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Determinants of Technology Licensing

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Abstract:
This paper empirically analyzes technology licensing with the help of a large panel data set of observed licensing transactions involving United States companies across all sectors during the 1990s. The stock of technological knowledge of the licensor, this company's prior licensing experience, the rate of growth of its primary industry, the strength of the intellectual property protection regime in that industry, and the nature of the new technologies produced by the licensor are found to be important determinants of the propensity to sell technology through nonexclusive licenses. The degree of technological/product complexity of the primary industry of the licensor proved a significant explanatory factor of the propensity for exclusive licensing (negative effect) and for cross licensing (positive effect). There are indications of a U-shaped relationship between stocks of technological knowledge and company tendency to sell technology.

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1. Introduction

Licensing agreements is a commonly observed type of inter-firm alliances, especially in technology-intensive industries. For instance, the recent study by Arora, Fosfuri and Gambardella (2001) points to over 15,000 known technology licensing transactions worldwide with a total value of over $320 billion in the period 1985-1997, implying an average of nearly 1,150 transactions worth $25 billion per year. Thompson Financial's SDC database used in this paper lists 10,069 publicly announced licensing agreements during the 1990s across all sectors around the globe. One frequently reads on the popular press that companies like Texas Instruments (TI) and International Business Machines (IBM) follow aggressive strategies of exploitation of their extensive technology patent portfolios through licensing. It is also understood that technology licensing agreements are frequently used by multinational corporations as an entry to foreign markets or as part of their foreign direct investment (licensing between affiliated companies). However, there is also conflicting evidence that companies in the United States, Western Europe, and Japan ignore a large fraction of their patented technologies, which could be licensed or profitably sold (British Technology Group1998). While the issue is related to the long debate among economists concerning market internalization and the creation of integrated companies and multinational corporations (Caves, 1982), there is no question that we need a lot more empirical work to explain when and why firms use the market to exploit proprietary technologies.

A voluminous literature in industrial economics has dealt with the factors that may inhibit the proper functioning of technology markets. In an eloquent paper forty years ago, Arrow (1962) described the problems of appropriability, indivisibility, and uncertainty that hamper the markets of technology. Once an idea is disclosed to a potential buyer, it was argued, the buyer could use the information without paying for it. Thus, the higher the degree of knowledge appropriability (i.e. the stronger the patent or intellectual property protection), the better the ability of the licensor to capture a larger share of the rents generated from the licensed technology. Under a weak intellectual property rights (IPR) regime, the licensee firm can use the licensor's technology without paying appropriately for it. In other words, strong IPR protection can be considered as the remedy for the well known "appropriability problem" in the market fortechnology.

Studies on contracts and transaction costs have elaborated on the causes and effects of moral hazard and asymmetric information in exchanging knowledge through arm's length transactions making the underlying contracts incomplete (Caves, 1996; Hart, 1995; Menard, 1996; Salanie, 2002). Merges (1998) argues that transaction costs of technology licensing are negatively related to the strength of patent protection. To counteract the licensee's incentive to shirk payment in the case of weak IPR protection the licensor's costs for monitoring and enforcement will increase.

On the other hand, evolutionary economics (Nelson and Winter, 1982; Nelson, 1995) and management theory have placed a lot of attention to the organizational aspects of the innovation process, showing that often the requisite capabilities and routines are difficult to exchange through the market (Teece, 1977). "Cognitive" limitations in the transfer of technology to another context require extensive adaptations and costs (Arora and Gambardella 1994). Arora and Fosfuri (2003) also point out that technology licensing may erode the profit of licensor due to the establishment of yet another competitor in the downstream product market.

Empirical literature on technology licensing has been less forthcoming. Several empirical studies of licensing behavior exist that are based on small samples of surveys, such as the study by Caves, Crookell, and Killing (1983) covering the United States, the United Kingdom and Canada. There are also some studies of licensing activity in particular industries such as chemicals (Grindley and Nickerson 1996) and electronics (Grindley and Teece 1997). But, to the best of our knowledge, econometric studies based on comprehensive data sets of observed licensing agreements across many industries are rare. One exception is the study of Anand and Khanna (2000). They use a relatively large sample of observed licensing agreements that occurred in the period 1990-1993 in three manufacturing sectors: chemicals and pharmaceuticals, computers and machinery and electronics (SIC 28, 35, 36). But their study falls short of examining licensing determinants at the business level. Our study covers a wider spectrum of industries that contribute significantly to observed technology licensing trends, including both manufacturing and services such as business services and software (SIC 73). Moreover, we engage in firm-level analysis using a large panel dataset that extends for a full decade.

This paper reports the results of an empirical examination of technology licensing behavior at the firm level based on a large panel data set of observed licensing transactions involving United States companies across all industry sectors during the period 1990-1999. The theoretical literature has made a convincing argument that both internal and external factors to the licensor determine the propensity of the firm to license its technology out to others. Our investigation explains the number of licenses granted by a firm on the basis of the characteristics of the selling company and the characteristics of the company's primary industry.[1]

We find that the stock of technological knowledge of the licensor, this company's experience with technology licensing, the rate of growth of its primary industry, the strength of the intellectual property protection regime in that industry, and the nature of the new technologies produced by the licensor company (general purpose technologies) are important determinants of the propensity to license out technology. These factors are highly significant when one examines either all kinds of licenses lumped together or the largest subgroup, nonexclusive licenses, individually. They are also significant in explaining cross licenses, save for the rate of industry growth and the infrastructural nature of licensor technology. The degree of technological/product complexity of the primary industry of the licensor proves a significant explanatory factor of exclusive licensing and cross licensing. Finally, we find indications of a U-shaped relationship between recent stocks of technological knowledge and company tendency to sell proprietary technology.

The rest of the paper is organized as follows. Section 2 provides the theoretical background. Section 3 describes the data. Section 4 presents the econometric methodology and specifies the empirical model. Section 5 discusses the main results. Finally, Section 6 concludes.

2. Theoretical Background

The theory section defines the basic context of licensing in an industry. We adapt the model of Arora and Fosfuri (2003) for this purpose, while complicating somewhat the payment mechanism and the knowledge appropriability regime.

