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The Impact of Technology Licensing Payment Mechanisms on Firms' Innovative Performance

Evidence from Small- and Medium-Sized Enterprises

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The Impact of Technology Licensing Payment Mechanisms on Firms' Innovative Performance

Evidence from Small- and Medium-Sized Enterprises

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Abstract: Although numerous papers have examined the ways in which firms can improve their innovative performance through technology alliances, empirical research on the effect of contract structures in technology licensing has been scarce. This study provides evidence that the payment mechanisms agreed upon in licensing contracts affect the licensee firms' innovative performance. Based on a dataset of technology licensing contracts concluded by small- and medium-sized enterprises around the world, this paper analyzes the influence of fixed-fee payments and ongoing payments—including royalty, milestone, and equity payments—on firm performance. The findings reveal that ongoing payments are more likely to positively influence the innovative performance of licensee firms. The results also suggest that equity grants to the licensor would not impact the licensee's performance as much as fixed-fee payments. These outcomes provide crucial insights into the ways in which small high-tech firms can utilize their external technology resources.

Keywords: Technology licensing, payment mechanism, innovative performance, small- and medium-sized enterprises.

JEL Classifications: L24, O31, C35.

1. Introduction

Technology licensing has become increasingly important to the competitive strategies of firms in high-tech industries. Shorter innovation cycles, rising development costs, and higher-risk technology create the motivation to penetrate a market rapidly and spread the costs and risks of innovation through technological alliances (Mowery et al. 1996). As a result, licensing has arguably become a more visible type of strategic technological alliance between companies (Kim and Vonortas 2006).

The role of technology licensing in knowledge transfer and firms' further innovation is often not considered. Contract/market-based unilateral alliances as typical forms of technology licensing have their limitations in terms of firms' ability to fully access the external technological capabilities. Some previous research shows that rather than market-based alliances, relational—bilateral or hierarchical—alliances, such as cooperative research and development (R&D) and equity joint venture, more efficiently enable the inter-firm transfer of technological capabilities so that the participants can afford better performance in their innovation (Mowery et al. 1996; Fey and Birkinshaw 2005; Lee and Cavusgil 2006; Sampson 2007).

However, the impact of diversified contract structures in technology licensing agreements, especially that of the payment mechanism, has been overlooked. We can observe various contractual modes in actual technology licensing agreements, and the mechanisms that influence the outcomes of contracts deserve to be more carefully examined. Of course, it is acceptable that firms engaged in relational and hierarchical alliances have stronger partnerships than those in contract-based alliances, but it is surely possible to connect the partners for a considerable time through even a market-based contract, as long as the contract structure is well organized.

This study provides empirical evidence that the payment mechanism agreed on in a licensing contract affects the licensee firm's innovative performance. Based on a dataset of technology licensing contracts concluded by small- and medium-sized enterprises (SMEs) around the world, this paper analyzes the influence of fixed-fee payments and ongoing payments—including royalty, milestone, and equity grants—on firms' innovative performance *ex post*.

Innovation in SMEs is hampered by lack of financial resources, scant opportunities to recruit specialized workers, and small innovation portfolios so that risks associated with innovation cannot be spread. SMEs need to draw heavily on their networks to find missing innovation resources (Vrande et al. 2009). In today's increasingly complex and knowledge-intensive world with shorter life cycles, exploitation of outside resources through technology "licensing-in" is a good way for SMEs to respond quickly to external opportunities and rapidly penetrate a market.

This article examines the role payment mechanisms in technology licensing to SMEs play in terms of intermediating the partnership between the parties involved in inter-firm contracts. Previous literature dealing with transaction costs and uncertainty has accepted the payment mechanism as just a means used to circumvent the problem of moral hazards, adverse selection, and the risk of technology inherent in licensing projects (Macho-Stadler et al. 1996; Bousquet et al. 1998; Jansen and Thursby 2001; Marjit and Mukherjee 2001; Feldman et al 2002; Lim and Veugelers 2003; Vishwasrao 2007; Bessy et al. 2008; Dechenaux et al. 2009). However, this study highlights payment mechanism functions that can influence the *ex post* innovative performance of licensee firms. This study affirms that SMEs can build enduring networks with their agreement partners, and secure access to external capabilities even through contract-based alliances.

