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A first look at linkage data of Japanese patent and enterprise census

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Innovation and Entrepreneurship: A first look at linkage data of Japanese patent and enterprise census*

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Abstract

This paper presents the results of a comprehensive analysis of the innovative activities of the entire population of Japanese firms by using a linked dataset of Establishment and Enterprise Census and the IIP Patent Database (JPO patent application data). As of 2006, it was found that about 1.4% of about 4.5 million firms filed patents, and substantial patenting activities were found not only in the manufacturing field but also in a wide range of fields such as B2B services and financial sectors. In addition, a firm's survival and growth are regressed with patenting and open innovation (measured by joint patent application with other firms and universities), and it is shown that innovative activities measured by patenting are positively correlated with such firm performance. It is also found that the relationship between patents and the survival rate is stronger for larger firms, while that between patents and firm growth is stronger for smaller firms.

Keywords: enterprise census, patent database, entry and exit of firms.
JEL Classification: L25; O13

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1. Introduction

Productivity increase is an important factor for economic growth in developed nations, and it is found that 20%-40% of productivity in the OECD countries is attributable to high-growth-rate new startups (OECD, 2003). The importance of entrepreneurship for economic growth is stressed by Schumpeter, who defines "innovation" as a new combination, with five types of activities such as new product development and adaption of new process (Schumpeter, 1934). Schumpeter also argues that "creative destruction" is an essential fact about capitalism (Schumpeter, 1942). Creative destruction, i.e., firms that succeed in innovation increase their market share, firms with low productivity withdraw from the market, has been making a significant contribution to the economic expansion for long time (Baumol, 2010).

Along this line, the view that small and medium-sized enterprises (SMEs) are a source of innovation is shared in every country of the world. However, empirical research on firm dynamics and its contribution to economic development shows mixed results. First, it is found that survival rate of new firms is low. According to Bartelsman et. al. (2005), in 10 OECD countries 20%-40% of new companies disappear within two years of establishment. Furthermore, it is also understood that there is a positive correlation between entry and exit of firms that occurs together with macroeconomic fluctuations (Bartelsman et. al., 2005). As a result of the churning effect resulting from market fluctuations, generation and dissolution of small inefficient firms that have not reached a sufficient scale occurs simultaneously. This phenomenon can be viewed as firms simply moving through a revolving door (Santarelli and Vivarelli, 2010). Moreover, Schumpeter also provides two kinds of concepts on innovation, that is, the roles of SMEs are important with respect to creative destruction (Schumpeter Mark I) and circumstances where oligopolistic economic rents occur at large firms are also essential for economic dynamics (Schumpeter Mark II).

Innovation and entrepreneurship is an important topic for Japan, because Japan has a lower firm's turnover rate, compared to those in the OECD countries such as Europe and the United States. The share of entry and exit of enterprises is much lower than that of the United States, and Japan's ranking in the Global Entrepreneurship Monitor for entrepreneurial spirit is near the lowest in the world (GEM, 2010). It is difficult to cultivate startups in Japan, especially hi-tech startups with a technical background, due to labor market rigidity, underdevelopment of venture capital activities supplying risk money to start up projects, and other factors (Motohashi, 2010). In addition, a larger firm with substantial technological capability plays an important role in Japanese national innovation system, and in-house orientation of large firm's R&D may hinder entrepreneurship activities. For hi-tech startups to grow, it is expedient to tie up with a large firm, but generally, large Japanese firms are not very proactive in assimilating new technology using startups. However, growing competitive pressure from Korean and Chinese firms, Japanese large firms become increasingly difficult to follow through with in-house R&D style. It is becoming important for large firms to form alliances with universities and startups to accelerate its innovation speed; moreover, it is understood that the promotion of hi-tech startups is important for changing Japan's innovation system from large firm's in-house to a network-style one (Motohashi, 2005).

In this paper, we show the results of an analysis relating to innovation and company dynamics using data that links the enterprise census and a patent database. The objective of this research is to derive new implications relating to the issue of whether new firms are a source of economic growth (source of growth firms) or "revolving door" ones. In conclusion, it would seem apparent that both exist in combination, but in this study we take the position that the former (source of growth firms) are firms that are making some efforts toward patent application and/or open innovation. Patent applications can be seen as a variable that reflects that a firm has made some effort toward achieving technological innovation. We look at the size, age and industry distribution of patenting activities for entire population of Japanese firms, and its impact on firm's survival and growth. In addition, we investigate the impact of open innovation activities, such as collaborative R&D with other firms and universities, on firm's performance.

This paper is structured as follows. First, we introduce the data source in this study, i.e., the Enterprise and Establishment Census data and the JPO patent database, called IIP Patent Database (Goto and Motohashi, 2007). Next, we present the results of linking both these using company name and address information; the descriptive statistics resulting from the linked data are discussed. Then, we show the results of a quantitative analysis on the relationship between open innovation and patent applications (drawn from this linked data) and the survival rate and growth speed of firms. Finally, we summarize our findings and provide discussions and policy implications.

2. Description of enterprise census and patent database

2-1. Enterprise and Establishment Census

The Enterprise and Establishment Census encompasses all business establishments in

Japan. Along with providing base statistical data such as the number of establishments and employees, it is also used as the survey body information set for governmental statistical surveys. This survey has been conducted twice every five years, and was named the Establishment Census until July 1991. From the October 1996 survey onward, the name was changed to the Enterprise and Established Census. From the October 1996 survey, due to the addition of “address of head office” as a survey item, it became possible to group business establishments by company name. Currently, statistical data until October 2006 is publicly available. Moreover, this 2006 survey will be the last Enterprise and Establishment Census. In 2009, a similar survey are conducted under the name of “Economic Census Preparatory Survey,” and preparations are underway for a statistical survey based on a new survey framework to commence from 2012, called “The Economic Census.”