Consider an oligopoly in which N firms have propriety technologies for the production of a good that can either be perfectly homogeneous or differentiated across technologies. When the good is differentiated, each variety is assumed to be an equally imperfect substitute for all others across all varieties. Apart from N incumbent technology owners, we assume that there exist many potential entrants who, even though cannot innovate, can produce if they receive the rights to use the technology from one of the incumbent technology owners. Their output is assumed to be homogeneous with that of the original licensor. Product market entry is costless. Incumbents can both produce by using their own technology and license their technology to prospective entrants.

Let k_i be the number of licenses sold out by firm $i = 1,2,\ldots N$. Each of N incumbents can enter into licensing contracts, thereby giving rise to a maximum of $\sum_{i=1}^{N} k_i$ possible new competitors in the product market using that respective technology. The maximum number of firms that can have the technology and can produce the good is equal to $\sum_{i=1}^{N} k_i + N$. Hence, the strategy set of each incumbent technology owner has two components: it can decide whether to license or not; it can also choose how many licenses to sell. For analytical convenience, we assume that k_i and N are continuous variables.

The licensor collects a fixed fee, F, and a royalty, r, per unit of output produced with the licensed technology. The licensing contract involves a fixed transaction cost, $T \geq 0$, all born by the licensor. This cost relates to gathering information about licensees and bargaining with them as well as writing and enforcing contracts. The licensor is able to collect payment at the rate q indicating the strength of intellectual property protection regime.

A one-shot, two-stage game is followed. The first stage corresponds to the technology market: N incumbent technology owners decide how many licenses k_i to sell.[2] The second stage corresponds to the product market: all firms with technology access produce and sell a product made by it. Thus, each incumbent

[1] A companion paper also introduces factors reflecting the relationship between the licensor and the licensee and characteristics of the latter (Kim and Vonortas, 2003). The econometric approach in that paper is radically different than the one presented here. The advantages of the current approach include that it can focus on the incentives of the licensor, rather than being confined to the relationship between pairs of organizations, and that it introduces the stock of technological knowledge as a basic factor affecting the propensity of a firm to sell proprietary technology.

[2] One license per entrant. We assume that once licensors commit the number of licenses, all other firms can observe it.

technology owner competes both with other incumbent companies and new entrants at the product market. Backward induction is used.

Second Stage: "Competition in the Product Market"

We assume Cournot competition in the product market. The inverse demand function for each product variety *i* is as follows:

$$p_i = 1 - (x_i + \sum_{k_i} x_i) - n \sum_{N-i} (x_j + \sum_{k_j} x_j) , \qquad (1)$$

for *i = 1,2,…N* , where p_i denotes prices, ($x_i + \sum_{k_i} x_i$) is quantities supplied by firms using the technology of firm *i*, and $n \sum_{N-i} (x_j + \sum_{k_j} x_j)$ is the sum of all quantities supplied by firms endowed with technology different from *i* (*N-i* stands for all varieties but *i*).

The term n stands for the degree of product differentiation across varieties. We assume that $n \in [0,1]$, with products being homogeneous for n = 1 and completely differentiated for n = 0. Higher n values represent more similar products across incumbent technology owners. For simplicity, production costs are assumed to be negligible; they are set at zero.

Each firm producing with variety *i* (technology owner or licensee) maximizes the following profit in the product market.

$$\max_{x_i} p^i = p_i \, x_i , \qquad (2)$$

From the first order conditions, we can compute the equilibrium price and profit at the product market (Appendix 1).

First Stage: "Competition in the Technology Market"

Given the results of quantity competition in the second stage of the game, the total profit of each incumbent technology owner *i* is given by:

$$V^i \ (k_i , k_{-i} , q , F , r , n , N , T) = p^i + q (F + r x_i) k_i - T \ k_i , \qquad (3)$$

for *i = 1,2,…N* , where *?* denotes the degree of technical knowledge appropriability. Knowledge is more appropriable the stronger the intellectual property rights enforcement regime in an industry is (e.g., patent protection enforcement level). We assume that *?* $\in [0,1]$, where perfect IPR protection corresponds to *?* = 1 and no protection corresponds to *?* = 0. In our setup, q accounts for the ability of the licensor to appropriate the rents generated from licensing technology. Thus, each incumbent technology owner *i*'s total profit is the sum of the profits from its own production (p^i) and total licensing income, including both the fixed fee and per-unit royalty payment from k_i licensees ($q(F + rx_i)k_i$), minus licensing transaction costs (=$T \ k_i$).

Each incumbent technology owner *i* chooses k_i in order to maximize its total profit given by (3). The first order condition for an interior maximum is:

$$V^i_k \ (k_i , k_{-i} , q , F , r , n , N , T) = qF + qrx_i + p^i_k + qrk_i x_{ik} - T \ \leq 0, \qquad (4)$$ [3]

[3] $V^i_{kk} = 2qrx_k + p_{kk} + qrkx_{kk} < 0$. Therefore, the second order condition is satisfied.

for $k_i \geq 0$ and $i = 1,2,\ldots N$, where $V_k^i = \frac{\partial V^i}{\partial k_i}$, $p_k^i = \frac{\partial p^i}{\partial k_i}$ and $x_{ik} = \frac{\partial x_i}{\partial k_i}$.

From the equation system (4) we can obtain a stable symmetric licensing equilibrium quantity of licenses, *k*.[4]

Proposition 1. The equilibrium number of licenses, *k*, is increasing in n .

Proof. $V_{kn} = p_{kn} + q(rx_n + rkx_{kn})$ where $x_n < 0$, $x_{kn} > 0$ and $p_{kn} > 0$. Then suppose that for some values of q, $V_{kn} < 0$. This implies that $V_{knq} = rx_n + rkx_{kn} < 0$. However, if $q = 0$, $V_{kn} > 0$, then $V_{knq} < 0$ implies that V_{kn} can not be negative for any q, resulting in a contradiction. Therefore, $V_{kn} > 0$.

Proposition 2. The equilibrium number of licenses, *k*, is increasing in *?*.

Proof. $V_{kq} = F + rx + rkx_k > q(F + rx + rkx_k) > p_k + q(F + rx + rkx_k) > 0$,

where $V_{kq} = \frac{\partial V_k}{\partial q}$.

Proposition 3. The equilibrium number of licenses, *k*, is decreasing in *T*.

Proof. $V_{kT} = -1 < 0$, where $V_{kT} = \frac{\partial V_k}{\partial T}$.