This paper is organized as follows. Section 2 reviews background theories and, develops hypotheses for empirical investigation. Section 3 provides the empirical model on which this paper is based. The overall results are discussed in section 4. Section 5 concludes.

2. Theories and hypotheses development

2.1. Technology licensing contracts and payment mechanisms

Technology licensing agreements require a payment mechanism to be chosen for the transferred technology. Possible payment mechanisms may include one or a combination of upfront lump-sum fees, royalties, milestone payments, and equity grants. In negotiating the contract structure, the licensor and licensee firms can seek to maximize the performance of the alliance. The inherent nature of inter-firm contracts with uncertainties and transaction costs has given rise to diverse payment mechanisms. With upfront or annual fees, the licensee has to pay an agreed amount of fixed costs. Meanwhile, royalties on a per unit and/or an *ad valorem* basis imply payments that are proportional to revenues received from the output. Milestone payments are also based on the outcome of the licensee, compensating the licensor at every achievement of some stipulated event in sales or development. In addition, licensees may also grant their own equities instead of paying large amounts of upfront fees. Given these various options, the contract parties choose the most suitable payment method for their purposes (Jensen and Thursby 2001).

In order to concentrate on the effect of partnership on innovative performance, this paper has categorized the various payment schemes into two types: fixed-fee payments and ongoing payments. Fixed-fee payments include upfront fees and annual fees, while ongoing payments are output-contingent payments, including royalties, milestone payments, and equity grants. The mixed method discovered in our data sample, which combines fixed fees and output-contingent payments, was assigned to ongoing payments.

Some previous findings provide insight to support the idea that sustainable partnerships can be induced through payment mechanisms (Macho-Stadler et al. 1996; Bousquet et al. 1998; Jansen and Thursby 2001; Marjit and Mukherjee 2001; Lim and Veugelers 2003; Elfenbein 2004; Dechenaux et al. 2009). According to this previous research, the choice of payment mechanism influences the performance of the alliance. Assuming risk neutrality and no need for additional effort by the inventor or licensee, a simple upfront fee is optimal (Jansen and Thursby 2001). However, the need for non-contractible inventor's effort presents a moral hazard problem because the inventor firm may *shirk* if it prefers research to development. The need for effort on the part of the licensee also suggests adverse selection problems, since firms may *shelve* inventions if profits are less than originally anticipated by the time development is completed (Dechenaux et al. 2009).

Previous studies show that some forms of ongoing payment address the moral hazard problems by linking the licensor's revenue to its effort and the future outcomes of the transferred technology. Because the inventor's effort increases the probability of commercial success, the inventor firm who expects marginal benefits from its efforts is incentivized to contribute to the project. Milestone payments and equity grants are particularly effective in resolving moral hazard problems without the inefficiency inherent in royalties because, unlike royalties, equity grants and milestone payments do not distort the licensee's production decision. While an increase in the royalty rate reduces the outputs and profits expected from a success, an increase in the equity share or milestone payment has no effect on them (Jansen and Thursby 2001; Dechenaux et al. 2009). In this sense, the presence of non-contractible inventor's effort indicates the main difference between fixed-fee payments and ongoing payments.

Additionally, according to Dechenaux et al. (2009), fixed-fee payments combined with ongoing payments help prevent a licensee from shelving a technology. The burden to pay high costs at a single time may be a heavy blow, especially for small- and medium-sized firms. Thus, a licensee's choice to pay fixed fees may reveal a commitment to put effort into *ex post* development.

2.2. Payment mechanism and knowledge transfer: hypotheses development

Since technology transfer does not merely imply granting patents and their licenses, the effective transfer of *tacit knowledge* embedded in patents should be the main concern of alliance partners (Arora 1996; Bozeman 2000). The knowledge transfer may be one of two types: explicit knowledge, which is knowledge of facts; or implicit or tacit knowledge, know-how to do something (Grant 1996). The recent *knowledge-based view* focuses on knowledge as a key competitive asset and emphasizes the capacity of a firm to acquire and integrate tacit knowledge (Mowery et al. 1996). New tacit knowledge inflows also augment the possibility of novel combinations of knowledge, which can result in new technologies and products (Fey and Birkinshaw 2005). Perceiving this potential, companies should access not only explicit knowledge, but also tacit knowledge from the partner firm in order to raise the possibility of further innovation.