Table 1 shows the trend in business establishment and employee numbers from the Enterprise and Establishment Census. The number of business establishments decreased from 6,290,730 in 1981 to 5,722,559 in 2006. In contrast, the total employee numbers showed an increasing trend until 1991, and since then having been seesawing between 52 million and 55 million people. Therefore, the average employee number per business establishment (business establishment size) showed an increasing trend. Furthermore, the business establishments here included all business entities engaging in economic activities and unpaid family workers (family run businesses) were included in workers. In other words, there were many business establishments with zero employees (non-employee establishments), included in this sample.

(Table 1)

To make the panel data for the Enterprise and Establishment Census, company and business establishment numbers (identifying numbers) from past surveys are required at the time of conducting the research. In this survey, business establishments are the main statistical unit and it is possible to link panel data at a business establishment-level using establishment identification numbers. However, it is a bit tricky to compile enterprise level panel datasets. From 1996 survey onward, the name and address of enterprise headquarter are surveyed for all establishment, allowing up to aggregate establishment data into enterprise level. However, this enterprise data cannot be liked inter-temporally due to lack of enterprise identification system. Therefore, we have treated the firms with same establishments between two period are identical.

2-2. IIP Patent Database

The IIP Database is compiled based on the Consolidated Standardized Data, which is made public twice a month by the Japan Patent Office. The Consolidated Standardized Data includes patent information recorded as a text file with SGML and XML tags. In this study, these text files are converted to an SQL database to allow easier statistical processing of the data. Furthermore, information that is believed to be needed most by researchers is released as a CSV-format text file. At present, this includes information made public from January 1964 until October 2009 (15th public release of Consolidated Standardized Data, 2009).

The data released publicly in CSV-format as the IIP Patent File includes patent application data (application number, application date, examination request date, technological field, number of claims, etc.); patent registration data (registration number, rights expiration date, etc.); applicant data (applicant name, applicant type, country/prefecture code, etc.); rights holder data (rights holder name, etc.); citation information (citation/cited patent number, etc.); and inventor data (inventor name, address) (Goto and Motohashi, 2007). Figure 1 shows the database structure and number of data for each table. For example, this includes the data for 11,254,825 patent applications, and of those, 3,507,336 patents are registered. To each of these respectively, a table relating to applicant and rights holder is linked. Moreover, citation data includes data relating to examiner citations, that is, the past patent literature that the examiner cites as their reason for rejecting the patent application.

(Figure 1)

Based on raw data from the Consolidated Standardized Data by JPO, IIP-patent database has created with substantial efforts are made for ready-made usable data for researchers. The most important points of revision are concerning inconsistency in the recording method of applicant names in raw data. For example, while older data from the 1960’s had names displayed in katakana (Japanese own characters), more recent data has been recorded in kanji (Chinese characters). Thus, it is not possible to merge records under the same name using the original text information. In addition, due to company name and its notation methods (such as “incorporated” or “inc.”) changes, modifications are required to make sure that the same company under difference expressions should be recognized as the same ones.

This work begins with utilizing the Patent Office’s applicant ID codes. However, because this code underwent several changes before it became the present-day nine-digit code, we had to rectify this first. It should be noted that the Patent Office applicant ID code may be suffered from false negative errors (two different codes being assigned to the same person, where only one should have been assigned), but there were no false positive errors (the same code being assigned to two different records), since this code is assigned by patent examiner by hand.

First, we made classifications of applicant type (individual inventor, company, non profit organizations or universities), by using applicant name information. Then, we have extracted only company applicant names, and assigned our own ID numbers by assuming that companies that exist in the same municipality with the same company name were actually the same company (Thoma et. al, 2010). Moreover, there is a possibility of false negatives occurring in cases where company name standardization using this method is insufficient or in cases where the company had changed its name. There is also the possibility of false positives occurring in cases where two different companies with the same name exist in the same area. Linking this patent data with enterprise and establishment census data mitigates this problem, discussed more in the next section.

3. Data linkage of establishment census and patent database

3-1. Linkage method and results

Linkage between Enterprise and Establishment Census and the IIP Patent Database was conducted by using identical company name (standardized one) and location (municipality level). It is possible to obtain head office name and address from the Enterprise and Establishment Census on only three occasions: 2001, 2004, and 2006 surveys. In the other years, linking by using company name is impossible so that we decided to link panel data and the patent database for two surveys: 2001 and 2006 (2004 was a simplified survey year). In the Enterprise and Establishment Census, each establishment are categorized as one of 1. a single unit establishment firm, 2. the head office of multiple establishments firm, 3. a branch of multiple establishments firm The number of business establishments for the 2001 survey and the 2006 survey by type are as follows.

(Table 2)

Because patent applications are usually managed by a whole company, instead of an individual establishment, so that applicant information from patent data should be linked with a headquarter of multiple establishment firm or a single establishment firm. However, we know some cases where the address of the applicant is not the one at firm's head office. In addition, names and addresses information at patent data and/or enterprise and establishment census data are not complete. Therefore, we performed matching two datasets by using both branch and head office information. In the process of name cleaning of patent database, there is only one firm in each name and location (municipality level) set. However, there are some cases where one firm from patent data is liked with multiple firms in the enterprise and establishment census data. In this case the priorities were set as, head office > individual business establishment > branch office, to ensure one to one link. As a result, 1.33% of all firms in 2001 and 1.42% of all firms in 2006 have one or more patent applications. From the number of patent applied, out of roughly 10 million patent applications, about 60% of patents were matched with the enterprise and establishment census. Furthermore, when patent applicants from overseas and patents applied for by individual inventors are excluded, and when the application year is limited up until 2006, the total number of patents will be 8,801,613. Of these, 5,772,461 are matched from the 2006 data, which means that 65.3% of the patents are covered.

