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Open Innovation and Firm's Survival: An empirical investigation by using a linked dataset of patent and enterprise census

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Open Innovation and Firm's Survival: An empirical investigation by using a linked dataset of patent and enterprise census[1]

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Abstract

This paper uses patent filings as an indicator of innovation and investigates the relationship between innovation and firms' survival, based on the linked dataset of the Census of Establishment and Enterprise and the Institute of Intellectual Property (IIP) Patent Database for Japanese firms. We have constructed the indicators on the organization of innovative activities, such as external collaboration in inventions and the type of collaborative partners, and disentangle two competing factors, i.e., technological capability (positive influence on firms' survival) and commercial risk (negative influence on firms' survival). We found that the risk factor surpasses the capability factor, thus the impact of patenting on survival has a negative correlation with firms' survival at the end.

JEL Classification: L25, O13
Keywords: Enterprise census, Patent database, Entry and exit of firms

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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).

A theoretical model of firm’s exit or survival is based on new and existing players at market, taking into account heterogeneous capabilities at firm. A passive learning model explains industrial dynamics in firm’s learning process of its own initial capability endowment which as not know at the time of entry (Jovanovic, 1982). In contrast, there is also an active learning model which takes into account the fact that firm’s capability is not only determined by its initial endowment, but subsequent investments (Ericson and Pakes, 1995). A pattern of industrial dynamics, such as firm’s entry, growth and exit, is quite different between two models, but the importance of firm’s capability as a predictor of firm’s survival and growth is confirmed in both models.

In this paper, we focus on firm’s technological capability and investigate its impact on firm’s growth by using the linked dataset of the enterprise census and a patent database in Japan. Empirically, there are only mixed results about the impact of innovative activity, such as R&D and patent, on firm's survival. Positive relationship is found in Esterve-Perez and Manez-Castillejo (2008) and Orgega-Argiles and Moreno (2007) and Cockburn and Wager (2007), while negative one is found in Buddlemeyer et. al (2010), Motohashi (2011) and Pederzoli et. al (2011). A negative factor may come from substantial risk associated with innovative activities, particularly for small and young firms. Therefore, we look into the organization of innovative activities, such as external R&D collaboration, in order to make a proper understanding of the balance between the risk factor (negative impact on firm's survival) and the technological capability factor (positive impact on firm's survival).

This paper is structured as follows. First, we introduce theoretical aspects of industrial dynamics and empirical literature to explain firm level entry, growth and exit in a real world. Then, hypotheses of the relationship between patenting and firm's survival by type of the organization of inventive activities are provided. Then, a description on the dataset in this study, i.e., the Enterprise and Establishment Census data and the JPO patent database are provided. Next, we show the results of a quantitative analysis to test the hypotheses developed in the section 2. Finally, we summarize our findings and provide discussions and policy implications.

2. Theory and Hypotheses

A theoretical model of firm's exit or survival is based on competition process of new and existing players at market, taking into account heterogeneous capabilities at firm. A passive learning model explains industrial dynamics in firm's learning process of its own initial capability endowment which as not know at the time of entry (Jovanovic, 1982). In every period a firm has to make decision on continue or exit with the belief on its capability, based on Bayesian inference of part experience at market. When a firm overestimates its capability, it may overinvest to grow faster, but the probability of failure and exit from market increases. Therefore, the rate of exit decreases by firm's age, as it learns own capability level by market experience over time.

The active learning model, instead, takes into account the fact that firm's capability is not only determined by its initial endowment, but subsequent investments (Ericson and Pakes, 1995). Here in every period, a firm has to make a decision on continue or exit again, but it also decides the level of investment in case of continuation. In this model, there are two state variables, the level of competency (positively correlated with firm's outcome) and the number of firms with in the same level of competency (negative correlated with firm' outcome). A Markov process is assumed in dynamics, in a sense that a firm's perception of own and its competitors' states is based on only those in the previous period. The level of investment for next period is determined by dynamic optimization problem to maximize the value of firm with exit option. An exit option is executed when the value of firm becomes less than an opportunity cost of staying in the market (an outside value of the firm). There are also entrants in this market, when the expected value of entry choice exceeds sunk cost of entry investment.

