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Understanding the Technology Market for Patents:

- New Insights from a Licensing Survey of Japanese Firms-

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東京大学知的資産経営・総括寄付講座　教授　元橋一之
帝塚山大学経済学部　蟹雅代

Intellectual Asset-Based Management

東京大学 知的資産経営総括寄付講座
Intellectual Asset-Based Management Endorsed Chair
The University of Tokyo

**Understanding the Technology Market for Patents:
New Insights from a Licensing Survey of Japanese Firms[1]**

Masayo Kani[a] and Kazuyuki Motohashi[b]

Abstract

This paper provides an empirical analysis of the technology market for patents in Japan, by using a novel firm-level dataset combining a JPO survey entitled Survey of Intellectual Property Activities, the IIP patent database, and the Licensing Activity Survey conducted by the University of Tokyo. In this paper, we use a two-step model to estimate the licensing propensity; the first step is to estimate the determinants of potential licensors (willingness to license), and the second step is for identifying factors behind actual licensing out (licensing propensity). We have found that significant numbers of patents held by firms are not licensed out, even through the owners are willing to do so. Our econometric analysis reveals that a major factor behind this technology market imperfection is the difficulty experienced by potential licensors in finding licensing partners.

JEL classification; D45, L22, O32

Keywords; technology market, licensing, patent, Japan

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[a] Lecturer, Faculty of Economics, Tezukayama University, 7-1-1 Tezukayama, Nara, Japan 631-8501. E-mail address: mkani@tezukayama-u.ac.jp, tel: +81-742-48-7148, fax: +81-742-48-9308

[b] Professor, Department of Technology Management for Innovation (TMI), University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan 113-8656. E-mail address: motohashi@tmi.t.u-tokyo.ac.jp, tel: +81-3-5841-1828, fax: +81-3-5841-1829

1. Introduction

In 2003, the Intellectual Property Strategy Headquarters, headed by the prime minister was created within the Japanese government, and an annual review process of the IPR policy of various related ministries has been introduced. This initiative is intended not only to strengthen patent rights, but also to activate the technology market in order to stimulate knowledge diffusion in the form of intellectual property rights. 'Development of a Knowledge-Based Nation by Intellectual Property' became the slogan of the Japanese government, and pro-patent policy reforms have been introduced. Alongside this public policy initiative, firms became aware of the importance of IP as a strategic tool for competitive advantage. IP departments at firms, which used to have the functions of patent application and dealing with infringement cases, are now actively engaged in activities for the strategic use of intellectual property rights, such as the decision to license or not.

In addition, licensing has become one of the important variables in a Japanese firm's innovation strategy in recent years. According to the R&D Collaboration Survey conducted by RIETI in February 2004, firms are treating external collaborations more positively compared with five years ago, regardless of industry and firm size (RIETI, 2004). Due to the globalization of the economy and competition in innovation spurred on by the catching up of East Asian economies such as Korea and Taiwan, it has become increasingly difficult for large Japanese corporations to sustain their in-house innovation model. The increasing importance of scientific knowledge in the R&D process of enterprises in certain industries, such as pharmaceuticals, is also a factor fostering external collaborations, particularly with universities and public research institutions (Motohashi, 2005). In this process of a shift towards a more open innovation era, the management of intellectual property forms a key component in the innovation strategy of high-tech firms. (Chesbrough, 2006)

However, it is found that the technology market for patents is far from perfect, due to high transaction costs and information asymmetry between potential licensors and licensees (Arora et al., 2001; Gans and Stern, 2003). A few years ago, an Internet-based technology market attracted great attention as a killer IT application in an open innovation era. However, it turns out that such an open system does not work well, and most firms providing technology marketplace services such as yet2.com and Nine Sigma have changed their business model to technology intermediary services based on confidentiality (Lichtenthaler and Ernst, 2008). Gambardella et al. (2007) show that a large number of firms do not license even thought they are willing to do so. They conclude that such patents are simply less appealing, but the large transaction costs associated with the market for patents hinders the licensing of even appealing patents.

This paper directly addresses the issue of technology market imperfection that is causing this substantial number of unlicensed patents. We use the qualitative survey data on hampering factors associated with licensing activities, such as ‘difficulty in finding partners’ and ‘licensing negotiation and contract cost,’ taken from the Licensing Activity Survey, conducted by the University of Tokyo. This data is linked with the data on quantitative information on licensing activities at firms, taken from the JPO survey entitled SIPA (Survey of Intellectual Property Activities), and individual Japanese patent data, from the IIP (Institute of Intellectual Property) patent database (Goto and Motohashi, 2007), to estimate econometric models on the determinants of licensing and not licensing. The next section of this paper is devoted to the theoretical background of licensing propensity based on a survey of empirical analyses on the licensing and technology market. This section is followed by a description of datasets and some summary statistics. Section 4 is the quantitative analysis section, where the determinants of the licensing and not licensing propensity are estimated by using econometric models. Finally, a section for conclusions with managerial and policy implications is provided.