(Table 3)

Due to a variance in the spelling of company name and incomplete addresses, linkage cannot properly be made in some cases and, some companies that have submitted patent applications are treated as firms without patents. However, discontinued businesses that did not exist in 2006 were also included in the roughly 35% of unmatched patents. To conduct an assessment on this point, we made a firm-level analysis of patent data. First, the number of applicants, excluding individual inventors, who are located in Japan and have applied for at least one patent by 2006, is 167,430. As is shown in Table 3, the number of companies that we were able to link to the enterprise and establishment census data was 64,630, which was just under half of the total number of applicants. Figure 2 looks at the application status of the 167,430 applicants and illustrates cumulative number firms by last year of patent applications. For example, the number of applications corresponding to the year 2000 was 91,315. This shows the number of firms which applied patent in 2000 or before, but have not applied ever after 2000. It is not likely that firms that have not filed a patent application over a long period still existed in 2006. The number of firms that had not applied for a patent for more than ten years was roughly 70,000 (firms that last filed an application in 1996 and had not filed a new patent application until 2006), and the remaining number was roughly 97,000. When you consider that 64,000 of these were linked, you could say that a certain level of linkage performance has been achieved. The number of companies shown to be without patents in Table 3 is about 4.5 million, so that roughly 30,000 (97,000-64,000) of unidentified patents does not make a substantial bias.

(Figure 2)

3-2. Descriptive statistics on the distribution of patenting firms

Here, we use the above linkage data and conduct an analysis of how the ratio of companies applying for patents varies depending on company size, age and industry type. First of all, with respect to company size by the number of employees, the larger the company is, the higher is the ratio of companies applying for patents (Table 4).

(Table 4)

On the other hand, we are unable to see a clear trend relating to the company age and the ratio of patent applications. Table 5 shows the ratio of patent applications by establishment year of companies[1]. While there is a mildly higher ratio for firms that have been around for longer, this is not as great as the difference that we saw in the ratio by company scale. It is possible to assume that there is a positive correlation between the company scale and the company age. However, there are also many companies that are old but remain small in size. It is thought that these companies have a stable business in a niche market, and in many cases they are strangers to the kind of innovation activities seen in patents. Meanwhile, because innovation activities go hand in hand with risk, on the flip side of having the chance of becoming a large company with success, there is a strong possibility of failure, which will lead to the company being driven out of business. Therefore, the possibility for an innovative company to remain small in scale for a long time is assumed to be small.

(Table 5)

Tables 6 and 7 show the share of with patent firms by industry. Of the roughly 65,000 firms applying for patents, 27,000 belong to the manufacturing industry. We can see that

[1] In the Business Establishment and Company Statistics, there is only data for the establishment year of business establishments, so when a company is composed of multiple business establishments, we took the establishment year of the oldest business establishment to be that company's establishment year.

patent applications, which are the outcome of technological innovation, are typically seen in the manufacturing industry. However, we should also pay attention to the fact that there were many company patent applications in firms belonging to the wholesale and retail industries, the construction industry, and others such as the IT service industry. Furthermore, with respect to patent company application ratio, the IT industry exceeds the manufacturing industry. When we take a more detailed look at the manufacturing industry, the ratio of companies applying for patents in the chemicals industry is the highest. This reflects the fact that patent right can be enforced more strongly in chemical industry including pharmaceutical industry (Cohen et. al, 2002). In addition, the share of with patent firms is high in the precision machinery and electronics sectors, centering around electronics device technology.

(Table 6) (Table 7)

Table 8 looks at the share of with patent firms with respect to the entering, continuing (surviving), and exit of firms in/from the market between 2001 and 2006. When looking at firms as a whole, the firms that survived in the two periods of 2001 and 2006 have the highest ratio of patents. However, looking at the numbers in terms of company size shows that the smaller-sized category has a lower patent ratio among continuing companies. This could be seen as support for the hypothesis that innovation activities, such as patenting, go hand in hand with higher risk. On the other hand, for firms on a larger scale, the patent application ratio is higher for continuing companies because they are able to absorb substantial risks backed by its substantial in-house resources.

(Table 8)

Table 9 shows the share of with patent firms to indicate whether they are a new entrant, continuing, or a exit (from the market) company, categorized by the company establishment year. Looking at the number by new entrant, continuing, and exit, in general, companies with earlier establishment year had higher patent application ratio.

(Table 9)

Finally, Tables 10 and 11 represent the state of firm dynamics by industry. Table 10 is separated between industries that have a high ratio of company patent application for continuing firms when compared to new entrants and exit firms (manufacturing, IT, etc.), and industries that demonstrate the opposite pattern (forestry, real estate, medical welfare, etc.). The details of the manufacturing industry show that in most business categories, the ratio is largest for continuing firms, followed by new entrants and withdrawn firms.

(Table 10) (Table 11)

4. Econometric analysis of (open) innovation and firm survival and growth

Here, we use patents as an indicator of innovation to analyze its relationship with firm's survival and growth. In addition, we construct some indicators on open innovation, by using patent database. Concretely, we use whether a patent are applied jointly with other firms other firms (inter-firm linkages) and/or with university (industry-academia linkages). Furthermore, in order to track industry-academic linkages by patent database, we have used inventor information as well as applicant information, since industry-academia joint inventions had been usually patented solely by the firm until 2004, when national universities in Japan were incorporated and entitled to claim the patent right (Muramatsu and Motohashi, 2011).