A pattern of industry dynamics, i.e., entry, continue and exit, looks quite different between passive learning and active learning model. In a former model, a firm growth pattern is described as a path of approaching to certain level of firm size, depending on capacity endowment (larger endowment leads to larger size), with continuous flux entry and exit, particularly for young firms, which do not know its capability, precisely.. In contrast, active leaning model draws more dynamic picture with continuous changes of relative position of firms and firm's exit can happen regardless of its age. A reality is off course in-between, although empirically, relatively persistent ranking order of productivity over time is found (Baily et. al, 1992; Bartelsman and Doms, 2000), and exit is likely to occur more in younger firms (Bartelsman et. al, 2005). A growth pattern of firm cannot be determined solely by its initial endowment, but capability upgrading efforts are serially correlated over a long time. The assumption of Markov process in Ericson and Pakes (2005) is too strong, and to what extent the impact of investment stays over time determines the degree of persistency of industrial dynamics.

In both model, the level of firm's capability and market competition are important predictors for firm's survival. Empirically, the level of firm's capability is measured by firm size, such as the number of employees, or more specific type of capability such as skill level of employees (Gimeno, et. al, 1997), financial resources (Carpenter and Peterson, 2002) and trademarks (Buddelmeyer et. al, 2010) to see how it does matter with firm's survival. The results find these capability measures have positive impacts on firm's survival in general.

However, it is interesting to see that the impact of technological capability is not always positive to firm's survival. Esteve-Perez and Manez-Castillejo (2008) and Orgega-Argiles and Moreno (2007), which use R&D as an index for technological capability showed that the positive relationship between R&D and company survival is particularly seen in the hi-tech industry. Moreover, Cockburn and Wagner (2007) and

Buddelmeyer et. al (2009) using patent as an indicator. The former literature deals with internet service providers, again high-tech, and finds positive relationship. However, Buddelmeyer et. al (2010), analyses the impact of patent application and patent stock separately, and find negative impact of recent patent application on firm's survival, after controlling for the impact of patent stock (with positive relationship with firm's survival). They argue that uncertainly embodies in radical innovation activity surpasses the capability effect, implied by patenting. A negative relationship between patent and firm's survival is also found in Motohashi (2011) and Pederzoli et. al (2011). Patent filing implies that technology new to the world is developed so that the firm is conducting substantial "exploration" over "exploitation" activities (March, 1991). It is required more organizational learning in exploring process which is riskier to be successful at the end (March, 1991).

In this paper, we investigate the balance between uncertainty in innovative activities and technological capabilities in relationship with firm's survival. Broadly speaking there are two types of uncertainty associated with innovation activities, i.e., technological risk and commercial risk. Technological risk is found in research and development activities, which is not always leading to successful completion. When a firm comes to the point of patent filing, it overcomes such technological risk, but there is still commercial risk where not all patent leads to commercial success. Therefore, the findings in Buddelmeyer et. al (2010), Motohashi (2011) and Pedezoli et. al (2011) are supposed to be explained mainly by substantial commercial risk still remaining in patenting technologies. However, a firm filing more patent is likely to be superior in its technological capability as well. This is particularly the case when a firm's patent is important and high in its commercial value. It is found that a patenting entrepreneur is more likely to receive venture capital financing so that signaling effect of patenting to potential investors may improve its survival rate as well (Haeussler et. al, 2009). .

H1: The impact of patenting on the firm's survival is determined by the balance of the levels between the uncertainty in innovation activities (negative) and technological capability.

H1a: When a filing patent is less at its commercial risk, technology capability effect surpasses uncertainty one, so that the impact patent filing on firm's survival is positive.

H1b: When a great commercial risk is associated with filing patent, uncertainty effect surpasses technological capability one, so that the impact patent filing on firm's survival is negative.