2. Theoretical background

There are numerous studies investigating the determinants of licensing propensity. For example, in the pharmaceutical industry, compared with other industries, a patent may be used more as a means of appropriating rents from a technological innovation (NISTEP, 1997; Cohen et al., 2002). Therefore, the licensing propensity is relatively higher for this industry (Anand and Khanna, 2000). A high licensing propensity is also found in the electronics industry, due to the substantial number of patents involved in cross-licensing (Grindley and Teece, 1997). Cross-industry variation of licensing propensity can be explained by typology of innovation, whether it is of a discreet or complex nature (Merges and Nelson, 1990). Typical discreet innovations can be found in the chemical (including pharmaceutical) industry, while complex innovations are found in electronics. Therefore, while active licensing activities are found in both industries, the motivations for licensing differ.

Whether a firm licenses or not depends also on complementary assets to intellectual property rights, such as marketing and production resources (Arora and Fosfuri, 2003). The licensing of patents may induce patent owner ‘rent dissipation’ due to the creation of a potential competitor in a product market. Therefore, a small company (likely to be a minor player in a product market with a small amount of complementary assets) tends to license out more, since the ‘revenue effect’ from licensing fees will be larger than the ‘rent dissipation effect.’ In this regard, the degree of market competition also has an important bearing on the licensing propensity. If a product market is close to perfect competition, a firm will not be very concerned about the rent dissipation effect, since monopoly rent is already small. A firm facing such a market competition environment is assumed to be to be more likely to license out

Naturally, the licensing propensity depends on the characteristics of inventions. For example, in a science-based industry such as biopharmaceuticals, where scientific content is important for innovation, the technological contents can be expressed more explicitly. This helps licensing deal-making because potential licensors are able to understand the technological contents more clearly (Arora and Cambardella, 1994; Arora and Ceccagnoli, 2006). Gambardella et al. (2007) list other patent characteristics affecting licensing propensity, including the generality of a technology by the spectrum of potential applications, the economic value of a technology and patent breadth measured by technology classes covered by the patent.

The characteristics of the technology market should be taken into account as a determinant of licensing propensity. There are various factors affecting the degree of clearness of the technology market for patents. One factor is the degree of patent right enforcement. Stronger patent protection can facilitate licensing activities because it is difficult for anyone to develop peripheral technology without infringements. Some industry variation, such as higher licensing propensity in the pharmaceutical industry, can be explained by this factor (Anand and Khanna, 2000). It is also found that the effectiveness of patent protection is positively related to licensing propensity after controlling for industry difference (Arora and Ceccagnoli, 2006).

Another factor associated with technology market imperfection is information asymmetry between potential licensor and licensee. A patent document provides rich information about the invention, but it is impossible to give an explicit description of all technological contents associated with the invention. Furthermore, a patent applicant is not willing to disclose everything, but wishes to retain some information about the invention as trade secrets. Therefore, a potential licensee has to make a licensing decision with only limited information about the whole technology. This is why Internet-based technology market services do not work effectively (Lichtenthaler and Ernst, 2008). Aghion and Tirole (1994) provide a theoretical model of innovation management organization, taking into account information asymmetry between R&D and marketing departments. In this regard, the nature of the scientific contents of a technology, discussed previously, is one of the factors affecting the degree of information asymmetry. More codified technology may help to reduce information asymmetry between a potential licensor and licensee, which would result in a clearer technology market for patents (Teece, 1986; Arora and Gambardella, 1994).

In addition, the cost associated with licensing contracts, negotiations and finding licensing partners, is also an important factor in determining technology market characteristics. Razgaitis

(2004) shows a number of relevant factors behind licensing deal failures, such as the difficulty in finding partners and the failure to reach mutual agreement in licensing conditions for US and Canadian firms. Recently, the OECD has conducted a survey on European countries and Japan, finding that similar factors are also relevant for these countries (Zuniga and Guellec, 2009).

3. Data and Variables

3.1 Data

In this paper, we have constructed a novel dataset combining three data sources; the Survey of Intellectual Property Related Activities (SIPA), the IIP Patent Database (IIP-PD) and the Licensing Activity Survey (LAS). As a result of the data linkage, we obtained a cross-section of data for about 1,200 Japanese firms in 2006. The following is a description of these datasets.

Survey on Intellectual Property Related Activities (SIPA): The Survey on Intellectual Property Related Activities (SIPA) is an annual statistical survey conducted by JPO (Japanese Patent Office). JPO began this survey in 2002 in order to collect data on various IP-related activities including applications, licensing and litigation concerning patents, utilities, designs and trademarks. The survey is conducted for all applicants exceeding a certain threshold number of applications in the previous year[2] and randomly sampled applicants for the remainder of the group (Motohashi, 2008). In this paper, we use the 2007 survey data, which refers to activities in 2006. After throwing out individual investors and public research organizations, we were left with approximately 4,500 samples to be linked with the other datasets.

SIPA covers a broad range of survey items. The survey consists of four parts, (1) applications for IPR, (2) usage of IPR, (3) information on IPR sections at firms and (4) IP-related infringements. In this paper, we mainly use the data from section (2), which covers data on the number of IPR usages by various types of status, such as usage by owner, and licensing out and in by type of licensing contract.

IIP Patent Database (IIP-PD): The IIP (Institute of Intellectual Property) Patent Database (IIP-PD) is an individual patent database, constructed from the Seiri Hyojunka Data, (organized and standardized data) by JPO, for innovation study researchers (Goto and Motohashi (2007)). For each patent, it includes data on the date of each stage from filing to the expiration of a right, data on applicants, right holders and inventors, and technology classification.