Table 12 is a look at the ratio of open innovation firms with respect to company patent applications between 2001 and 2006 organized into new entrant, continuing, and exit firms. First, eixt firms, when compared to continuing firms, had a lower ratio of open innovation. On the other hand, new entrants also had a relatively lower index than continuing firms, but differences as large as that with exit firms were not seen. According to an empirical analysis of research conducted concerning firms' market entry, exit, and productivity, firms with a lower productivity had a higher chance of discontinuation in near future (Griliches and Regev, 1995; Baily et. al, 1992; Matsuura and Motohashi, 2005). The presence of open innovation may represent higher innovative capability of firms, particularly the case for joint research with universities, or open innovation also means sharing the risks associated with innovation activity with partners, particularly for the case of inter-firm collaborations, which raises firm's survival rate. In addition, when we take a look at continuing firms, both inter-firm cooperation and industry-academia cooperation are on the increase from 2001 to 2006, and this shows that open innovation is progressing.

(Table 12)

Table 13 is a look at the open innovation index by company size. The ratio of inter-company linkages increases along with size of the firm, and the ratio of industry-academia linkages shows a U-shaped distribution with higher value for large-scale and small-scale firms. This result for industry-academia linkages with respect to company size is consistent with the results based on the survey questionnaire on external R&D collaborations (Motohashi, 2008).

(Table 13)

Tables 14 and 15 take a look at the distribution by industry. Furthermore, to make a time series comparison possible, we will look at continuing firms only. Industries with a high number of patent applications are manufacturing and wholesale/retail, but the open innovation ratio is increasing in all industries. When we look at differences by business category, we see that the ratio of open innovation is increasing for service industries, such as IT as well as electricity/gas and other public utilities, and finance and insurance industry, although the number of firms is small for these sectors. Taking a granular look at the manufacturing industry, inter-company linkages are mostly increasing in the machine industry, while industry-academia linkages are increasing in the chemical industry and petro-chemistry.

(Table 14) (Table 15)

Table 16 estimates companies' survival function. We conduct a Probit estimate using independent variables such as company size and dummy variable for with patent application firm, as a dependent variable, which is 0 for continuing companies and 1 for exit companies in the period from 2001 to 2006. In addition to including dummy variables for industry, firm size and firm age, we use the scale valuable for size, age (taking logarithm of each) and a cross term of them as an independent variable in some specifications.

Model 1 looks at the relationship between patent dummy and continuation of companies, and from the fact that it is positive and statistically significant, we can see that companies applying for patents in 2001 have a high survival probability. Model 2 includes a cross term of logarithmic value of patent variable and a firm size as independent variables. A positive and statistically significant relationship can be seen with respect to a cross term implies that there is a positive relationship between patents and survival probability in large companies; however, for smaller companies, the inverse is true and there is a negative relationship (patent dummy's coefficient is minus). Model 3 looks at the relationship with firm age, and we found that older firms had a high probability of survival. Finally, Model 4 uses firm size, age and their cross term with patent variables. For the cross term with patents, we obtained a positive and statistically significant relationship for both firm scale and age, but the coefficients of cross terms of these two were negative. This shows that the relationship between patents and survival probability is positive when firm scale is large (firm age is larger), but that influence gets smaller as firm age increases (firm scale is large).

(Table 16)

Next, Table 17 used the same dependent variables to look at the relationship with firm growth. The dependent variable is a logarithmic value of a company's employee number, and with respect to continuing firms between 2001 and 2006, which was estimated using a fixed-effect model, by a balanced panel data for these two years. In Model 1, we've found that there is a positive correlation between patent applications and firm growth. Model 2 uses patents and a cross term of firm size and age in 2001, and we found that the smaller and younger the company is, the stronger is the positive correlation between patents and firm growth. Models 3 and 4 look at the relationship with open innovation. We could not see a relationship with company growth just by looking at the logarithmic values for inter-firm linkages and industry-academia linkages. However, we found that for inter-firm linkages, the smaller the firm is, the stronger is the relationship to firm growth.

(Table 17)

A positive coefficient of patent on firm's growth, particularly found in smaller and younger firms may be explained by selection bias, since a larger and an older firm with patent are more likely to survive in Table 16. This finding supports the risk hypothesis of patenting, that is, firms applying patent still faces greater risks associated with its commercialization than firms without patent. A younger and smaller firm is more vulnerable to such risk, and survival rate becomes smaller as compared to established large firms. As a result, younger and smaller firms with patent and survived in these two periods tend to show stronger growth performance. A stronger impact of inter-firm linkage for smaller firms may be due to the fact that collaborating with other firms mitigates commercialization risk associated with patented technology, particularly for smaller firms. Along this line, no size effect on industry-academia linkage can be understood that such activities are far from commercialization stage, so that risk mitigation effect by open innovation tends to be small.

5. Discussion and conclusions

This paper presents, for the first time, the results of a comprehensive analysis of the innovative activities of the entire population of Japanese firms by using a linked dataset of Establishment and Enterprise Census and the IIP Patent Database (JPO patent application data). As of 2006, it was found that about 1.4% of about 4.5 million firms filed some patents and substantial patenting activities were found not only in manufacturing field but also in a wide range of fields such as B2B services and financial sectors. In addition, firm's survival and growth are regressed with patenting and open innovation (measured by joint patent application with other firms and universities), and it is shown that innovative activities measured by patenting are positively correlated with such firm performance. It is also found that the relationship between patent and survival rate is stronger for larger firms, while that between patent and firm growth is stronger for smaller firms.

