
athrho								
Constant	-0.379***	-0.889***	-0.0915	-0.800***	-0.268***	-0.523***	-0.582***	0.00801
	(0.0419)	(0.0350)	(0.153)	(0.0377)	(0.0596)	(0.0298)	(0.0295)	(0.0355)
N	9741	9741	9741	9741	9741	9741	9741	9741
Log likelihood	-9431.9	-8859.7	-10108.9	-8525.3	-9328.9	-8375.7	-8380.7	-10152.4
rho	-0.361	-0.711	-0.0913	-0.664	-0.261	-0.480	-0.524	0.00801
chi2	60.04	452.9	0.301	352.7	28.68	192.8	230.3	0.00102

[*] $p < 0.1$, [**] $p < 0.05$, [***] $p < 0.01$ Huber-White-Sandwich standard errors in parentheses: clustered by industry, bootstrapped 100 replications.
[#]Regressions using instruments that failed to converge are omitted: cost, lackinfo, skill, turnover.