However, researchers with the knowledge-based view concede that the transfer of tacit knowledge is difficult. The primary reason is that knowledge that is highly context-specific and tacit in nature is revealed only through its possessors' application and practices. Because it is hard to aggregate idiosyncratic knowledge that is dispersed among many individual specialists, the efficiency of knowledge transfer decreases. Given the immobility of tacit knowledge, this article investigates how to improve a firm's innovative performance by organizing contract structures for technology licensing.

As discussed above, the output-contingent payment more effectively induces the inventor's non-contractible efforts since the revenues from *ex post* development are directly connected to the licensor firm's profit as the extent of its share. A typical example of the non-contractible effort is transferring tacit knowledge, such heuristics, rules of thumb, and other tricks of the trade. Its nature is tacit and ambiguous and the quality or the extent of such services may vary according to the efforts made by the licensor. The transferred tacit knowledge would not only contribute to the mutual success of the technology license but would also be a critical source of additional innovation on the part of the licensee. When combined with internal innovative capacity, shared knowledge and information would definitely increase the innovative outcomes of the partner.

Moreover, the inventor's involvement in commercialization also requires the active participation of the licensee in the process of joint development. Many previous works suggest that face-to-face interaction between partners is most effective for knowledge transfer (Arora 1996; Grant 1996). Deep interdependency between the parties for a prolonged period of time can create the opportunity for sharing tacit knowledge and mutual learning (Fey and Birkinshaw 2005). Each party can share complex or tacit knowledge through joint decisions made by technical employees (Sampson 2007).

In this sense, ongoing payments are generally expected to have a strongly positive impact on the licensee firm's innovative performance *ex post*.

- Hypothesis 1: Technology licensing agreements with ongoing payments generally contribute more to firm innovation than agreements with fixed fee payments only.

When we suppose that ongoing payments will facilitate intimate partnership between contract parties and result in improved performance, the effect of equity grants should also be considered. Some research has insisted that equity grants can intensify the relationship between partners, because they create a special ownership structure (Lim and Veugelers 2003; Marjit and Mukherjee 2001; Pisano 1989; Sampson 2007).

By aligning the incentives of partners[1], equity participation can reduce the possibility of opportunistic behavior in sharing knowledge, particularly in the case of complex or tacit knowledge. Opportunism by an equity partner is penalized through reductions in the value of its equity holding. Restrictions on each party's right to buy out the other or to sell their position can be used to prevent premature termination of a relationship (Pisano 1989). Boards of directors in equity relationships also play important role in the coordination of knowledge transfer. Each party exchanges strategic information for joint management. The board of directors that is granted explicit power to monitor and control alliance activities can improve information sharing over the course of the alliance in a cooperative direction (Sampson 2007).

However, the impact of equity grants on further innovation might be ambiguous. In technology licensing contracts where knowledge is relatively codifiable, simple, or closely related to a partner's knowledge base, information sharing and coordination through equity ownership is less likely to be beneficial. Furthermore, equity participation can slow decision-making processes as firms' jointly making decisions—via a joint board of

[1] Licensor's ownership of licensee's equity enables the licensor to share in additional benefits (profit) from the licensee's subsequent innovation due to knowledge transfer from the licensor.

directors—seek to reach agreement. In particular, small- and medium-sized enterprises in the high-tech industry, where the technological risk is very high and innovation cycles are getting shorter, should make faster day-to-day decisions and more timely responses to issues that arise over the course of the project. However, the coordination and centralized decision making required in equity ownership would slow decision-making processes and obstruct fast responses to unpredictable challenges, thwarting the innovative progress (Sampson 2007).

The above discussion leads us to the following hypothesis.

- Hypothesis 2: The impact of equity grants in technology licensing agreements on SMEs' innovative performance is ambiguous. Technology licensing agreements including equity grants may contribute less or more to the licensee's innovation than agreements with other types of ongoing payments.