This paper uses patent application as an indicator of innovation. By applying for patents, firms can retain the fruits of their research, having cleared a certain level of technological risk. However, an economic risk remains as to whether this technological outcome will give rise to an economic return. In other words, while firms that apply for many patents have a large technological capacity, the other side of the equation is that they could be thought to also have a greater risk. According to the results of a regression analysis relating to survival probability, the number of patent applications (logarithmic) has a positive influence on continuation of a company, and this can be viewed as an expression of the effect of a technological capability. Also of interest are the papers by Esteve-Perez and Manez-Castillejo (2008) and Orgega-Argiles and Moreno (2007), which use R&D as an alternative index. In their analysis results, their literature showed that the positive relationship between R&D and company survival is particularly seen in the hi-tech industry, and this is consistent with our findings on innovation and a company's survival. Moreover, the researches by Cockburn and Wagner (2007) and Buddelmeyer et. al (2009) with respect to analyses concerning patents and survival rates are also useful. Most of these papers admit the positive relationship between both of these, but with respect to Buddelmeyer et. al (2009), analyses were conducted by separating between patents and patent stock that a company retains, and with patents and the patent applications that a company files each year. The former showed a positive effect and the latter showed a negative effect. Shedding light on this, patent applications are a sign that high-risk investment is happening, and due to it being a high-risk return, there is a negative impact on survival rate.

The findings in this study generally support the argument in Buddelmeyer et. al (2009), in a sense that patenting involves counteracting factors of "technological superiority" and "greater commercialization risk". The results in survival regressions can be explained by "greater commercialization risk" hypothesis, that is, small companies are more vulnerable to risks associated with patents, so that survival rate becomes lower. On the other hand, the growth regression results may be understood that "technology superiority" effect by patenting is more clearly expressed in smaller firms. However, the growth regressions are conducted only by surviving firms. Therefore, a further study is needed for evaluating "technology superiority effect" after controlling for sample bias associated with growth regressions.

Another contribution of this study is digging into the impact of open innovation for firm's growth, and it is found that inter-firm linkage is more strongly correlated with firm's growth for smaller firms. By applying patents with other firms, commercialization activities may be conducted jointly. In this sense, commercialization risk associated with patent is shared among these firms, and this risk mitigation effect may be greater for small firms. This logic is consistent with no size effect for industry-academic linkage, whose activities are generally far from commercialization stage.

One of implications from our study is that we reconfirm the importance of SME innovation policy. Our findings suggest that small firms are facing greater risks associated with patenting. A patent can be understood as an intermediate output in innovation process, but there is still great risk associated before the innovation process completes by commercialization of the technology. Therefore, it is necessary for the government to provide some supports, not only in research and development, but in technology commercialization activities.

Another implication is the importance of effective use of open innovation in a process of firm growth. By networking with other firms, smaller firms may be able to mitigate risk associated with innovation activities. Therefore, policy instruments for SME innovation are not only direct financial support, but also institutional arrangements to facilitate networking of small firms.

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Table 1: Number of establishments and employees in the census

Date	# of establishments		# of employment		emp/est
1981.7.1	6,290,703		45,961,266		7.31
1986.7.1	6,551,741	0.82%	49,224,514	1.38%	7.51
1991.7.1	6,559,337	0.02%	55,013,776	2.25%	8.39
1994.4.20	6,550,245	-0.05%	54,366,015	-0.39%	8.30
1999.7.1	6,203,249	-1.08%	53,806,580	-0.21%	8.67
2001.10.1	6,138,312	-0.52%	54,912,703	1.02%	8.95
2004.6.1	5,728,492	-2.28%	52,067,396	-1.76%	9.09
2006.10.1	5,722,559	-0.05%	54,184,428	2.01%	9.47

Table 2: Number of Establishments by type

	Single Est.	Headquarter	Branch	Total
2001 Survey	4,722,947	229,436	1,185,929	6,138,312
2006 Survey	4,238,068	228,664	1,255,827	5,722,559

Table 3: Linking performance with patent database

	2001	2006
# of firms	5,082,267	4,627,530
with patent	66,852	64,640
% with patent	1.32%	1.40%
# of patent	6,202,304	5,752,461
% of coverage	62.86%	58.30%

Table 4: Share of patenting firms by size (2006 data)

	With patent		W/O patent	All
0	28	(0.0%)	1,385,156	1,385,184
1	920	(0.1%)	627,732	628,652
2	2,155	(0.4%)	501,320	503,475
3	2,336	(0.6%)	374,286	376,622
4–5	4,724	(0.9%)	493,577	498,301
6–10	9,217	(1.7%)	544,238	553,455
11–100	32,688	(5.2%)	592,940	625,628
101–1000	11,343	(21.4%)	41,780	53,123
1001–	1,229	(39.8%)	1,861	3,090

Table 5: Share of patenting firms by establishment year (2006 data)

	With patent		W/O patent	All
-1954	8,273	(1.8%)	460,419	468,692
1955-64	7,934	(2.2%)	345,260	353,194
1965-74	12,355	(1.9%)	650,224	662,579
1975-84	11,052	(1.4%)	789,711	800,763
1985-94	12,989	(1.3%)	962,876	975,865
1995-99	5,332	(1.0%)	505,513	510,845
2000	1,302	(1.2%)	111,691	112,993
2001	1,080	(0.9%)	113,962	115,042
2002	1,005	(1.0%)	104,480	105,485
2003	985	(0.8%)	124,388	125,373
2004	1,009	(0.8%)	131,260	132,269
2005	745	(0.6%)	126,226	126,971
2006	457	(0.4%)	108,249	108,706

Table 6: Share of patenting firms by industry (2006 data)