In addition, it is important to distinguish exit of firm by its dissolution or acquisition. A start-up firm with higher technological capability can be an attractive target for M&A market. Therefore, a negative association between patenting and firm's survival may be attributed to the firms exited due to acquisition by other firms. The differences in antecedents of firm's exit between dissolution and acquisition have been investigated in the past (Mitchell, 1994: Grilli et. al, 2010). Srinivasan et. al (2008) extends these studies by taking into account firm's technology management strategy, and finds the positive relationship between the firm's technology capability and firm exit by acquisition, while such relationship turns into negative for firm exit by its dissolution. Therefore, another annex to hypothesis 1 can be constructed as follows,

H1c: When a firm's exit is driven by acquisition, instead of dissolution, the impact of patent filing is negative.

Moreover, open innovation, i.e., external collaboration on R&D, mitigate the uncertainly associated with innovation activities, may mitigate this commercial risk. Zheng et. al (2010) explains two types of benefits from inter-firm network' benefits for entrepreneurs 's (1) transferred benefit and (2) perceived benefit. A higher failure rate for young firms can be explained by the fact that the routine and the policy to manage the business uncertainty is not well developed yet. Transferred benefit refers to the "pipe" through which information and knowledge supplement to overcome such uncertainty from the partners may be transferred. In addition, there is a perceived benefit from inter-firm network which works as the "prism" signaling the firm's quality of managing its relationship with partners (Zheng et. al, 2010).

However, R&D collaboration may also infer a firm's limited technological capability, as compared to panting technology developed solely by itself. Bederbos et. al (2010) shows the negative relationship between the degree of co-patenting and the value of firms. They argued that potential disadvantages of R&D collaboration, such as coordination costs and reduction of potential future revenue by co-ownership of technology, may surpass its potential benefits such as access to new technology and lower risk in technology commercialization. This is particularly the case when a firm collaborates with a large and established firm which has more R&D resources than smaller firms. A coordination cost for R&D collaboration is relatively large for a firm with smaller managerial resources, and its potential benefits from shared technology with large firms are relatively small with smaller compelemtary assets. In addition, if a firms co-patents with some particular firm, its bargaining position in post invention rent sharing negotiation is supposed to be small. Therefore, the hypotheses related to open innovation and firm's survival is as follows;

H2: The impact of open innovation on the firm's survival is determined by the balance of factors between positive ones such as transferred and perceived benefit and negative ones such as less technological competency signal and benefit sharing effect.

H2a: Positive factors surpass negative ones when a firm is enough capable technologically.

H2b: Negative factors surpass positive ones when a firm collaborates with large firms.

H2c: Negative factors surpass positive ones when a firm collaborates with smaller number of the same partners.

3. Dataset and descriptive statistics

In order to conduct an empirical analysis of patenting and firm's survival, we have constructed the dataset linking the Enterprise and Establishment Census by the Japanese Government and IIP Patent Database, complied by using JPO patent information.

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. We used the dataset until the survey conducted in October 2006, which is the last Enterprise and Establishment Census. In 2009, a similar survey was 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."

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 March 2011. 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).

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. 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. A detail description of data linkage works can be found in Motohashi (2011). The numbers of all firms in this dataset are 5,082,267 and 4,627,530 in 2001 and 2006, respectively, and the numbers of the firms with patent application are 66,582 (1.32%) and 64,640 (1.40%) in 2001 and 2006, respectively.

In this paper, we use only the samples with patent application in order to look at the relationship between open innovation and firm's survival in detail. In terms of the state of open innovation at firms, we use the indicator by looking at whether a patent are applied jointly with other firms other firms (inter-firm linkages) and/or with university (industry-academia linkages). It should be noted that national university could not claim its patent right before it was incorporated in 2004, so that we complement joint invention (with industry and academic researcher) information with joint application database. The detail description of identifying joint invention patents van be found in

Motohashi and Muramatsu (2012).