Licensing Activity Survey (LAS): The Licensing Activity Survey was conducted by the University of Tokyo in 2007. This survey was based on the international project coordinated by

[2] The threshold point is five IPRs (patents, utility models, design or trademarks)

the OECD and a common questionnaire was prepared for European and Japanese firms (Zuniga and Guellec, 2008). It surveys three areas, (1) patent propensity, appropriability importance, (2) licensing activities, and (3) changes in licensing activities and underlying factors. The survey was conducted with respect to 5000 firms sampled from the 2006 JPO patent applicant list, 1640 firms responding.

3.2. Dependent Variables

Based on this dataset, we have analyzed the propensity to license or not license. In this process, potential license patents (patents whose owners are willing to license) and actually licensed patents are distinguished, following the methodology in Gambardella et al. (2007). In this paper, the licensing propensity analysis is based on firm-level data, while Gambardella et al. (2007) use patent-level data. Our dataset ignores heterogeneity in the characteristics of patents owned by a firm, while firm-level data can represent a licensing propensity and strategy for a whole company. Another difference is that our paper addresses various factors which possibly cause technology market imperfections.

Figure 1 is a pictorial representation of our dependent variables. The whole width of the box represents the total number of patents owned by each firm. The total number of patents can be split into two parts, (1) patents for which there is a willingness to license and (2) patents for which there is no willingness to license. The first part can be further broken down into two parts, (1-1) patents actually licensed out and (1-2) patents for which there is a willingness to license but are not licensed out. Two kinds of indicators are used as dependent variables in this paper, LICENSE and POTENTIAL, as follows.

LICENSE = The share of the number of actually licensed patents to the total number of patents owned

POTENTIAL = The share of the number of not actually licensed patents to the total number of patents owned

In LICENSE, both denominator and numerator variables are obtained from SIPA. The value of POTENTIAL can be obtained from the following question in the LAS, ‘Share of your patent portfolio that you would be willing to license out, but could not actually license; share in total patents is 0%, 0-2%, 2-6%, 6-15%, or 15-100%, where the order of increasing share is denoted by a score of 0 to 4. The firms that answered 0% are not willing to license out, or have licensed out all patents which they are willing to license. The proportion obtained by adding LICENCE and POTENTIAL shows the parts of the portfolio that a firm is willing to license out, but we cannot employ this number in our analysis because POTENTIAL is based on a categorical variable.

Although LICENSE represents the licensing activity of a licensor, LICENSE takes the value of zero for two types of firms. One is a firm that has no willingness to license out, because the firm plans to use patent technologies exclusively for its own production and gain the technology monopoly rent. The other is a firm that would be willing to license out, but in fact was not able to do so. In order to distinguish between these two types of firms, we have created another variable called WILL, defined as follows.

$$\begin{aligned} WILL &= 0 \quad if\ \ LICENSE = 0\ and\ POTENTIAL = 0 \\ &= 1 \quad otherwise \end{aligned}$$

In this paper, we consider the actual licensor and the potential licensor separately.[3] By using LICENSE and WILL, we can come up with the following three types of firms.

- Group A, where firms are actual licensors, WILL=1 and LICENSE>0. These firms actually license out; 298 samples.

- Group B, where firms are potential licensors but not actual licensors, WILL=1 and LICENSE=0. These firms would be willing to license but in fact were not able to license out; 258 samples.

- Group C, where firms are neither potential nor actual licensors, or WILL=0. Such a firm has no willingness to license out; 81 samples.

In Group C, firms do not intend to utilize a license market because they plan to use patent technologies exclusively for their own production. On the other hand, firms in Group B are willing to license, but have not come to the stage of making an actual deal, and have been in the process of searching for possible licensees, or formulating a licensing agreement. Although for firms in both Group B and Group C the number of patents licensed out is zero, firms in Group B and Group C have different licensing out policies. We find that the number of firms in Group B is unexpectedly large, and that the potential license market should be larger than the observed market size, as is discussed by Gambardella et al. (2007).

[3] Note that we add a further issue, concerning whether a firm has been confronted with difficulties in making licensing deals (PARTNER and NEGOTIATE denoted in Section 3.3) in its licensing activity. Thus, WILL takes the value 0 if the firms that LICENSE=0 and POTENTIAL=0 have never been confronted with difficulties in making licensing deals.

3.3. Explanatory Variables

As explanatory variables to LICENSE and POTENTIAL, we have prepared two types of variables, one concerns the characteristics of the technology market and the other concerns the other determinant variables. Since our focus in this paper is on understanding the technology market, we start by explaining the former variables. The mean scores of each explanatory variable (as well as dependent variables) by the type of group (A, B or C) are provided in Table 1.

(1) Technology market variables

Degree of patent right enforcement: PROTECT

The degree of patent right enforcement is assessed by the following question in the LAS.

‘Of the four methods below, which is the best way to bring benefits to your company? Could you please rank patent protection?’

The four methods are patent protection, trade secret, complicated manufacturing or complicated products, and leading products in the market.

We convert the rank into a score. PROTECT takes the value 4 if the response indicated that patent protection is the best way to bring benefits. In Table 1, the average score is above 3, indicating that patent protection is the most or second most powerful method.