	With patent		W/O patent	All
A . Agriculture	193	(1.6%)	12,013	12,206
B . Forestry	25	(1.8%)	1,411	1,436
C . Fisheries	25	(1.1%)	2,312	2,337
D . Mining	71	(3.1%)	2,309	2,380
E . Construction	5,810	(1.2%)	491,276	497,086
F . Manufacturing	29,117	(6.5%)	446,897	476,014
G . Electricity, Gas, Heat Supply and Water	91	(12.9%)	708	799
H . Information and Communications	3,251	(8.7%)	37,435	40,686
I . Transport	742	(0.9%)	85,209	85,951
J . Wholesale and Retail Trade	15,916	(1.4%)	1,163,064	1,178,980
K . Finance and Insurance	257	(0.7%)	34,280	34,537
L . Real Estate	845	(0.3%)	289,647	290,492
M . Eating and Drinking Places, Accommodations	608	(0.1%)	677,437	678,045
N . Medical, Health Care and Welfare	249	(0.1%)	264,929	265,178
O . Education, Learning Support	326	(0.2%)	131,486	131,812
P . Compound Services	258	(1.7%)	15,300	15,558
Q . Services, N.E.C.	6,856	(0.8%)	907,177	914,033

Table 7: Share of patenting firms by industry (2006data; manufacturing in detail)

	With patent		W/O patent	All
09 Manufacture of food	1,609	(4.0%)	40,167	41,776
10 Manufacture of beverages, tobacco	404	(6.6%)	6,084	6,488
11 Manufacture of textile mill products	807	(3.4%)	23,480	24,287
12 Manufacture of apparel	760	(2.4%)	32,332	33,092
13 Manufacture of lumber and wood products	473	(3.1%)	15,382	15,855
14 Manufacture of furniture and fixtures	499	(1.9%)	25,900	26,399
15 Manufacture of pulp, paper and paper products	834	(8.1%)	10,286	11,120
16 Printing and allied industries	942	(2.6%)	36,930	37,872
17 Manufacture of chemical and allied products	1,401	(34.2%)	4,101	5,502
18 Manufacture of petroleum and coal products	95	(19.8%)	479	574
19 Manufacture of plastic products	1,972	(10.4%)	19,019	20,991
20 Manufacture of rubber products	383	(7.4%)	5,178	5,561
21 Manufacture of leather tanning, leather products	199	(3.0%)	6,671	6,870
22 Manufacture of ceramic, stone and clay products	1,324	(7.2%)	18,285	19,609
23 Manufacture of iron and steel	461	(8.9%)	5,187	5,648
24 Manufacture of non-ferrous metals and products	408	(10.7%)	3,813	4,221
25 Manufacture of fabricated metal products	3,224	(5.3%)	60,628	63,852
26 Manufacture of general machinery	5,706	(10.7%)	53,230	58,936
27 Manufacture of electrical machinery, equipment	2,013	(13.8%)	14,604	16,617
28 Manufacture of ICT equipment	499	(17.0%)	2,933	3,432
29 Electronic parts and devices	1,172	(13.6%)	8,595	9,767
30 Manufacture of transportation equipment	1,332	(7.1%)	18,700	20,032
31 Manufacture of precision instruments and machinery	1,205	(15.6%)	7,702	8,907
32 Miscellaneous manufacturing industries	1,395	(5.1%)	27,211	28,606

Table 8: Entry, continue and exit of firm by size

	Entry	Continue		Exit
		2001	2006	
all firms	1.07%	1.47%	1.49%	0.93%
0	0.01%	0.00%	0.00%	0.00%
1	0.26%	0.07%	0.12%	0.19%
2	0.57%	0.26%	0.38%	0.47%
3	0.76%	0.48%	0.58%	0.68%
4-5	1.03%	0.82%	0.92%	1.05%
6-10	1.46%	1.55%	1.74%	1.68%
11-100	3.05%	5.55%	5.94%	3.83%
101-1000	11.08%	24.00%	23.48%	12.65%
1001-	21.18%	47.49%	41.93%	30.22%

Table 9: Entry, continue and exit of firm by establishment year

	Entry	Continue		Exit
		2001	2006	
-1954	-	1.78%	1.78%	0.80%
1955-64	-	2.19%	2.25%	0.92%
1965-74	-	1.80%	1.86%	0.94%
1975-84	-	1.36%	1.36%	0.91%
1985-94	-	1.29%	1.29%	1.06%
1995-99	-	0.93%	0.97%	0.96%
2000	-	0.73%	0.94%	0.70%
2001	1.05%	-	-	-
2002	0.99%	-	-	-
2003	0.79%	-	-	-
2004	0.78%	-	-	-
2005	0.59%	-	-	-
2006	0.42%	-	-	-

Table 10: Entry, continue and exit of firm by industry

	Entry	Continue		Exit
		2001	2006	
A . Agriculture	1.07%	1.82%	1.75%	0.67%
B . Forestry	2.45%	1.52%	1.57%	1.62%
C . Fisheries	1.62%	0.65%	0.97%	0.49%
D . Mining	1.37%	3.46%	3.21%	1.61%
E . Construction	0.90%	1.22%	1.22%	0.84%
F . Manufacturing	5.26%	6.01%	6.25%	3.27%
G . Electricity, Gas, Heat Supply and Water	4.23%	14.24%	13.99%	5.46%
H . Information and Communications	6.56%	9.29%	9.47%	6.55%
I . Transport	0.50%	0.98%	0.97%	0.39%
J . Wholesale and Retail Trade	1.17%	1.43%	1.39%	0.86%
K . Finance and Insurance	0.52%	0.82%	0.87%	0.53%
L . Real Estate	0.39%	0.24%	0.27%	0.40%
M . Eating and Drinking Places, Accommodations	0.05%	0.11%	0.11%	0.05%
N . Medical, Health Care and Welfare	0.13%	0.07%	0.08%	0.07%
O . Education, Learning Support	0.37%	0.19%	0.19%	0.12%
P . Compound Services	1.24%	1.64%	1.73%	1.24%
Q . Services, N.E.C.	0.92%	0.69%	0.70%	0.84%

Table 11: Entry, continue and exit of firm by industry (manufacturing in detail)