In other words, firms license more the more homogeneous is the final good among technology owning incumbent firms, the more appropriable technical knowledge is, and the lower the transaction costs of licensing. The intuition is straightforward. When the technology (and the resulting product) is highly differentiated, each incumbent technology owner has its own market niche. Any entrant licensed by a technology owner will be a direct comp etitor to the licensor but only a distant competitor to other technology owners. In contrast, when the good produced by incumbent technology owners is more homogeneous, the revenue loss from increased competition by licensees is better spread across all incumbents, thus raising the technology owner's incentive to license. Moreover, by enabling licensors to capture a higher share of the returns of their licensed technology, better appropriated technical knowledge (due to, say, stronger patent or copyright protection enforcement) induces firms to license more. Higher transaction costs decrease the licensor's profit directly.

3. Data

The data used in this analysis were collected from the *Innovation Network Databank (INNET)* of the Center for International Science and Technology Policy (CISTP) at the George Washington University. *INNET* features longitudinal information on strategic alliances, US patents, and business performance for many thousands of companies since 1985. For this paper we have used the section on licensing agreements. The basic information has been drawn from the SDC database of Thomson Financial which records all publicly announced alliance deals worldwide tracked down in the Security Exchange Commission filings in the United States, newswires, press, trade magazines, professional journals, and the like. SDC provides information on contract type (i.e. licensing agreement, marketing agreement, joint venture, joint development or production, etc.), description of the deal, the date of agreement, identities of participant firms (primary SIC code, name, nation, parent companies, etc.), and the SIC code of the alliance. Of interest to our case, the SDC also identifies different kinds of licensing agreements (i.e. exclusive, nonexclusive, cross licensing) and the roles of the participants in them (licensor, licensee).

[4] See Appendix 2 for the proof of existence and stability of the equilibrium.

The most serious limitation of SDC is its bias towards US organizations, due to the data collection methodology (language, geography, ability to be equally inclusive around the globe). We have, thus, decided to limit our analysis to licensing agreements during the 1990s (1990-1999) involving at least one US company.

There were 10,069 licensing agreements announced from January 1, 1990 to December 31, 1999 worldwide, involving 20,840 participants, corresponding to 8,193 different organizations. We used Standard & Poor's CompuStat (publicly traded companies in the United States) to cross-identify individual companies and extract financial information on each one. We have also eliminated all agreements for which we've been able to identify fewer than two participants. We came out with an initial set of 1,295 licensing agreements that involve 2,733 identified participants, corresponding to 1,153 companies traded in the United States.

We subsequently read through the description of every agreement to distinguish between licensors and licensees and to ascertain that the licenses in our sample refer to technology. We have also cleaned this set of agreements from public announcements of termination and litigation of past licensing agreements. These procedures decreased our set to 1,071 licensing agreements for which we have identified at least two participants (i.e. licensor and licensee). These agreements involve 2,295 participants, corresponding to 985 independent companies. We also needed to drop firms in sectors where information on key variables for our subsequent analysis (concentration ratios, industry patents, growth rates) is unavailable. We have, thus, reached a final sample of 934 companies (licensors and licensees) traded in United States[5]. We have linked this sample to the NBER patent database to obtain longitudinal information on patenting histories of these companies since the early 1970s.

Table 1 (see appendix 4) shows the licenses granted by sector (licensor main line of business) between 1990 and 1999 in our sample. The Table is based on a point-to-point tabulation counting deals between pairs of firms (a licensor and a licensee). In other words, a license agreement is counted as many times as there are identified licensees.

Business services (SIC 73) and electronics (SIC 36) are the most active sellers of technology through licensing in our sample. Both these sectors are not known for strong IPR regimes (although strengthening during the 1990s). They are trailed by chemicals and pharmaceuticals (SIC 28), a sector that has traditionally enjoyed strong IPR protection Chemicals companies registered the highest (by far) share of exclusive licenses whereas electronics companies registered the highest share of cross licensing, as expected on the basis of the IPR regimes in these industries (Grindley and Teece, 1997).

Table 2 (see appendix 5) breaks down the license deals in our sample by granting firm (point-to-point tabulation). About one third of the participants (264 firms) only bought technology (pure licensees). The remaining 670 firms sold at least one license during the 1990s; this group is highly skewed towards the firms that sold only one or two licenses. The group of licensors also includes those who had a mixed role (sell and buy technology).

4. Econometric Methodology and Modeling Approach

4.1. Econometric Model for Count Panel Data[6]

We use count panel data where the dependent variable – the number of licenses granted by a particular firm in a given year – is discrete, non-negative, with numerous zero entries, generating non-linearities. Conventional linear regression models are, thus, inappropriate. The simplest model form to accommodate count data is the Poisson Regression Model. This model, however, has been criticized on its property of equality between its first two conditional moments: $E(y_{it} / x_{it}) = V(y_{it} / x_{it}) = l_{it}$. It is not uncommon to find that the conditional variance is larger than the conditional mean empirically, implying 'overdispersion'. For example, because of unobserved effects such as the management's ability to negotiate with licensees effectively, some firms are likely to sell a much larger number of licenses in a given time period than average while the majority of firms will be well below the average licensing activity or will have none. In panel data unobserved 'heterogeneity' is commonly presumed present; the failure to include firm specific effects may lead to overdispersion.

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[5] Our final data is unbalanced panel in a sense that not all sample firms in CompuStat have financial information consecutively throughout the whole period, 1990-1999.

[6] For further discussions, see Cameron and Trivedi (1986), Winkelmann and Zimmermann (1995), Cincer (1997), and Blundell, Griffith and van Reenen (1999).

One possible way to accommodate unobserved heterogeneity is to include 'fixed' or 'random' effects into the Poisson regression model. In the presence of overdispersion, however, a more efficient estimator can be based on the Negative Binomial (Negbin) Model, which addresses the failure of the Poisson by adding a parameter that reflects unobserved heterogeneity among observations. Negbin also has limitations. For instance, the negative binomial specification imposes a constant variance to mean ratio across firms. Hausman, Hall, and Griliches (1984) overcome these shortcomings by introducing 'fixed' effects and 'random' effects negative binomial model. For the random effects and fixed effects overdispersion models:

$$y_{it} / g_{it} \sim \text{Poisson}(g_{it}),$$

where $g_{it} / d_i \sim \text{gamma}(l_{it}, 1/d_i)$ and d_i is the dispersion parameter. In the random effects model, d_i is allowed to vary randomly across firms; $1/(1 + d_i) \sim \text{Beta}(a, b)$.

A necessary assumption is that unobserved firm-specific effects are uncorrelated with the independent variables for random effects specification. We employ a random effects negative binomial model for this analysis[7].