Scientific nature of technology: SCIENCE

The proxy for the scientific nature of a technology is based on the number of non-patent literature (typically research paper) citations per patent. SCIENCE is an average of the citation counts involving patents owned by a firm (from IIPDB). As is discussed in the previous section, the scientific nature of a technology is the nature of the technology per se, but it can be interpreted as being more codified knowledge, which leads to greater clearness in the technology market as well. Table 1 shows that the value of SCIENCE for Group A (actual licensors) is larger than for groups B and C (not actual licensors).

Difficulty in making licensing out deals: PARTNER and NEGOTIATE

The following question in the LAS is intended to capture the difficulty in making licensing out deals: ‘What hampering factors have you encountered in your licensing activity?’ The survey requests information concerning two factors:

- Identifying partners is difficult: PARTNER,
- Drafting and negotiating contracts is too complex/costly: NEGOTIATE.

Respondents are asked to rate the importance of each factor on a scale of 0 to 3 (‘0’ indicates no relation, and ‘3’ indicates that the factors are very important). PARTNER and NEGOTIATE represent high transaction costs in a license market. These factors are the cause of the situation where a firm which would be willing to license out was not actually able to do so.

In Table 1, both PARTNER and NEGOTIATE take the value of zero in Group C since these firms are not willing to license out. Comparing Group A and Group B, PARTNER shows almost the same value of 1.6 in both cases, implying that it is difficult to find licensing partners. As for NEGOTIATE, the score for Group B is slightly higher, and is not considered to be as problematic as PARTNER.

Opportunity to find potential licensing partners: OPPORTUNITY

We measure the degree of opportunity to find potential partners in the technology market by the extent to which a firm’s patent belongs in the same technology category as the others. We calculate the Herfindahl Hirschman Index (HHI) with respect to each IPC main group first by IIP-PD, then a firm-level index is constructed using a weighted average of HHI at firm level (by using the corresponding HHI of the IPC of each patent owned). Finally, we subtract this figure from 1 in order to come up with a firm-level index, reflecting the extent to which a firm has patents whose technology class is popular among other patent holders. We assume that these other patent holders may be potential licensees, so this diversification index of patents by technology class can be interpreted as an index indicating opportunities for finding licensing partners.

(2) Non-technology market variables

Firm size: EMP

For firm size, we use the number of employees given in SIPA. This also represents complementary assets. We employ the logarithms of EMP in the econometric model, named log(EMP). In Table 1, the firm size of actual licensors in Group A is three times larger than those that are not actual licensors in Groups B and C.

Specialized R&D: RD

We employ the dummy variable that a firm makes a special business of R&D if the propensity for R&D denoted by the share of R&D cost in sales is larger than 30%. The average in Table 1 shows the proportion of specialized R&D firms. The proportion in Group A is twice as large as those that are not actual licensors in Groups B and C.

Affiliate dealing: AFFIL

The number of licensing deals with affiliated firms causes LICENSE to increase artificially, and so we include control variables for this in our mode. AFFIL80-100, AFFIL60-80, AFFIL40-60, AFFIL40-60, AFFIL20-40, AFFIL0-20 take the value 1 if the LAS respondent indicated that the share of licensing out with affiliated partners is 80-100%, 60-80%, 40-60%, 20-40%, and 0-20%, respectively. All five dummy variables take the value 0 if the firm does not license out, as in Groups B and C. Any one out of the five dummy variables takes the value 1 if the firm licenses out, as in Group A. That is, the proportions of firms in Group A sum to 1.

Cross-licensing: CROSS

The number of patents licensed includes three types of license contracts; licenses for license revenue, cross-licenses, and license pools. Unlike licenses for license revenue, cross-licenses and license pools are used for coordination with other firms.[4] Therefore, we consider that these could show a different structure of licensing activity, and control for the share of cross-licensing out by use of a variable named CROSS. To identify the type of firm, we use the share of cross-licensing out in the LAS. CROSS80-100, CROSS60-80, CROSS40-60, CROSS40-60, CROSS20-40, CROSS0-20 take the value 1 if a LAS respondent indicated that the share of cross-licensing out is 80-100%, 60-80%, 40-60%, 20-40%, and 0-20%, respectively. All five dummy variables take the value 0 if the firm does not license out. Thus cross-licensing is controlled for in our empirical study.

Industry dummy variables:

In order to control for industry characteristics of licensing activities, six industry dummy variables, CHEMICALS, PHARMACEUTICALS, ELECTRONICS, MACHINERY, TRANSPORTATION, and INSTRUMENTS are included.

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[4] A typical case of substantial cross-licensing can be found in the semiconductor industry, where it has become difficult to make a product using only in-house technology, thus making it necessary for all firms to in-license technology. A working solution in this case is to make cross-licensing agreements between big players (Grindley and Teece, 1997). In order to prepare for future cross-licensing agreements, there is some incentive for a firm to build up a strong patent portfolio. Therefore, the share of unused patents for future cross-licensing deals tends to be large. On the other hand, since cross-licensing involves substantial numbers of patents, the licensing propensity may become large for cross-licensing firms.