According to Dechenaux et al. (2009), fixed-fee payments prevent the licensee from shelving—which means that the licensee leaves the transferred technology unused and makes no attempts to develop it further—because of the burden to pay high costs at a single time. It may cause a heavy blow, especially for small- and medium-sized firms. Thus, once a licensee firm's choice to pay fixed fees may reveal its commitment to putting effort into *ex post* development. Given the positive effect of ongoing payment, the additional effect of fixed fees can be addressed. The licensee's diligence to replenish the sunk costs is expected to generate a synergy effect with the partnership through the ongoing payment.

- Hypothesis 3: Ongoing payments mixed with fixed fees contribute more to firm innovation than payments lacking fixed fees.

3. Research methods

3.1. Data

In order to clarify the relationship between the payment mechanism and a firm's innovative performance after an inter-firm technology licensing alliance, this paper employs a dataset constructed from technology licensing agreements in which SMEs participate as technology buyers (licensees). Because relatively larger companies tend to operate multiple R&D projects at the same time, it is difficult to capture the impact of a particular alliance on their performance. Since this paper limits itself to SMEs, the major findings associated with a firm's alliance activities are comparatively trustworthy and can be used to correlate a specific technology transfer contract to the firm's performance.

The basic information about technology licensing agreements has been drawn from the Securities Data Company (SDC) Database of Thomson Financial. The SDC provides information on various contract-specific characteristics: the contract type (e.g., technology licensing agreement, technology joint venture, joint development, etc.), the date of the agreement, identities of the participant firms (name, primary standard industrial classification (SIC) code, parent company, parent nation, etc.), and the deal text. The deal text identifies the roles of the participants—licensor and licensee—and the financial details that apply to the payment mechanism adopted in the agreement.

The sample used in this paper includes all kinds of technology licensing agreements—exclusive and non-exclusive—commenced during the years 1997-2004. Several steps were taken to increase the reliability of the dataset. First, leaving *completed* contracts among the total 5,892 agreements, *terminated* or *pending* contracts were removed to limit analysis to alliance features that had been mutually agreed upon. Second, 614 licensing alliances were chosen that had announced financial details in the deal text, and from which payment mechanisms specified in the text could be extracted. Third, using the number of employees—a statistic gained from "DATA Stream" in the SDC database, a database that includes financial information of listed enterprises worldwide—the sizes of firms were identified. This study considers firms with fewer than 1,000 employees to be small- and medium-sized firms[2].

These data on firm technology licensing were finally combined with patent data from the US Patent and Trademark Office (USTPO). This treatment and some additional cleaning of the data resulted in 118 licensing agreements with two identified participants (licensor and licensee), involving 221 companies in 19 nations.

Of the sample, 62% are same-nation alliances, in which the two partner firms are headquartered in the same nation, and 38% involve international licensing. Meanwhile, we identified the industry sectors where participant firms operate their main businesses, based on information from the *standard industrial classification* (SIC) code in the SDC data. Same-industry licensing, where participants share the first two digits in the SIC code, made up 44% of the sample.

The main interest of this paper is the payment mechanism chosen in technology licensing agreements. Table 1 shows the total number of alliances underlying this empirical analysis. Thirty three percent of the sample agreements adopted fixed-fee payments only, while 67% used ongoing payments. Among 79 alliances that adopted ongoing payments, sixty licensing alliances (76%) included fixed fees, and the remainder, nineteen alliances (24%), had payments based only on *ex post* outcomes with no fixed fees. In addition, 15 alliances (19%) included equity grants to the licensor, and in nine of these alliances (11%), fixed fees together were also used.

[2] In some cases, we cannot identify the exact number of employees of companies (licensees) in our data sample from the SDC database because it does not provide the data for unlisted companies. For these firms, we checked whether they fall into the category of SME using other sources, such as Internet searching for their homepages.

Table 1. Total number of alliances in sample, by payment mechanism.

Payment mechanism		Number of alliances	
Fixed fee only		39	(33%)
Ongoing		79	(67%)
Total		118	(100%)
Ongoing			
	Including fixed fee	60	(76%)
	Not including fixed fee	19	(24%)
	Including equity	15	(19%)
	Not including equity	64	(81%)
	Including equity & fixed	9	(11%)
	Not including equity & fixed	70	(89%)
	Total	79	(100%)

3.2. Variables

3.2.1. Dependent variable

The innovative performance of a licensee firm was measured by the number of patents granted in the three years after the agreement, a variable labeled *post patents*. For example, if an agreement was commenced in 1997, the total number of patents granted to the firm during 1998-2000 was counted to construct the dependent variable *post patents*. The criterion for year of patent was the patent application date. Since firms who have attained R&D outcomes tend to apply for patents in most developed countries, the patents, once applied for, could be supposed to represent the results of the firm's innovative performance. Furthermore, a one-year lag was added between agreement commencement and patent application, because R&D efforts after a contract need some time to yield outcomes (Sampson 2007).