4.2. Model Specification

We estimate the following licensing equation:

$$L_{it} = f\,[Y_{it}, W_{it}] \quad \text{for } i = 1, \dots, N \quad and \quad t = 1, \dots, T, \tag{5}$$

where L_{it} is the number of licenses granted by firm *i* at *t*, Y_{it} is a vector of characteristics of firm *i*, and W_{it} is a vector of characteristics of this firm's primary industry *I*.

4.2.1. <u>*Dependent Variable*</u>

Licenses are of three types: exclusive, nonexclusive, and cross license. We run separate regressions for all licenses lumped together and for each of the three types.

(i) ***ALLICENSE*** = number of licenses (all types) granted by firm *i* at period *t*;

(ii) ***NONEXCLULICENSE*** = number of nonexclusive licenses granted by firm *i* at period *t*;

(iii) ***EXCLULICENSE*** = number of exclusive licenses granted by firm *i* at period *t*;

(iv) ***CROSSLICENSE*** = number of cross licenses granted by firm *i* at period *t*;

4.2.2. <u>*Independent Variables*</u>

(a) Firm level (licensor) characteristics

It goes without saying that the only candidate licensors are those companies that create new technologies. Following long tradition in economics, we approximate the ability to replenish the stock of technological knowledge by the observed stock of patents that the company has received up to a point in time. We use both the current and lagged patent stock of a company as there can be a sizeable lag between obtaining a patent and licensing a technology – not least because firms typically loath selling out state-of-the-art technologies. The value of the patent stock depreciates reflecting technological obsolescence due to newer developments in the specific or competing technologies (products), and ultimately the expiration of legal rights. The annual depreciation rate is taken here to be 15%.[8]

PATENT = firm *i*'s patent stock at period *t*.

$$PATENT = I_{i,t} + (1-?)\,PATENT\text{-}1,$$

[7] Hausman test cannot reject the null hypothesis of no serial correlation at 5% significance.

[8] Fifteen percent is frequently taken as the rule of thumb in knowledge depreciation in the empirical literature. Our results do not change significantly with higher values (20%, 30%).

PATENT-1 = firm *i*'s patent stock at period *t-1*.
PATENT-2 = firm *i*'s patent stock at period *t-2*.
PATENT-3 = firm *i*'s patent stock at period *t-3*.
PATENT-4 = firm *i*'s patent stock at period *t-4*.

where $I_{i,t}$ is the number of patents received by firm *i* at time *t* and *?* is the rate of knowledge depreciation. Due to the unavailability of strong theoretical results on the timing of technology sales, we use stocks of knowledge in five points in time in order to test for the lag distribution of the patent-licensing relationship. 'Patent-intensive' firms may be inclined to license out for various reasons. For example, they may have more technologies available than they can exploit internally. They may be interested in extending the revenue stream from technologies that have past their prime for internal use but which are still of value to others [(frequently a North-South type of exchange)]. They may also want to exploit proprietary technologies that they consider peripheral. They may license in order to establish and dominate a de facto standard. Finally, they may license strategically in order to prevent other firms develop their own technologies. More and more companies have increasingly tried to supplement income from the active management of intellectual property, frequently involving technology sales. The anticipated sign of ***PATENT*** and its lags is positive.

SALES = sales of firm *i* in period *t*.

Sale figures have been used as proxy for firm size. Research-oriented startup firms often earn their profits through licensing arrangements with more established, incumbent firms, in commercializing a new technology (Gans and Stern 2000). Indeed, small firms are usually under severe cash flow constraints. In certain industries such as pharmaceuticals the costs of fielding products is very high (clinical trial costs may run into the hundreds of millions of dollars). Small firms (e.g., biotechnology companies) often cannot even attempt to market their inventions without assistance from larger established pharmaceutical companies. It may be hypothesized that small firms may be pressured to license technologies more frequently than larger companies. On the other hand, large companies may license a lot because of strategic incentives, in order to influence standards, and in the effort to extend income from technologies that are either not-state-of-the-art or peripheral to their own internal operations. The expected sign for ***SALES*** is ambiguous.

EXPERIENCE = 1 if licensor firm *i* had sold a license up to period *t-1*.
= 0 otherwise.

Experience is used as a proxy for the transaction cost of licensing (*T* in the theoretical model). Experience in gathering information about prospective licensees, negotiating, writing contracts and enforcing them will lower the cost of licensing for the seller. A positive sign for ***EXPERIENCE*** is expected in all types of licensing.

(b) Industry level characteristics

We use the characteristics of the primary sector of the licensor while acknowledging the limitations of the approach due to the proliferation of diversified companies that may not license in their primary line of business. Our selection of the primary sector of the licensor is based on the consideration that, in most companies, it will significantly influence strategic behavior across the firm.

CONCENTRATION = concentration of industry of firm *i* at *t*.

Low concentration implies that the firms already have many competitors (lower market power) in their primary product market (Caves, 1970)., Low concentration can be associated with higher values for n in our theoretical model (more homogeneous technologies among licensors), which raises the incentive of a licensor to create another licensee since this action will dissipate licensor's profit less than it would in a less competitive market. In reverse, high concentration would be typically associated with higher market power, more clearly differentiated technologies and products among incumbents and, according to the theory, relatively lower incentives to license out by any one of them. A negative sign is expected for ***CONCENTRATION***.

GROWTH = growth rate of industry of firm *i* at *t*.

The higher the growth rate of industry output, ceteris paribus, the less an entrant's supply will depress industry price and output (Orr 1974). Accordingly, firms in high growth industries will have a better incentive to license out related technologies since rent dissipation due to increased competition with licensee entrants is kept relatively low. A positive sign for ***GROWTH*** is expected in all types of licensing.

INDUSTRY PATENT = *Patent / R&D expenditures* of industry of firm *i* at *t* (propensity to patent).

Patent-intensity is used as a proxy of the strength of the intellectual property protection system as perceived by the members of an industry. It is, of course, well understood that the existing uniform legislation for intellectual property affects different industries differently due to the variation in their characteristics. In turn, the perceived strength of the intellectual property system directly affects the ability of a firm to appropriate technical knowledge. The literature has generally advocated a positive link (Anand and Khanna, 2000). This variable can, then, be considered as a proxy for q in the theoretical model. The expected sign for ***INDUSTRY PATENT*** is positive. The expected sign changes to negative in the case of cross licensing that can be an efficient mechanism for overcoming the hazards of weak IPR protection.