Table 1 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. Empirically, it is found that low productivity firms, low in its competitive position at market are more likely to exit (Griliches and Regev, 1995; Matsuura and Motohashi, 2005). Its open innovation activity may be less active as compared to a continuing firm. In contrast, it is found that Schumpeterian dynamics, i.e., entry of high productivity firm and exit of low productivity one, contributes to aggregated productivity growth (Baily et. Al, 1992), so that open innovation at entry firms is supposed to be more active.

(Table 1)

Table 2 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 2)

Tables 3 and 4 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 3) (Table 4)

4. Econometric Analysis

In this chapter, an econometric analysis is conducted to test the hypotheses in the section 2. We use the information whether the firms existed in 2001 survived until 2006 (survival) or not (exit). Therefore, the dependent variable for our econometric models is binary variable of 1 (for survive) or 0 (for exit). In addition, we made a distinction between acquisition and dissolution in case of exit. Since the Establishment and Enterprise Census provides the information both for establishments and firms, so that the identification for acquisition is made for exited firms during the period between 2001 and 2006, some of whose establishments can be found in 2006 as well. We ran Probit estimation model with independent variable as follows.

First, log of the number of patent filings (Lpatent) is used as an independent variable. In addition, we need to control for the size and the age of firm, by including Lemp (log of the number of employees in 2001) and Lage (log of age in 2001), since these two factors are found to be important predictor for firm's survival.

In terms of open innovation activity at firm, we have constructed two types of variable from patent database, i.e., a dummy variable for joint application with other firms (d_firm) and a dummy variable for joint application or joint invention with universities (d_univ). As for the degree of commercial risk associated with patent, we use the number of forward citations and generality index of patent. The number of forward citations is the most frequently used patent quality indicator (Nagaoka, et. al, 2010), which reflects the size of subsequent inventions based on the original patent. In order to control for different propensity to be cited by technology and time, we take the ratio of the number of forward citations to its average by technology classification and application year. Presumably, a patent with large number of subsequent patents is more commercially viable. The generality reflects versatility of patents, which can be calculated as follows (Hall et. al, 2001),

$$\text{generality} = 1 - \sum_i \left({}^{\#\, of\, forward\, ciations\, in\, technology\, "i"} \big/ {}_{total\, \#\, of\, forward\, citation} \right)^2$$

The greater the generality is, the patent is cited in broad range of technology field, and such wider applicability is supposed to reduce the degree of commercial risk associated with the patent.

In terms of the variables for the organization of R&D coloration, we use the information whether the patent co-applied with a firm with more patent applications than itself (Larger firms), and the Herfindahl-Hirschman Index by the number of counterparts (HHI) to reflect the degree of concentration to some particular firms for co-application partners. Since these indicators are created at patent level, we take averages of those for each firm.

The results by using all firms with patent application in 2001 (57, 268 out of 5,082,267 firms) are provided in Table 5. A negative and statistically significant coefficient is found to Lpatent, when we control for the size and the age of firms. Therefore, the risk factor associated with innovative activities is larger than the technological capability factor. Since we have controlled for the size (including R&D resources) and the age (including technological accumulation by learning), the number of patent applications tends to capture more risk factor which are left out.

(Table 5)

In Model 2, we include open innovation and patent quality indicator as an independent variable as well, and have found that collaborating with firm decreases survival probability of firms. As regards to hypothesis 2, it is presumed that the impact of negative factors is greater than that of positive ones. In order to check this presumption, we include the cross terms of collaboration variables and Lpatent in Model (3). Here, we see positive and statistically significant coefficient to the cross term, which can be interpreted that the impact of collaborating with firm becomes positive when the number of patent is large. Therefore, the hypothesis 2a is supported.