Admittedly, simple patent counts are insufficient in themselves to stand proxy for the value of innovation, because patents vary enormously in their technological and economic significance. Due to this limitation, the weighted counts by the number of citations made by later patents have been suggested in a few works (Trajtenberg 1990; Sampson 2007). However, since the patent data was collected from 1998 to 2007 (three years after the licensing contract), the wide age difference among patents might cause bias problems. Since older patents have more opportunities to be cited, their citation numbers might be larger than those of younger patents (Trajtenberg 1990), which could confuse the relative innovativeness of patents. To avoid this problem, the simply aggregated number of patents was used in this analysis.

3.2.2. Independent variables

Ongoing is a dummy variable coded as 1 if the licensing alliance *i* has adopted one of the output contingent payments—royalty, milestone, or equity—otherwise it is 0. Moreover, interaction terms were used to discover additional effects of equity grants and fixed-fee payments. *Ongo×equity* is a dummy variable meaning the cases that particularly include equity grants among ongoing payments, and the cases that include fixed-fee payments among ongoing payments were assigned to the *Ongo×fixed* dummy. Finally, the *Ongo×equity×fixed* dummy was constructed by multiplying the *Ongo×equity* dummy with the *Ongo×fixed* dummy in order to check the presence of an additional interaction effect between equity grants (*equity*) and fixed fees (*fixed*).

3.2.3. Control variables

Control variables include some factors related to a firm's internal innovative capacity and the partner's capacity. To investigate a firm's (licensee's) internal capacity for technological innovation, we measured the number of patents that the firm retained. *Prior patents* captures the firm's prior R&D spending, propensity to patents, and technological capabilities (Sampson 2007). This variable is counted within a three-year window before the agreement.

In addition, the ability to manage inter-firm alliances could be important for improving *ex post* performance. It is expected that a firm who has conducted numerous technology transfer agreements would generate better innovation performance than one who has experienced fewer or none. To capture this effect, the *pre-experiences* dummy and *other alliances* dummy were used. The *pre-experiences* dummy equals 1 if the licensee firm has any technology licensing experience since 1991, and 0 otherwise. The *other alliance* dummy represents whether the licensee firm participated in multiple technology licensing agreements during the three years after the focal agreement.

To control the partner firm's innovative capacity, the number of partner's patents (*partner patents*) was counted, using the same method as *prior patents*. Additionally, the size of the partner was controlled by the *partner-big* dummy, which equals 1 if the number of the partner firm's employees exceeds a thousand, otherwise it is 0.

Same nation (1 if two partner firms are headquartered in the same nation) and *same industry* (1 if two partners' main businesses belong to same industry) dummies were included. The close physical proximity is expected to reduce the challenges for mutual coordination and, thus, affect post-alliance patenting (Sampson 2007). Moreover, to adjust the wide gap in the analyzed period of 1997-2004, the *year 1990s* dummy was coded 1 if the licensing alliance was commenced in the 1990s, and 0 if commenced in the 2000s.

Finally, dummy variables for licensees' primary industries were included in order to control the differences in propensity to patent (Arora et al. 2008) across industries. Based on the two-digit SIC code, the six major industries in our sample (*SIC28, SIC36, SIC38, SIC73, SIC80, and SIC87*)[3] were controlled. The most dominant industry with the highest

[3] Names for the industries are "Chemicals And Allied Products (SIC28)," "Electronic and Other

number of observations is Chemicals and Allied Products (*SIC28, n=55*), followed by *SIC38 (n=14*), *SIC87* (*n=10*), *SIC73* (*n=6*), and *SIC80* (*n=5*).

Descriptive statistics are presented in Table 2 and Table 3.

Table 2. Descriptive statistics.