4. Econometric analysis and discussion

4.1 Determinants of LICENSE

We estimate the determinants of licensing propensity (LICENSE) in order to analyze what factors determine the licensing activity, reported in Table 2. We start by estimating the Tobit model for the licensing propensity using the full sample, reported in Model (1) in Table 2. Firstly, we find a positive and significant effect for PROTECT, suggesting that stronger patent protection would be an advantage in licensing out. For patent technology, potential demand would exist because it is difficult to develop peripheral technology around more strongly protected patent technology. Secondly, OPPORTUNITY has a positive and significant effect on licensing propensity. In a more competitive technology market, it would be easier for firms to obtain licensing opportunities, causing licensing propensity to increase. Thirdly, log(EMP) is negative and has a significant effect on licensing propensity, which is consistent with the hypothesis of complementary assets (Arora and Fosfuri, 2003).

In contrast, difficulties in making licensing out deals (PARTNER, NEGOTIATE) are not statistically significant. Neither did we find statistically significant results for SCIENCE or RD.

As in the previous section 3.2, we classify firms into three groups according to the number of patents licensed and the willingness to license out, which consists of the actual licensors (Group A), the potential but not actual licensors (Group B), and the not potential licensors (Group C). In the econometric model, where we analyze the determinants of licensing propensity, the firms in Group B or Group C have a licensing propensity of zero. That is, a zero realization for the dependent variable represents a corner solution (i.e. in Group C) or a negative value for the underlying latent dependent variable (i.e. in Group B), (Blundell and Meghir, 1987). However, in the Tobit model all zero values taken by the dependent variable would correspond to a corner solution, and this assumption is too restrictive for our study. Thus, we employ the Double Hurdle model, which overcomes the restrictive assumption by Cragg (1971). Blundell and Meghir (1987) label the Double Hurdle model a bivariate model, against the standard univariate Tobit model, because ‘bivariate’ is the definition of a separate process determining zero-one discrete behavior from that determining continuous observation. When we apply the Double Hurdle model to our data, both the willingness to license and actual licensing are classified. That is, two hurdles must be cleared in order to observe the non-zero licensing propensity, the first hurdle being whether a firm is willing to license out or not, and the second hurdle being whether the firm is actually able to make licensing out deals.

Model (2) in Table 2 shows the results of the Double Hurdle model with independent, homoskedastic and normally distributed error terms.[5] An identification between the first hurdle (willing to license or not) and the second hurdle (actually licensing propensity) is made by using PATRNER, NEGOTIATE, AFFIL and CROSS dummies only for the second step explanatory variables, since all of them are irrelevant to the first hurdle. PARTNER and NEGOTIATE represent an exogenous factor to a licensor's ex-ante licensing decision, but both affect ex-post licensing outcomes. In addition, AFFIL and CROSS can be obtained only for a firm actually licensing out. On the other hand, the remainder of the explanatory variables can be taken into account in the potential licensor's ex-ante licensing decision. Compared with the results of the Tobit model in Model (1), the sizes of the coefficients for the results of a LICENSE equation in Model (2) are quite different. This suggests that the result of the Tobit model has an estimation bias, and that we should control for willingness of licensing out when estimating the licensing propensity.[6]

In the Double Hurdle model, the signs and statistical significances in the LICENSE equation are not very much different from those in the Tobit model (Model (1)). We therefore compare the results of the first hurdle (WILL) and second hurdle (LICENSE) in Model (2). First, we find that PROTECT has a positive sign for both WILL and LICENSE. A firm which, for any reason, believes that the patent system is a strong tool for appropriating rent from its technological innovation, may be willing to make greater use of the technology market for patents. In addition, stronger patent protection leads to more ex-post licensing deals through a clearer technology market.

Secondly, OPPORTUNITY is statistically significant in the inference concerning willingness to license, and is also positively related to actual licensing propensity. This result suggests that a firm takes into account the number of potential licensees in its ex-ante licensing decision making. In addition, this factor also affects actual licensing deals. Again, the characteristics of the technology market have a bearing on licensing propensity in this regard.

SCIENCE has a positive effect on WILL, but does not have a significant effect on LICENSE. The scientific nature of an invention is well perceived by its inventor, which is already taken into account in ex-ante licensing expectations, and there will thus be no surprise in the technology market for patents. A similar result can be found in RD, a dummy variable for a

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[5] The estimation program of the Double Hurdle model has not been incorporated into the standard statistical software, and user-written programs are used. We use the program written for STATA by Julian Fennema, http://www.sml.hw.ac.uk/somjaf/Stata/.

[6] Flood and Grasjo (2001) evaluate the differences between some types of Tobit model and the Double Hurdle model by a Monte Carlo simulation, and clarify the serious bias problem of the Tobit model. Note that they also point out that an incorrect selection equation in the Double Hurdle model can cause serious bias in the estimated parameters.

specialized R&D firm, which has a strong incentive to license out (with less complementary assets such as production and marketing resources). It should be noted that SCIENCE is statistically significant even after controlling for RD.

Finally, log(EMP), representing firm size, has a negative effect on licensing propensity, which is different to the positive effect on willingness. Firm size could influence the willingness to license out in two ways. One is that a large firm may be less willing to license because the firm has sufficient complementary assets for production using patent technology, described as 'Complementary assets such as production and market facilities' in Section 2. The other is that a large firm may be willing to license because the firm may patent non-core innovations in order to build a sizable patent portfolio to be used in cross-licensing negotiations, causing the firm to be more likely to license the non-core technology (Gambardella et al., 2007). We find a positive effect of firm size on willingness. As for the negative effect on licensing propensity, it would suggest that a large firm has a sizable patent portfolio, resulting in the denominator of licensing propensity being large.