COMPLEXITY = 1 if firm *i* belongs to a complex product industry;
= 0 otherwise.

Cohen, Nelson, and Walsh (2000, 2002) distinguish between "complex" versus "discrete" product industries on the basis of whether a new product is comprised of numerous separately patentable elements or of relatively few. Electronic products will typically be good examples of the former, thus characterized as complex. Drugs or chemicals are typically good examples of the latter, the patentable element often being a single formula (Rycroft and Kash, 1999). As a result, simple technologies can be better protected (strong IPR) whereas complex technologies may be easier to invent around (weak IPR). Following Cohen, Nelson and Walsh (2002), we use SIC 35 as a crude cut-off point between complex product industries (35 and above) and simple product industries (below 35). As defined, simple product industries include ferrous and non-ferrous metals, chemicals, petrochemicals, drugs, food, tobacco, and so forth. Complex product industries include machinery, computers, electrical equipment, scientific instruments, and all kinds of services. Better IPR protection raises the prospects of licensing. This variable can be considered as a second proxy for q in the theoretical model. A negative sign for ***COMPLEXITY*** is generally expected. Again, the expected sign changes to positive in the case of cross licensing for the reason mentioned above.

INFRA = 1 if the primary industry of firm *i* can be described as ICTs, biotechnology, or advanced materials;
= 0 otherwise.

Information and communication technologies (ICTs), biotechnology, and advanced materials have "infrastructural" characteristics. They have penetrated throughout the economy during the past 2-3 decades and have thus dramatically altered the basic meaning of high technology: rather than referring to the output of R&D-intensive industries, high tech now refers to a style of work applicable to just about any business (Branscomb and Florida 1998; Porter 1998). The penetration of these so-called general purpose technologies – information technology in particular – has gradually shifted the locus of high technology production from exclusively manufacturing to a combination of manufacturing and service industries. Technology is rapidly transforming the nature of the products of both sectors (Hauknes 1998; Leech, et al. 1998; OECD 2000). We would, as a result of widespread use, expect these technologies to be exchanged more widely and frequently than others. A positive sign of ***INFRA*** is anticipated.

Appendix 3 provides additional detail regarding the construction of certain variables. Table 3 (see appendix 6) shows descriptive statistics for the variables. Table 4 (see appendix 7) provides the correlation matrix for the cumulative license case (ALLICENSE). Not surprisingly, patent stocks in successive years are highly correlated.

5. Results

5.1 Estimation

Estimation results for the dependent variables *ALLICENSE, NONEXCLULICENSE, EXCLULICENSE*, and *CROSSLICENSE* are reported in Tables 5-8 respectively (See appendices 8, 9, 11).

Each Table shows the results for two models: model 1 contains firm level explanatory variables only; model 2 adds industry level variables.

We obtain strong results for all licenses grouped together, for nonexclusive licenses, and for cross licenses (Tables 5, 6, 8 respectively). The explanatory variables tend to maintain their signs, size and significance levels across models. PATENT (and lags), EXPERIENCE, and INDUSTRY PATENT are found to be important explanatory factors, statistically significant across all three tables. INFRA and GROWTH are statistically significant for all licenses and for nonexclusive licenses. COMPLEXITY has the expected sign across the board but is statistically significant only for exclusive licenses and cross licenses.

Results are weak in the case of exclusive licenses (Table 7) where the only statistically important explanatory variable is COMPLEXITY. It must be pointed out that this licensing category has the smallest number of observations of all three (a little less 10% of the total, Table 1) with almost one-third concentrated in the sector of chemicals and drugs (SIC 28).

Two explanatory variables, company size (SALES) and industry concentration (CONCENTRATION) do not seem to be significant determinants of the propensity to license out technology. One reason of the failure of the latter is that, as constructed here, industry concentration is a very crude proxy of product/technology homogeneity among licensors.

5.2. Discussion

A number of important observations arise in the econometric results above. We discuss each of the three licensing categories separately. The aggregate licensing category is omitted since it is very much dominated by nonexclusive licenses (more than 90% of the total). Cross licenses is a hybrid activity and incorporates a number of both nonexclusive and exclusive licenses.

5.2.1. Nonexclusive licenses

The stock of technical knowledge, as expected, was found to be significant for selling technology (a sine qua non). Importantly, the results point at a potential U-shaped structure of patent stock coefficients. The current patent stock is positive and very significant on the propensity to license out, as is the stock of several years in the past. In between, the patent stock becomes less significant and even reverses sign. We are not familiar with extant empirical literature on licensing indicating such a relationship.

Prior involvement in licensing and the relevant experience that comes with it is clearly very important in determining incentives to license out technology. This concurs with both the theory in Section 2 and with plenty of anecdotal evidence.

Industry patent intensity – a proxy of the strength of the intellectual property protection system in the industry – has a strong positive effect on the propensity of a firm to sell technology in a nonexclusive manner. Patent intensity varies extensively across industries according to the nature of the technology and history of business practice. This result also concurs with both the theory in Section 2 and with anecdotal evidence.

The rate of growth of the principal sector of the licensor positively affects the propensity of firms to license out their technology. Licensees often create additional competition for the incumbent technology owners. The adverse effects of such competition should be of lesser importance when the industry grows fast, ceteris paribus.

Sectors that can be classified as information and communication technologies (ICTs), biotechnology, and advanced materials exert a significant positive influence on firms to license out technology. Such general purpose technologies have "infrastructural" characteristics in the sense that they find users spread out across the economy. This demand is relatively "safe" in the sense that the sale of technology will typically not create additional competition, thus raising incentives to license out.

5.2.2. Exclusive licenses

Technological/product complexity of the sector – i.e., the degree to which new products tend to be comprised of numerous, separately patentable elements or relatively few – is the only statistically significant factor in this analysis influencing the decision of a technology owner to provide an exclusive license. The "simpler" the technology is the higher the tendency to engage in exclusive licensing.