In model (4), we further include cross terms of patent quality indicators and Lpatent. While we cannot get a statistically significant coefficient to the number of forward citations, but we find a negative and statistically significant coefficient to generality index and positive ad statistically significant one to the cross term of generality and Lpatent. That is, the versatility of filing patent is negatively related to firm’s survival, but it becomes positive impact when the firm’s technological capability is large enough. We further include cross terms of patent quality indicators and open innovation variables, and have found that the versatility of technology is positively related to firm’s survival when a firm collaborates with firms. Therefore, the hypotheses 1a and 1b are partially supported. In addition, it is found that there may be some complementary relationship between open innovation and technology versatility.

Table 6 shows the results comparing the model in Table 5 between acquisition and dissolution samples. The model (1) in Table 6 is the same specification as the model (1) of Table 5, and the model (2) in Table 6 corresponds to the model (5) in Table 5. We have found that the negative and statistically significant coefficient to Lpatent in acquisition samples, so that the hypothesis 1c is supported. However, the same pattern is found also for dissolution samples. Therefore, it is confirmed that a risk factor surpasses potential benefit by patent filing. In addition, we can also find the evidence to support hypothesis 1a in positive and statistically significant coefficient to Lpatent*d_firm in dissolution samples. A major difference in the results between acquisition and dissolution samples is found in the opposite sign of coefficients to age and employment size. It is found that older and larger firms are more likely acquired by other firms. This finding is consistent to Mitchell (1994), due to increasing mismatch between owner's expectation and management organizational capabilities for growth over time. In addition, a potential buyer may hesitate to acquirer new and small firms which do not show their market competency yet (Grilli et. al, 2010).

(Table 6)

Table 7 and 8 shows the results by using the sample of firms collaborating with other firms, since the variable of "large firm" and "hhi" can be constructed only for those samples. In addition, the samples are further broken down into those with exit by acquisition (Table 7) and dissolution (Table 8). We have new independent variable, Univ_share, the share of patents jointly invented with university, here. In Model (1), we have found the same results as are shown in Table 6. The hypothesis 2 is developed, mainly for firms exited by dissolution so that the results in Table 8 are used here. In model (2), a positive and statistically significant coefficient to collaborating with university is found. A firm with collaborating with university may be superior in its technological capability, and there may be less concern about rent dissipation by bargaining with its co-applicant for economic valuation of patent.

(Table 7) and (Table 8)

In Model (3), we have found that "Larger firm" has negative and statistically significant coefficients, which directly supports hypothesis 2b. In addition, "HHI", the concentration ratio of co-application partners, is negative correlated with firm's survival, since being dependent on smaller number of particular partners in open innovation implies a firm's weaker bargaining position (hypothesis 2c). In Model (4), interactive terms of these partnership structure variables with Lpatent are included, and found that negative impact of “hhi” are consistent over the number of patents, while a negative effect of the share of large firms as a partner increases by the number of patent filings. Therefore, hypothesis 2a is not supported. However, it should be noted that the coefficient to Lpatent turns into not statistically significant in model (4), so that the risk factor associated with patent filing is now loaded on the cross terms of Lpatent and the partnership structure variables.

5. Discussion and conclusions

This paper uses patent filing as an indicator of innovation and investigates the relationship between innovation and firm’s survival, based on the linked dataset of the Census of Establishment and Enterprise and IIP Patent Database for Japanese firms. We have constructed the indicators on the organization of innovative activities, such as external collaboration in invention and the type of collaborative partners, and disentangle two competing factors associated with innovative activities, i.e. technological capability (positive influence on firm’s survival) and commercial risk (negative influence on firm’s survival). We have found that the risk factor surpasses the capability one, so that the impact of patenting on survival becomes negative on firm’s survival at the end for Japanese firms. The findings in this study generally support the argument in Buddelmeyer et. al (2010), 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.

An innovative activity is essential to firm’s growth and productivity, but a failure of risky investment is likely to lead to a failure of the firm itself. We would expect learning effects with innovative activities even though it ends up with failure, but when a firm goes into dissolving, the experience of such innovative activities will be lost as well. Therefore, we would expect substantial social welfare loss associated with exit of firms investing in risky R&D project. In addition, the negative correlation between innovative activities and firm’s survival may stifle hi-tech entrepreneurial activities. Therefore, we have to reconfirm the importance of SME innovation policy, which mitigates such risk factor in an innovation process.