In summary, we have found statistically significant coefficients with predicted signs for some technology market variables for PROTECT, OPPORTUNITY and SCIENCE. However, the pattern of statistical association with WILL and LICENSE differs across these variables. PROTECT and OPPORTUNITY affect both dependent variables, and SCIENCE affects only WILL. The factors having a statistically significant relationship with WILL simply confirm rational decision making by firms, which is consistent with the theoretical background. From a policy perspective, the factors affecting LICENSE are more important, since policy actions influencing these factors may induce more active licensing activities among firms.

4.2 Determinants of POTENTIAL

As suggested in Gambardella et al. (2007), the observed number of licensing deals is smaller than the potential number of licensing deals, and the potential licensing market may be larger because potential licensors do not always conclude licensing deals. Why is it that not all potential licensors are able to make licensing out deals? We estimate the determinants of POTENTIAL by using the same specification as with the LICENSE equations. The results are reported in Table 3, which consists of Model (1) using the full sample and Model (1-2) using a subsample of potential licensors with an ordered probit model.[7] Model (2) shows the result of using the Double Hurdle model.

[7] Model (1) includes firms that are not potential licensors, that is, have no willingness to license out. These firms have a value of zero for POTENTIAL. The subsample for Model (1-2) consists of firms that are willing to license out.

Here only PARTNER has a positive and significant effect on POTENTIAL among the various technology market variables. In addition, the coefficient of OPPORTUNITY, representing the potentiality to find partners is positive, but not statistically significant. We can therefore, conclude that 'finding a licensing partner' is an important technology market factor which cannot be managed at the level of the individual firm. On the other hand, we cannot find a statistically significant result with PROTECT in the not licensing estimation. In the WILL equation in Model (2), SCIENCE (as well as log(EMP) and RD) is statistically significant and positive, which is consistent with the results in Model (2) of Table 2.

5. Conclusion

In this paper, we have provided an empirical analysis of the technology market for patents in Japan, by using a novel firm-level dataset combining a JPO survey, entitled Survey of Intellectual Property Activities, the IIP patent database, and the Licensing Activity Survey conducted by the University of Tokyo. We use a two-step model to estimate the licensing propensity; the first step is to estimate the determinants of potential licensors (willingness to license), and the second step is to identify factors behind actual licensing out (licensing propensity). We have found that significant numbers of patents at firms are not licensed out, even through the owner is willing to do so. This may be due to that the fact that the technology market is far from perfect, and that there are obstacles to the trading of patents on the market (Gambardella et al., 2007).

Our econometric models are focused on understanding the characteristics of the technology market. We have tested four types of factors behind market imperfections, i.e., (1) the degree of patent enforcement, (2) the scientific nature of a technology (reduced information asymmetry), (3) the difficulty in making licensing out deals, and (4) the opportunity to find potential licensing partners. It is found that the scientific nature of a technology influences ex-ante licensing decisions by firms, and that this is not related to the licensing (or not licensing) outcomes after controlling for firms' ex-ante willingness to license. In contrast, the difficulty in finding partners (or opportunities to find licensing partners) is related to both ex-ante willingness and the ex-post licensing outcome. The degree of patent enforcement is also related to both ex-ante and ex-post licensing propensity, but neither of them is related to the not licensing propensity.

A direct policy implication from our study is that information dissemination activities are important for activating the technology market for patents, since the difficulty in finding partners is a primal factor behind a substantial number of unlicensed patents, despite willingness on the part of the owners to license out. However, it should be noted that Internet-based technology marketplaces (Internet shops for patents) do not work effectively (Lichtenthaler and Ernst, 2008), and substantial efforts are required by intermediaries for technology transfer to occur. Therefore, promoting technology intermediary service companies such as Inno Centive and Nine Sigma is another option for policy makers.

References

Aghion, P. and J. Tirole (1994), The management of innovation, *The Quarterly Journal of Economics*, MIT Press, 109(4), pp. 1185-1209.

Anand, B. and T. Khanna (2000), The structure of licensing contracts, *Journal of Industrial Economics*, March 2000, 48, pp. 103-135.

Arora, A. and M. Ceccagnoli (2006), Patent protection, complementary assets and firm’s incentive for technology licensing, *Management Science*, 52(2), pp. 293-308.

Arora A. and A. Fosfuri (2003), Licensing the market for technology, *Journal of Economic Behavior & Organization*, 52, pp. 277-295.

Arora, A. and A. Gambardella (1994), The changing technology of technical change: General and abstract knowledge and the division of innovative labor, *Research Policy*, 23, pp. 523-532.

Arora, A., A. Fosfuri and A. Gambardella (2001), *Markets for Technology, The Economics of Innovation and Corporate Strategy*, MIT Press.

Blundell, R. and C. Meghir (1987), Bivariate alternatives to the Tobit model, *Journal of Econometrics*, 34, pp. 179-200.

Chesbrough, H. (2006), *Open Business Models: How to Thrive in the New Innovation Landscape*, Harvard Business School Press.

Cohen, W., A. Goto, A. Nagata, R. Nelson and J. Walsh (2002), R&D spillovers, patents and the incentives to innovate in Japan and the United States, *Research Policy*, 31, pp. 1349-1367.

Cragg, J. (1971), Some statistical models for limited dependent variables with application to the demand for durable goods, *Econometrica*, 39(5), pp. 829-844.