Complexity is one of the trickier factors to explain and, yet, one of the most important in explaining firm strategy relating to new technologies. As defined here, complexity has implications for the enforceability of intellectual property protection: simple products (even though potentially very high tech) are typically associated with easier protection (lower costs). Sectors like chemicals and pharmaceuticals, for example, have persistently reported higher reliance on formal mechanisms of protecting IPR such as patents than sectors like electronics, computers, and machinery (Levin et. al, 1987; Cohen et. al, 2002). Our data bears out the expected negative relationship between the degree of technological/product complexity in a sector and the propensity of a firm in that sector to sell technology through exclusive licenses.[9]

5.2.3. Cross licenses

The patent stock and prior licensing experience have similar effects on cross licenses to those on nonexclusive licenses. An important difference between the two comes in industry patent intensity – a proxy of the strength of the intellectual property protection system in that industry. Whereas industry patent intensity has a positive effect on the propensity of a firm to sell technology through nonexclusive licenses, it has a strong negative effect on the firm's willingness to engage in cross licensing. This important difference was fully anticipated: anecdotal evidence indicates that firms use license swaps as a mechanism to overcome the hazards of weak IPR protection.

Technological/product complexity of the sector has a positive effect on the propensity to cross license (in sharp contrast to its negative effect on exclusive licensing). This was also anticipated on the basis of evidence that in sectors like electronics, computers and office machines (which dominate our cross licensing observations, Table 1) the role of patents has been changing in more recent years from an IP protecting instrument to a strategic instrument facilitating deals, exchanges, and alliances (Hall and Ziedonis, 2001). If so, one would expect firms in complex technology industries to engage extensively in cross licensing, turning it into a mechanism for overcoming the hazards of weak intellectual property protection (by creating a "mutual hostage" or "mutual cooperation" situation of providing each other's technologies).

6. Conclusion

Scientific and technological knowledge have been argued to be subject to significant complications related to indivisibilities, imperfect appropriability, and significant uncertainty that, arguably, inhibit markets to attain socially optimum outcomes (Lundvall and Borras, 1999). Even so, markets for technology have become increasingly important in recent decades as phenomena like increasing competition through globalization, accelerating rates of technological change, outsourcing and collaborating have become pervasive.

This paper has empirically investigated one type of technology market: technology licensing. We have investigated the incentives of companies to license out their technology across all industries with an extensive panel data set describing such arrangements announced during the previous decade (1990-1999).

We find that the stock of technological knowledge of the licensor, this company's experience with technology licensing, the rate of growth of its primary industry, the strength of the intellectual property protection regime in that industry, and the nature of the technologies/products produced by the licensor (general purpose technologies) are important determinants of the propensity to sell technology through nonexclusive licenses. The largest subgroup of licensing activity (more than 90% in our sample), nonexclusive licensing can be considered the closest to an arm's length market for technology.

The degree of technological/product complexity of the primary industry of the licensor is found negatively related to both nonexclusive and exclusive licenses, but its effect is statistically significant only in the latter case. In contrast, technological complexity is found positively (and significantly) related to cross licensing. This is so possibly because cross licensing often aims at easing complicated IPR protection hazards between the engaged parties, an explanation also corroborated by the finding of a strong negative effect on cross licensing of industry patent intensity. Incentives to engage in cross licenses are also affected significantly by the stock of technological knowledge of the licensor, this company's licensing experience, and the strength of the intellectual property protection regime in its primary sector. Finally, we find indications of a U-shaped relationship between recent stocks of technological knowledge and company tendency to sell technology.

These results are highly encouraging. Many of the factors that one would expect to shape seller incentives in an arm's length market for technology indeed prove important in explaining incentives to provide nonexclusive licenses. In contrast, these factors fail to explain incentives to engage in exclusive licensing, an arguably quite different activity that permits the technology owner to sell only once. Other factors, much more

[9] The expected negative sign persists also in the case of nonexclusive licenses but the statistical significance of the estimator is low.

strategic in nature and highly variable across cases, must be important determinants of exclusive licensing. As a hybrid, cross licensing reflects the influence of factors affecting both nonexclusive and exclusive licensing.

The sample of companies engaged in the examined licensing agreements were publicly traded in the United States in order to obtain the necessary longitudinal company performance data. While this introduces limitations in terms of explaining international agreements, we believe that many of the results are general enough and could go through for international licensing agreements as well. In addition to locational and cultural factors, future enhancements could benefit from introducing the characteristics of the licensees and of their industries as well as a set of variables describing the relationship between the licensor and licensee (e.g., independent or affiliated, in same or different value chains, and so forth).

Appendix 1

Equilibrium profit

Each firm producing with variety i (either technology owner or licensee) maximizes (2) in the product market: The first order condition is given by:

$$1-2x_i-\sum_{k_i} x_i - n\sum_{N-i}(x_j+\sum_{k_j} x_j) = 0. \qquad \text{(A.1)}$$

Imposing symmetry across firms using same technology, and by adding and subtracting $n(x_i+\sum_{k_i} x_i)$, we obtain:

$$1-2x_i-k_i x_i - n\sum_{N}(x_j+\sum_{k_j} x_j) + n(x_i+k_i x_i) = 0, \qquad \text{(A.2)}$$

from which

$$x_i = \frac{1-n\sum_N (1+k_j)x_j}{(2-n)+(1-n)k_i}. \qquad \text{(A.3)}$$

Now, multiply both sides by $n(1+k_i)$ and sum up across all varieties to obtain:

$$\sum_N n(1+k_j)x_j = \left[1-n\sum_N (1+k_j)x_j\right]\sum_N \frac{n(1+k_j)}{(2-n)+(1-n)k_j}. \qquad \text{(A.4)}$$

Substituting (A.4) into (A.3) produces the Nash equilibrium quantity produced by each firm producing variety i:

$$x_i\ (k_i, k_{-i}, n, N) = \left[(2-n)+(1-n)k_i\right]^{-1}\left[1+\sum_N \frac{n(1+k_j)}{(2-n)+(1-n)k_j}\right]^{-1}. \qquad \text{(A.5)}$$

Then, substitution of (A.5) in (1) and then (2) allows to compute the equilibrium profit at the product market for each firm using technology i as follows:

$$p^{i}(k_i, k_{-i}, n, N) = \left[(2-n)+(1-n)k_i\right]^{-2}\left[1+\sum_{N}\frac{n(1+k_j)}{(2-n)+(1-n)k_j}\right]^{-2}. \qquad \text{(A.6)}$$

Appendix 2

Proof of existence and stability of equilibrium.