	Entry	Continue		Exit
		2001	2006	
09 Manufacture of food	2.54%	3.90%	4.06%	2.17%
10 Manufacture of beverages, tobacco	5.29%	6.33%	6.38%	3.38%
11 Manufacture of textile mill products	3.11%	3.36%	3.34%	1.22%
12 Manufacture of apparel	1.82%	2.29%	2.37%	0.96%
13 Manufacture of lumber and wood products	3.12%	2.81%	2.97%	1.40%
14 Manufacture of furniture and fixtures	1.91%	1.80%	1.89%	1.39%
15 Manufacture of pulp, paper and paper products	6.18%	7.23%	7.67%	3.93%
16 Printing and allied industries	2.13%	2.50%	2.55%	1.25%
17 Manufacture of chemical and allied products	15.66%	28.10%	28.48%	15.30%
18 Manufacture of petroleum and coal products	9.63%	16.75%	18.68%	9.43%
19 Manufacture of plastic products	7.02%	9.41%	9.80%	4.90%
20 Manufacture of rubber products	4.78%	6.92%	7.28%	2.32%
21 Manufacture of leather tanning, leather products	2.07%	3.07%	3.03%	1.29%
22 Manufacture of ceramic, stone and clay products	4.73%	6.61%	7.03%	3.47%
23 Manufacture of iron and steel	3.91%	8.67%	9.05%	3.94%
24 Manufacture of non-ferrous metals and products	7.18%	9.65%	10.12%	4.81%
25 Manufacture of fabricated metal products	3.60%	5.05%	5.26%	2.75%
26 Manufacture of general machinery	8.15%	9.52%	9.93%	6.97%
27 Manufacture of electrical machinery, equipment	10.50%	11.70%	12.45%	6.84%
28 Manufacture of ICT equipment	11.18%	14.45%	15.36%	9.90%
29 Electronic parts and devices	10.35%	11.79%	12.40%	6.37%
30 Manufacture of transportation equipment	4.64%	7.05%	7.02%	4.17%
31 Manufacture of precision instruments and machinery	12.96%	13.44%	13.66%	8.57%
32 Miscellaneous manufacturing industries	5.24%	4.59%	4.81%	3.16%

Table 12: Entry, continue and exit of firm and open innovation

	Inter firm network		U-I collaborations	
	2001	2006	2001	2006
Entry		41.7%		13.2%
Continue	37.4%	43.4%	12.0%	14.4%
Exit	33.7%		8.1%	

Table 13: Share of open innovation firm by size (only for continuing firms)

	Inter firm network		U-I collaborations	
	2001	2006	2001	2006
0	0.0%	20.0%	10.0%	20.0%
1	23.1%	29.3%	8.7%	10.6%
2	24.1%	30.1%	5.1%	7.3%
3	20.6%	27.6%	4.0%	6.0%
4-5	22.5%	29.4%	4.2%	6.3%
6-10	24.0%	32.1%	4.1%	6.1%
11-100	33.6%	41.6%	8.1%	11.0%
101-1000	60.1%	61.1%	26.8%	29.3%
1001-	78.4%	68.0%	55.3%	49.1%

Table 14: Share of open innovation firm by industry (only for continuing firms)

	# of firms	Inter firm network		U-I collaborations	
		2001	2006	2001	2006
A . Agriculture	165	27.3%	35.8%	9.7%	17.6%
B . Forestry	17	17.6%	29.4%	11.8%	11.8%
C . Fisheries	13	15.4%	23.1%	7.7%	15.4%
D . Mining	75	41.3%	53.3%	17.3%	20.0%
E . Construction	4,972	34.0%	39.7%	11.1%	12.2%
F . Manufacturing	24,780	38.5%	45.0%	10.9%	13.5%
G . Electricity, Gas, Heat Supply and Water	87	63.2%	67.8%	35.6%	42.5%
H . Information and Communications	1,860	29.1%	38.1%	6.8%	10.3%
I . Transport	637	41.4%	50.4%	8.3%	8.6%
J . Wholesale and Retail Trade	13,611	41.2%	45.7%	15.0%	16.8%
K . Finance and Insurance	173	37.6%	44.5%	11.0%	12.7%
L . Real Estate	545	23.3%	29.0%	4.6%	5.7%
M . Eating and Drinking Places, Accommodations	531	24.7%	26.4%	8.1%	8.7%
N . Medical, Health Care and Welfare	127	22.8%	29.9%	8.7%	15.7%
O . Education, Learning Support	168	25.0%	25.0%	14.9%	16.7%
P . Compound Services	222	0.0%	0.0%	71.6%	94.1%
Q . Services, N.E.C.	4,816	32.5%	39.8%	10.9%	14.2%

Table 15: Share of open innovation firm by industry (only for continuing firms; manufacturing in detai)