Flood, L. and U. Grasjo (2001), A Monte Carlo simulation study of Tobit models, *Applied Economics Letters*, 8, pp.581-584.

Gambardella, A., P. Giuri, and A. Luzzi (2007), The market for patents in Europe, *Research Policy*, 36, pp.1163-1183.

Gans, J. S. and S. Stern (2003), The product market and the market for "ideas": Commercialization strategies for technology entrepreneurs, *Research Policy*, 32(2), pp. 333-350.

Goto, A., and K. Motohashi (2007), Construction of a Japanese Patent Database and a first look at Japanese patenting activities, *Research Policy*, 36(9), pp. 1431-1442.

Grindley P. and D. Teece (1997), Managing intellectual capital: Licensing and cross-licensing in Semiconductors and Electronics, *California Management Review*, 39(2) pp. 8-41.

Lichtenthaler, U and H. Ernst (2008), Innovation intermediaries: Why internet marketplaces for technology have not yet met the expectations, *Creativity and Innovation Management*, 17(1) pp. 14-25.

Merges R. P. and R. Nelson (1990), On the complex economics of patent scope, *Columbia Law Review*, 90, pp. 836-876.

Motohashi, K. (2005), University-industry collaborations in Japan: The role of new technology-based firms in transforming the National Innovation System, *Research Policy*, 34(5), pp. 583-594

Motohashi, K (2008), Licensing or not licensing?: Empirical analysis on strategic use of patent in Japanese firms, *Research Policy,* 37(9), pp. 1548-1555.

NISTEP (National Institute of Science and Technology Policy) (1997), Appropriability and technological opportunity in innovation: A Japan-U.S. comparative study using survey data, (in Japanese) NISTEP REPORT No. 48.

Razgaitis, S. (2004), US/Canadian licensing in 2003: Survey results, *Journal of the Licensing Executives Society* 34, pp. 139-151.

RIETI (Research Institute of Economy, Trade and Industry) (2004), Report on RIETI's survey on external collaboration in R&D for Japanese firms (in Japanese), Research Institute of Economy Trade and Industry, March 2004.

Teece, D. J. (1986), Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy, *Research Policy* 15, pp. 285-305.

Zuniga, M. P. and D. Guellec (2009), Who licenses out patents and why?: Lessons from a business survey, STI Working Paper 2009/5, OECD, Paris.

Figure 1. Illustration of licensing and not licensing indicators

<table>
<tr><td colspan="2"># of patents for which there is a willingness to license</td><td rowspan="2"># of patents for which there is no willingness to license</td></tr>
<tr><td>Actually licensed</td><td>Not actually licensed</td></tr>
</table>

Total number of patents owned by a firm

LICENSE = The share of the number of actually licensed patents to the total number of patents owned

POTENTIAL = The share of the number of not actually licensed patents to the total number of patents owned

Table 1. Descriptive statistics

Variable		Data source	A(298)		B(258)		C(81)	
			Mean	S.D.	Mean	S.D.	Mean	S.D.
WILL	Dummy	SIPA&LAS	1	0	1	0	0	0
LICENSE	Value	SIPA	0.126	0.205	0	0	0	0
POTENTIAL	Score	LAS	1.909	1.547	1.415	1.554	0	0
PROTECT	Score	LAS	3.460	0.720	3.329	0.825	3.222	1
SCIENCE	Value	IIPDB	0.231	0.633	0.131	0.424	0.083	0
PARTNER	Score	LAS	1.607	1.096	1.601	1.009	0	0
NEGOTIATE	Score	LAS	0.671	0.868	0.891	0.931	0	0
OPPORTUNITY	Value	IIPDB	0.868	0.063	0.873	0.065	0.866	0.078
EMP	Value	SIPA	2174	4396	557	521	775	3387
RD	Dummy	SIPA	0.027	0.162	0.008	0.088	0.012	0.111
AFFIL80-100	Dummy	LAS	0.349	0.477	0	0	0	0
AFFIL60-80	Dummy	LAS	0.050	0.219	0	0	0	0
AFFIL40-60	Dummy	LAS	0.054	0.226	0	0	0	0
AFFIL20-40	Dummy	LAS	0.050	0.219	0	0	0	0
AFFIL0-20	Dummy	LAS	0.497	0.501	0	0	0	0
CROSS80-100	Dummy	LAS	0.081	0.273	0	0	0	0
CROSS60-80	Dummy	LAS	0.023	0.152	0	0	0	0
CROSS40-60	Dummy	LAS	0.047	0.212	0	0	0	0
CROSS20-40	Dummy	LAS	0.050	0.219	0	0	0	0
CROSS0-20	Dummy	LAS	0.799	0.402	0	0	0	0

Note: Values in parentheses are the numbers of firms in the groups, A, B and C.