Innovation and entrepreneurship is an important topic, particularly 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). According to our findings, a risk associated with innovative activities may be loaded too much on entrepreneur, instead of being shared with other parties such as venture capitalist. Therefore, policies to activate factor market, such as labor and financial market, are important.

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. In the United States, substantial positive spillover effects from failure of high tech startups in high-tech industry to existing firms are observed (Knott and Posen, 2005; Hoetker and Agarwal, 2006). However, this may not be the case for Japan, where labor market is more rigid, and technology spillovers embodied in human capital cannot be expected to the extent in the United States. Therefore, some coordinated mechanism to re-distribute innovative labor and assets when mismatch with their owner's business strategic goal becomes significant. Recent intense international competition in high-tech product market makes large Japanese firms to change its in-house R&D model, and seek for open innovation style (Motohashi, 2005). Therefore, public intervention to create coordinator in such innovation market, as is found in the Innovation Cooperation Network of Japan, is justified in some areas where market function is particularly weak.

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Table 1: 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 2: 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 3: 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 4: 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 5: Regression results on firm's survival: All samples

	(1)	(2)	(3)	(4)	(5)
Lemp	0.104 (6.41)**	0.106 (6.49)**	0.107 (6.57)**	0.107 (6.56)**	0.107 (6.56)**
Lage	0.160 (10.04)**	0.163 (10.19)**	0.170 (10.52)**	0.17 (10.53)**	0.17 (10.52)**
Lemp*Lage	0.032 (5.83)**	0.032 (5.79)**	0.030 (5.53)**	0.03 (5.54)**	0.03 (5.55)**
Lpatent	-0.063 (14.83)**	-0.055 (10.87)**	-0.079 (10.21)**	-0.081 (9.76)**	-0.079 (9.19)**
d_firm		-0.088 (5.72)**	-0.146 (6.63)**	-0.135 (6.05)**	-0.144 (6.00)**
d_univ		0.051 (1.87)	0.048 (1.15)	0.052 (1.24)	0.061 (1.27)
cited		0.000 (0.10)		0.002 (0.90)	0.002 (0.95)
generalty		-0.095 (1.89)		-0.243 (3.13)**	-0.291 (3.59)**
Lpatent*d_firm			0.041 (3.75)**	0.036 (3.21)**	0.034 (3.02)**
Lpatent*d_univ			-0.007 (0.59)	-0.008 (0.73)	-0.008 (0.67)
Lpatent*cited				-0.004 (1.85)	-0.003 (0.94)
Lpatent*generalty				0.139 (2.90)**	0.115 (2.22)*
d_firm_cited					-0.005 (0.66)
d_firm*generalty					0.228 (2.07)*
d_univ_cited					-0.001 (0.05)
d_univ*generalty					-0.094 (0.45)
Constant	-0.050 (0.09)	-0.032 (0.06)	-0.024 (0.04)	-0.011 (0.02)	-0.024 (0.04)
Industry dummy	Yes	Yes	Yes	Yes	Yes
Observations	57268	57268	57268	57268	57268