	# of firms	Inter firm network		U-I collaborations	
		2001	2006	2001	2006
09 Manufacture of food	1417	25.12%	29.78%	9.10%	12.00%
10 Manufacture of beverages, tobacco	366	26.78%	31.15%	11.20%	14.75%
11 Manufacture of textile mill products	760	37.24%	44.21%	9.08%	11.97%
12 Manufacture of apparel	665	20.75%	26.47%	2.71%	3.91%
13 Manufacture of lumber and wood products	413	29.54%	34.38%	7.75%	10.65%
14 Manufacture of furniture and fixtures	419	19.81%	26.25%	5.97%	8.35%
15 Manufacture of pulp, paper and paper products	714	34.31%	41.18%	5.46%	7.42%
16 Printing and allied industries	810	28.02%	34.32%	5.06%	6.17%
17 Manufacture of chemical and allied products	1169	57.31%	61.33%	26.43%	29.68%
18 Manufacture of petroleum and coal products	70	52.86%	57.14%	21.43%	30.00%
19 Manufacture of plastic products	1693	42.35%	50.97%	9.45%	11.70%
20 Manufacture of rubber products	327	44.65%	51.99%	11.93%	12.84%
21 Manufacture of leather tanning, leather products	183	15.85%	20.77%	1.09%	1.09%
22 Manufacture of ceramic, stone and clay products	1167	40.36%	48.41%	15.77%	19.88%
23 Manufacture of iron and steel	398	46.98%	51.76%	16.58%	17.84%
24 Manufacture of non-ferrous metals and products	349	54.44%	57.31%	16.62%	17.48%
25 Manufacture of fabricated metal products	2803	35.39%	43.74%	7.53%	10.31%
26 Manufacture of general machinery	4809	40.53%	46.60%	10.63%	12.89%
27 Manufacture of electrical machinery, equipment	1611	46.74%	53.01%	12.04%	14.65%
28 Manufacture of ICT equipment	413	44.07%	50.12%	13.32%	18.16%
29 Electronic parts and devices	935	45.35%	54.97%	12.51%	17.43%
30 Manufacture of transportation equipment	1178	48.47%	54.33%	16.47%	19.02%
31 Manufacture of precision instruments and machiner	983	40.69%	46.59%	13.22%	17.50%
32 Miscellaneous manufacturing industries	1128	24.20%	29.96%	4.79%	5.76%

Table 16: Firm's survival and innovation activities (Probit Model)

	(1)	(2)	(3)	(4)
Patent	0.141 (24.15)**	-0.254 (17.48)**	-0.204 (10.42)**	-0.389 (7.83)**
Log(emp)		0.094 (163.46)**		-0.01 (5.31)**
Log(age) emp=<100			0.183 (266.10)**	0.148 (142.60)**
Lof(emp)*log(age)				0.035 (54.50)**
Log(emp)*patent		0.108 (24.88)**		0.143 (8.03)**
Log(age)*patent			0.122 (17.90)**	0.06 (3.44)**
Lof(emp)*log(age) *patent				-0.016 (2.63)**
Constant	0.036 (1.00)	-0.141 (2.79)**	0.118 (3.12)**	0.084 (2.23)*
Industry dummy	Yes	Yes	Yes	Yes
Size summy	Yes	No	Yes	No
Age summy	Yes	Yes	No	No
Observations	5037471	5037471	4456259	4456259

Absolute value of z statistics in parentheses
* significant at 5%; ** significant at 1%

Table 17: Firm's growth and innovation activities (Fixed Effect Model)

	(1)	(2)	(3)	(4)
Log(patent)	0.026 (7.48)**	0.260 (19.78)**	0.025 (5.24)**	0.027 (5.25)**
Log(patent)*log(emp)		-0.018 (6.59)**		
Log(patent)*log(age)		-0.058 (12.85)**		
log(univ+1)			-0.004 (0.44)	0.033 (0.82)
log(firm+1)			0.004 (0.52)	0.275 (12.13)**
log(univ+1)*log(emp) *log(patent)				-0.01 (1.50)
log(firm+1)*log(emp) *log(patent)				-0.019 (4.34)**
log(univ+1)*log(age) *log(patent)				0.013 (1.01)
log(firm+1)*log(age) *log(patent)				-0.065 (8.67)**
Constant	3.471 (674.31)**	3.295 (602.60)**	3.470 (669.30)**	3.282 (613.47)**
Observations	101939	86259	101939	86259
Number of group	52799	44643	52799	44643
R-squared	0.00	0.01	0.00	0.01

Absolute value of z statistics in parentheses
* significant at 5%; ** significant at 1%

Figure 1: Structure of IIP Patent Database

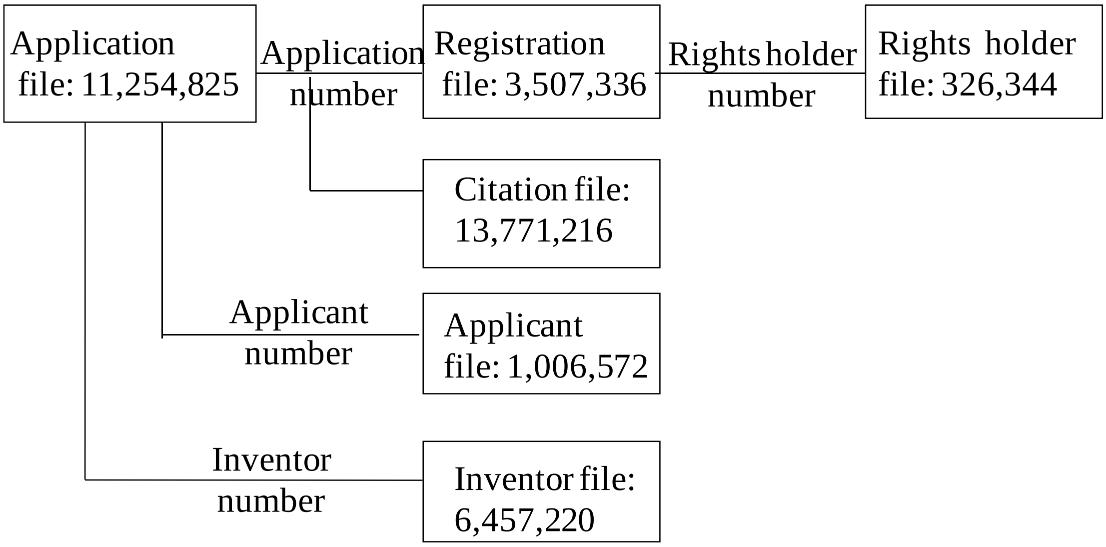

Figure 2: Cumulative number of firms by last year of patent applications