Table 2. Estimation of licensing propensity:
The Tobit model and the Double Hurdle model

	(1)		(2)			
Dependent var.	LICENSE		WILL		LICENSE	
PROTECT	0.036	(0.012)***	0.054	(0.016)***	0.015	(0.007)**
SCIENCE	0.014	(0.026)	0.088	(0.031)***	0.012	(0.021)
PARTNER	−0.007	(0.01)			0.013	(0.009)
NEGOTIATE	−0.018	(0.013)			0.004	(0.009)
OPPORTUNITY	0.482	(0.159)***	0.361	(0.196)*	0.231	(0.091)**
EMP	−0.039	(0.009)***	0.066	(0.017)***	−0.025	(0.008)***
RD	0.045	(0.118)	0.175	(0.098)*	0.039	(0.095)
AFFIL80−100	1.409	(0.168)***			0.141	(0.017)***
AFFIL60−80	1.412	(0.165)***			0.121	(0.027)***
AFFIL40−60	1.396	(0.166)***			0.151	(0.04)***
AFFIL20−40	1.387	(0.16)***			0.132	(0.019)***
AFFIL0−20	1.420	(0.162)***			0.172	(0.016)***
CROSS80−100	0.088	(0.048)*			0.094	(0.054)*
CROSS60−80	0.202	(0.107)*			0.168	(0.11)
CROSS40−60	−0.014	(0.036)			0.006	(0.04)
CROSS20−40	0.035	(0.056)			0.040	(0.051)
CHEMICALS	−0.113	(0.029)***	0.063	(0.036)*	−0.048	(0.021)**
PHARMACEUTICALS	0.026	(0.08)	2.820	(0.047)***	0.034	(0.05)
ELECTRONICS	−0.038	(0.035)	−0.036	(0.035)	−0.024	(0.017)
MACHINERY	−0.088	(0.027)***	0.156	(0.036)***	−0.038	(0.019)**
TRANSPORTATION	−0.062	(0.027)**	−0.034	(0.049)	−0.034	(0.019)*
INSTRUMENTS	0.186	(0.125)	0.100	(0.093)	0.039	(0.039)
Constant	−1.526	(0.235)***	4.780	(0.186)***	−0.140	(0.086)
Log likelihood	92.328		264.244			
Wald test	255.25					
No. samples	637		637			

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. Values in parentheses are robust standard errors. Inference (1) is the result of the Tobit model, and inference (2) employs the Double Hurdle model. Inference (2) consists of the first hurdle (WILL) and the second hurdle (LICENSE). CROSS0-20 is dropped for the inferences due to multicollinearity.

Table 3. Estimation of POTENTIAL: The Ordered Probit model and the Double Hurdle model

	(1)	(1-2)	(2)	
Dependent var.	POTENTIAL	POTENTIAL	WILL	POTENTIAL
PROTECT	0.085 (0.059)	0.089 (0.063)	0.039 (0.028)	0.103 (0.081)
SCIENCE	−0.008 (0.092)	−0.023 (0.093)	0.058 (0.033)*	0.025 (0.127)
PARTNER	0.268 (0.047)***	0.141 (0.049)***		0.463 (0.064)***
NEGOTIATE	0.008 (0.051)	−0.084 (0.052)		0.090 (0.072)
OPPORTUNITY	1.111 (0.805)	1.248 (0.839)	0.307 (0.207)	1.754 (1.103)
EMP	0.049 (0.034)	0.043 (0.035)	0.063 (0.013)***	0.057 (0.049)
RD	0.409 (0.374)	0.558 (0.38)	0.354 (0.096)***	0.502 (0.498)
AFFIL80−100	0.160 (0.129)	−0.036 (0.13)		0.339 (0.173)*
AFFIL60−80	0.442 (0.166)***	0.321 (0.174)*		0.702 (0.288)**
AFFIL40−60	0.856 (0.228)***	0.572 (0.243)**		1.547 (0.316)***
AFFIL20−40	0.989 (0.264)***	0.784 (0.278)***		1.551 (0.334)***
AFFIL0−20	0.704 (0.125)***	0.497 (0.128)***		1.149 (0.171)***
CROSS80−100	−0.170 (0.256)	−0.209 (0.252)		−0.193 (0.357)
CROSS60−80	−0.218 (0.527)	−0.268 (0.538)		−0.236 (0.681)
CROSS40−60	0.010 (0.316)	−0.051 (0.339)		0.053 (0.401)
CROSS20−40	0.433 (0.29)	0.418 (0.301)		0.442 (0.368)
CHEMICALS	−0.029 (0.138)	−0.101 (0.142)	0.032 (0.033)	0.055 (0.191)
PHARMACEUTICALS	0.419 (0.271)	0.339 (0.264)	2.528 (0.048)***	0.666 (0.395)*
ELECTRONICS	0.277 (0.133)**	0.357 (0.144)**	−0.126 (0.054)**	0.321 (0.19)*
MACHINERY	0.080 (0.149)	0.009 (0.151)	0.113 (0.032)***	0.166 (0.206)
TRANSPORTATION	0.267 (0.194)	0.320 (0.205)	−0.027 (0.061)	0.353 (0.263)
INSTRUMENTS	−0.029 (0.234)	−0.077 (0.24)	0.013 (0.058)	0.052 (0.33)
CONSTANT			4.993 (0.232)***	−2.181 (1.08)**
Log likelihood	−861.659	−817.424	−1091.344	
Wald test	135.16	74.97		
No. samples	637	556	637	

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. Values in parentheses are robust standard errors. The data for Inference (1) is the result of the ordered probit model using the full sample, and inference (1-2) uses a subsample of firms that have a willingness to license out (WILL=1). Inference (2) employs the Double Hurdle model, and consists of the first hurdle (WILL) and the second hurdle (POTENTIAL). CROSS0-20 is dropped for the inferences due to multicollinearity.