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

Table 6: Regression results on firm's survival: Acquisition or Dissolution

	(1)		(2)	
	Acquisition	Disolution	Acquisition	Disolution
Lemp	-0.347	0.092	-0.345	0.095
	(9.00)**	(5.36)**	(8.91)**	(5.51)**
Lage	-0.205	0.113	-0.200	0.124
	(4.47)**	(6.77)**	(4.32)**	(7.39)**
Lemp*Lage	0.074	0.058	0.074	0.056
	(6.09)**	(9.80)**	(6.03)**	(9.43)**
Lpatent	-0.036	-0.060	-0.035	-0.085
	(5.30)**	(12.57)**	(2.14)*	(9.27)**
d_firm			-0.112	-0.146
			(2.50)*	(5.67)**
d_univ			-0.042	0.041
			(0.53)	(0.78)
cited			0.008	0.001
			(1.05)	(0.60)
generalty			-0.208	-0.281
			(1.28)	(3.28)**
Lpatent*d_firm			0.019	0.039
			(0.96)	(3.25)**
Lpatent*d_univ			-0.007	0.011
			(0.43)	(0.87)
Lpatent*cited			-0.008	0.000
			(1.87)	(0.10)
Lpatent*generalty			0.100	0.102
			(1.12)	(1.81)
d_firm_cited			-0.001	-0.008
			(0.11)	(0.81)
d_firm*generalty			0.137	0.218
			(0.63)	(1.87)
d_univ_cited			0.007	-0.002
			(0.33)	(0.13)
d_univ*generalty			0.087	-0.159
			(0.23)	(0.72)
Constant	3.131	-0.026	3.14	0.006
	(7.54)**	(0.05)	(7.52)**	(0.01)
Industry dummy	Yes	Yes	Yes	Yes
Observations	45727	55912	45727	55912

Absolute value of z statistics in parentheses

* significant at 5%; ** significant at 1%

Table 7: Regression results on firm's survival: Co-patenting & Acquisition samples

	(1)	(2)	(3)	(4)
Lemp	-0.418	-0.410	-0.407	-0.408
	(5.92)**	(5.79)**	(5.75)**	(5.73)**
Lage	-0.283	-0.273	-0.272	-0.271
	(3.11)**	(2.99)**	(2.98)**	(2.97)**
Lemp*Lage	0.103	0.100	0.100	0.1
	(4.70)**	(4.56)**	(4.56)**	(4.54)**
Lpatent	-0.032	-0.035	-0.033	-0.007
	(3.35)**	(3.50)**	(3.20)**	(0.29)
Univ share		-0.072	-0.055	-0.059
		(0.65)	(0.49)	(0.53)
Lpatent* Univ share		0.000	0.000	0.000
		(0.98)	(0.94)	(0.75)
HHI			0.058	0.042
			(1.06)	(0.52)
Larger firms			-0.051	0.054
			(0.86)	(0.59)
Lpatent*HHI				0.007
				(0.29)
Lpatent*Large firm				-0.041
				(1.46)
Constant	3.152	3.133	3.120	3.057
	(9.76)**	(9.70)**	(9.56)**	(9.18)**
Industry dummy	Yes	Yes	Yes	Yes
Observations	14718	14712	14712	14712

Absolute value of z statistics in parentheses

* significant at 5%; ** significant at 1%

Table 8: Regression results on firm's survival: Co-patenting & Dissolution samples

	(1)	(2)	(3)	(4)
Lemp	0.093 (2.59)**	0.094 (2.61)**	0.100 (2.77)**	0.104 (2.89)**
Lage	0.101 (2.73)**	0.103 (2.77)**	0.105 (2.84)**	0.11 (2.95)**
Lemp*Lage	0.060 (5.13)**	0.060 (5.06)**	0.058 (4.94)**	0.056 (4.76)**
Lpatent	-0.029 (4.01)**	-0.032 (4.25)**	-0.040 (5.14)**	0.021 (1.17)
Univ share		0.187 (2.51)*	0.181 (2.42)*	0.17 (2.28)*
Lpatent* Univ share		0.000 (0.29)	0.000 (0.31)	0.000 (0.07)
HHI			-0.100 (3.06)**	0.016 (0.31)
Larger firms			-0.075 (2.29)*	0.014 (0.27)
Lpatent*HHI				-0.054 (2.90)**
Lpatent*Large firm				-0.043 (2.10)*
Constant	-2.134 (2.72)**	-2.137 (2.73)**	-2.010 (2.58)**	-2.167 (2.77)**
Industry dummy	Yes	Yes	Yes	Yes
Observations	17468	17460	17460	17460

Absolute value of z statistics in parentheses

* significant at 5%; ** significant at 1%