Let's define $\Psi(k,q,F,r,n,N) \equiv V_k^i(k,q,F,r,n,N)$, evaluated at symmetric equilibria $k_i = k$ and $k_{-i} = k$. Then we can write $\Psi(k) = g(k) f(k)$, where $f(k)$ is quadratic in *k*, with $g_{kk} < 0$, and $f(k) = \frac{[1+(1+k)(1+n(N-1))]^{-3}}{(2-n)+(1-n)k} > 0$. Notice that the set of symmetric equilibria is the solution of $\Psi(k) = T$, and stability requires that $\Psi(k) < 0$. Let k_1 and k_2 be the two roots of $g(k) = 0$, with $k_2 > k_1$. Since $g(k) < 0$ at any $k > k_2$ and $f(k) > 0$, $\Psi(k) < 0$. Let first $\Psi(0) - T > 0$, then $k_2 > 0$ and since $\Psi(k) < 0$ for any $k > k_2$. Now let $\Psi(0) - T < 0$ then $k = 0$, which is the symmetric equilibrium where no firm license. Therefore, there exist at least one stable Nash equilibrium.

Appendix 3

Variables

PATENT. Firm's patent stock is calculated using the following formula:

$$PATENT = I_{i,t} + (1-r)\ PATENT1,$$

where $I_{i,t}$ is the number of patent granted to the firm by U.S. Patent Office in a particular year from 1968 to 1999, and r is the depreciation rate which is taken to be 15%. We assume the initial patent stock is zero. Since we have data between 1968 – 1999, the assumption over initial stock makes no practical difference.

SALES. Firm's sales amount is extracted from CompuStat (millions of dollars).

CONCENTRATION. The 4-firm concentration ratio is used (U.S. Census Bureau, 1992). Concentration ratios were unavailable for SIC 1-19. Small numbers of companies in those sectors were dropped.

GROWTH. Percent change of GDP, $\left(\frac{GDP_t - GDP_{t-1}}{GDP_{t-1}}\right) \times 100$, where GDP is Real Gross Domestic Product by two digit industry in 1996 dollars (billions) (Bureau of Economic Analysis).

INDUSTRY PATENT. Total number of patents in a firm's primary two digit SIC industry divided by total R&D expenditures in that industry. Both numbers are constructed by aggregating over firms in CompuStat (net of firm's own patents and R&D).

INFRA. The database CorpTech (Corporate Technologies,1999) classifies industries by functional sector (e.g., energy, biotechnology, advanced materials) as well as by SIC and maps one into the other. We use these classifications.

Appendix 4

Table 1. Total Number of Licenses Granted in Sample, by Industry, 1990-1999[a]

Industry[b]	*All Licenses*[c]	*Nonexclusive Licenses*	*Exclusive Licenses*	*Cross-Licenses*[d]
SIC 73	421 (22.9%)	405 (24.5%)	16 (8.8%)	44 (14.3%)
SIC 36	375 (20.4%)	358 (21.6%)	17 (9.3%)	123 (40.2%)
SIC 28	344 (18.7%)	275 (16.6%)	69 (38.0%)	30 (9.8%)
SIC 35	302 (16.4%)	291 (17.6%)	11 (6.0%)	68 (22.2%)
SIC 38	116 (6.3%)	102 (6.2%)	14 (7.7%)	19 (6.2%)
SIC 87	62 (3.4%)	49 (3.0%)	13 (7.1%)	3 (0.9%)
SIC 37	31 (1.7%)	27 (1.6%)	4 (2.2%)	5 (1.6%)
SIC 48	29 (1.6%)	25 (1.5%)	4 (2.2%)	7 (2.3%)
SIC 23	22 (1.2%)	14 (0.8%)	8 (4.5%)	0 (0%)
SIC 20	22 (1.2%)	17 (1.0%)	5 (2.7%)	3 (0.9%)
Others	114 (6.2%)	93 (5.6%)	21 (11.5%)	5 (1.6%)
Total	1,838 (100%)	1,656 (100%)	182 (100%)	307 (100%)

[a] Point-to-point tabulation. A license from one firm to another is counted as one deal. A license of one firm to two others is counted as two deals. And so forth.

[b] SIC 73=Business Services; SIC 36=Electronic & Other Electronic Equipment; SIC 28=Chemicals; SIC 35=Industrial Machinery & Equipment; SIC 38=Instruments & Related Products; SIC 87=Engineering and Management Services; SIC 37=Transport; SIC 48=Communications; SIC 23=Textiles; SIC 20=Food; Others include SIC 22, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 39, 49, 50, 51, 59, 67, 78, 79, 80.

[c] Sum of exclusive and nonexclusive licenses. It includes cross licenses.

[d] Cross licenses may be either nonexclusive or exclusive.

Appendix 5

Table 2. Total Number of Licenses Granted in Sample, By Firm, 1990-1999[a]

Number of All Licenses Granted[b]	*Number of Firms*	*Percent*
0	264	28.23
1	363	38.83
2	117	12.52
3	66	7.06
4	38	4.06
5	28	2.99
6	6	0.64
7	10	1.07
8	9	0.96
9	5	0.53
10	2	0.21
11	5	0.53
12	4	0.42
13	1	0.10
14	1	0.10
15	1	0.10
16	1	0.10
17	1	0.21
18	1	0.21
20	1	0.10
23	2	0.21
26	2	0.21
28	2	0.21
29	1	0.10
42	1	0.10
46	1	0.10
54	1	0.10
Total	934	100.00

[a] Point-to-point tabulation. A license from one firm to another is counted as one deal. A license of one firm to two others is counted as two deals. A license of one firm to three others is counted as three deals. And so forth.

[b] Includes nonexclusive, exclusive, and cross licenses.

Appendix 6

Table 3. Descriptive Statistics of Variables

Variable	***Mean***	***Std. Dev.***	***Min***	***Max***
<Dependent Variables>				
(i) ALLICENSE	.19	.58	0	13
(ii) NONEXCLULICENSE	.17	.56	0	12
(iii) EXCLULICENSE	.02	.12	0	2
(iv) CROSSLICENSE	.03	.19	0	7
<Independent Variables>				
(Firm level characteristics)				
PATENT	97.07	502.7	0	10,374.56
PATENT-1	89.5	467.15	0	8,963.01
PATENT-2	83.33	437.74	0	7418.84
PATENT-3	78.54	415.03	0	6699.81
PATENT-4	74.39	394.00	0	5683.3
SALES	3,925.06	13,531.34	0	195,805
EXPERIENCE	.3	.45	0	1
(Industry level characteristics)				
CONCENTRATION	34.29	16.25	1	90
GROWTH	5.99	9.26	-47.27	203.9
INDUSTRY PATENT	.51	2.09	.034	40.32
COMPLEXITY	.24	.43	0	1
INFRA	.54	.49	0	1

Appendix 7

Table 4. Correlation Matrix for ALLICENSE

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.**ALLICENSE**	1.0000								
2.**PATENT**	.2566	1.0000							
3.**PATENT-1**	.2392	.9962	1.0000						
4.**PATENT-2**	.2231	.9867	.9965	1.0000					
5.**PATENT-3**	.2100	.9747	.9889	.9973	1.0000				
6.**PATENT-4**	.2013	.9611	.9785	.9908	.9976	1.0000			
7.**SALES**	.1186	.5149	.5227	.5283	.5309	.5326	1.0000		
8.**EXPERIENCE**	.1588	.1721	.1673	.1618	.1560	.1505	.1043	1.0000	
9.**CONCENTRATION**	.0114	-.0287	-.0272	-.0260	-.0259	-.0261	.0011	-.0103	1.0000
10.**GROWTH**	.0218	.1742	.1764	.1781	.1788	.1796	.3066	.0696	-.1122
11.**INDUSTRY PATENT**	.0508	.0680	.0645	.0614	.0589	.0565	.0583	-.0507	.1417
12.**COMPLEXITY**	-.0206	-.0264	-.0263	-.0263	-.0261	-.0261	-.0282	-.0080	-.0945
13.**INFRA**	.0361	-.0552	-.0537	-.0528	-.0522	-.0518	-.1238	.0570	.1117

	10.	11.	12.	13.
10.**GROWTH**	1.0000			
11.**INDUSTRY PATENT**	-.1042	1.0000		
12.**COMPLEXITY**	-.0663	-.1305	1.0000	
13.**INFRA**	-.1876	-.0805	-.1512	1.0000

Appendix 8

Table 5. Random effects negative binomial estimates for all licenses

ALLICENSE	***Model 1***	***Model 2***
PATENT	.0033**	.0034**
	(.001)	(.0013)
PATENT-1	.0021	.0023
	(.0051)	(.0052)
PATENT-2	-.0058	-.0057
	(.0092)	(.0092)
PATENT-3	-.0062*	-.0061*
	(.0034)	(.0034)
PATENT-4	.004**	.0043**
	(.0012)	(.0011)
SALES	.000082	.00008
	(.0003)	(.00029)
EXPERIENCE	.165**	.1647**
	(.083)	(.0845)
CONCENTRATION	_	.0012
		(.0029)
GROWTH	_	.0017**
		(.0004)
INDUSTRY PATENT	_	.2998**
		(.1002)
COMPLEXITY	_	-.0101
		(.0218)
INFRA	_	.4764**
		(.0927)
Constant	-.617**	-.623**
	(.2201)	(.2159)
N	9340	9340
Log-Likelihood	-3328.626	-3316.242

** significant at 5%; * significant at 10%; Standard errors are in parentheses.

Appendix 9

Table 6. Random effects negative binomial estimates for nonexclusive licenses

NONEXCLULICENSE	*Model 1*	*Model 2*
PATENT	.0042**	.0042**
	(.001)	(.0012)
PATENT-1	.0038	.0039
	(.0025)	(.0025)
PATENT-2	-.003	-.0028
	(.0054)	(.0053)
PATENT-3	-.0058*	-.0059*
	(.0031)	(.0032)
PATENT-4	.0033**	.0033**
	(.0009)	(.0009)
SALES	.00001	.00001
	(.00087)	(.00089)
EXPERIENCE	.2364**	.2367**
	(.0886)	(.0894)
CONCENTRATION	_	.0016
		(.0031)
GROWTH	_	.0021**
		(.0008)
INDUSTRY PATENT	_	.3481**
		(.1097)
COMPLEXITY	_	-.0039
		(.0219)
INFRA	_	.4892**
		(.1002)
Constant	-.9003**	-.9219**
	(.1785)	(.2293)
N	9340	9340
Log-Likelihood	-3152.11	-3055.341

** significant at the 5% level; * significant at 10% level; Standard errors are in parentheses.

Appendix 10

Table 7. Random effects negative binomial estimates for exclusive licenses

EXCLULICENSE	*Model 1*	*Model 2*
PATENT	.0004	.0002
	(.0021)	(.0011)
PATENT-1	-.0017	-.0016
	(.0045)	(.0044)
PATENT-2	.0005	.0008
	(.0037)	(.0035)
PATENT-3	-.0019	-.0016
	(.0068)	(.0063)
PATENT-4	.0017	.002
	(.004)	(.0043)
SALES	7.49e-06	7.55e-06
	(6.11e-06)	(6.19e-06)
EXPERIENCE	.4018	.4016
	(.3356)	(.3343)
CONCENTRATION	_	.0019
		(.0101)
GROWTH	_	.0027
		(.0059)
INDUSTRY PATENT	_	.1612
		(.1319)
COMPLEXITY	_	-.0649**
		(.0021)
INFRA	_	.3046
		(.2057)
Constant	-4.3877	-4.1657
	(9.18)	(8.65)
N	9340	9340
Log-Likelihood	-611.582	-600.4249

** significant at the 5% level; * significant at 10% level; Standard errors are in parentheses.

Appendix 11

Table 8. Random effects negative binomial estimates for cross licenses

CROSSLICENSE	*Model 1*	*Model 2*
PATENT	.0043**	.0044**
	(.001)	(.0012)
PATENT-1	.0021	.0023
	(.0037)	(.0035)
PATENT-2	-.0079	-.0081
	(.0094)	(.0092)
PATENT-3	-.0089*	-.009*
	(.0049)	(.005)
PATENT-4	.0035**	.0035**
	(.0008)	(.0008)
SALES	-8.34e-06	-8.35e-06
	(7.71e-06)	(7.82e-06)
EXPERIENCE	1.0002**	1.0003**
	(.168)	(.1677)
CONCENTRATION	_	.0034
		(.011)
GROWTH	_	.0047
		(.0052)
INDUSTRY PATENT	_	-1.109**
		(.347)
COMPLEXITY	_	.6334**
		(.2526)
INFRA	_	.2442
		(.2041)
Constant	-1.345**	-1.874**
	(.341)	(.453)
N	9340	9340
Log-Likelihood	-832.056	-814.674

** significant at the 5% level; * significant at 10% level; Standard errors are in parentheses.

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