	Variables	Obs.	Mean	Std. Dev.	Min	Max
(1)	Post patents	118	21.44	53.65	0	317
(2)	Ongoing	118	0.67	0.47	0	1
(3)	Ongo×equity	118	0.13	0.33	0	1
(4)	Ongo×fixed	118	0.46	0.50	0	1
(5)	Ongo×equity×fixed	118	0.06	0.24	0	1
(6)	Prior patents	118	31.46	110.59	0	1044
(7)	Pre-experiences	118	0.49	0.50	0	1
(8)	Other alliances	118	0.46	0.50	0	1
(9)	Partner patents	118	122.36	454.88	0	4147
(10)	Partner-big	118	0.25	0.43	0	1
(11)	Same nation	118	0.62	0.49	0	1
(12)	Same industry	118	0.44	0.50	0	1
(13)	Year1990s	118	0.88	0.32	0	1

Electrical Equipment and Components, except Computer Equipment (SIC36)," "Measuring, Analyzing, and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks (SIC38)," "Business Services (SIC73)," "Health Services (SIC80)," and "Engineering, Accounting, Research, Management, and Related Services (SIC87)" respectively.

Table 3. Correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Post patents	1.00												
(2) Ongoing	0.05	1.00											
(3) Ongo×equity	-0.11	0.27	1.00										
(4) Ongo×fixed	-0.07	0.65	0.01	1.00									
(5) Ongo×equity×fixed	-0.08	0.18	0.66	0.27	1.00								
(6) Prior patents	0.58	-0.10	-0.08	-0.09	-0.06	1.00							
(7) Pre-experience	0.11	0.26	0.03	0.25	0.04	0.00	1.00						
(8) Other alliance	0.03	0.25	0.01	0.32	0.06	-0.05	0.42	1.00					
(9) Partner patents	0.17	-0.04	0.01	-0.12	-0.02	0.00	-0.15	-0.10	1.00				
(10) Partner-big	0.03	-0.06	0.08	-0.05	0.11	-0.08	-0.17	-0.13	0.38	1.00			
(11) Same nation	-0.17	0.04	0.14	-0.08	0.05	-0.17	0.07	0.06	0.08	-0.16	1.00		
(12) Same industry	-0.08	0.19	0.12	0.21	0.14	-0.10	0.05	0.11	0.09	0.05	-0.15	1.00	
(13) Year1990s	0.12	0.08	-0.17	0.07	-0.13	0.08	0.10	0.13	0.08	-0.03	0.04	-0.26	1.00

3.3. Methodology

The dependent variable—the number of patents granted by a licensee firm in the three years after a technology licensing agreement—involves typical count data that require specific econometric methods. Since the dependent variable is discrete and non-negative with the preponderance of zeros and small values, we adopted the linear exponential family, such as the Poisson Regression Model (PRM) and the Negative Binomial Regression Model (NBRM) (Green 2008).

PRM has been criticized based on its property of equality between the conditional mean and variance function. It is common to find that the conditional variance is larger than the conditional mean empirically, implying "over-dispersion." In the presence of over-dispersion, the most common alternative is NBRM, which arises from a natural formulation of cross-section heterogeneity. The NBRM is a more generalized model, introducing an individual unobserved effect into PRM (Green 2008).

4. Results and discussion

4.1. Ongoing payment and innovation

Table 4 reports the estimation results obtained from PRM and NBRM. Robust standard errors were examined to accommodate extra correlation in the data. The signs and significance levels are similar in both models. Usually, the first step in the analysis of count data is to consider how well the Poisson model fits the data.

A likelihood ratio test of the null hypothesis of *no* over-dispersion confirms that the over-dispersion is significant[4]. Thus, the test results indicate that PRM is not appropriate, and we discuss the results of NBRM.

Table 4. Estimation results for payment mechanism and performance.

	Poisson Model (PRM)		Negative Binomial Model (NBRM)	
Post patents	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
Ongoing	1.2210**	0.0710	0.7774*	0.4575
Ongo×equity	− 1.4374**	0.1501	− 1.2690*	0.7362
Ongo×fixed	− 0.9910**	0.0677	− 0.1010	0.5325
Ongo×equity×fixed	0.0801	0.2327	− 0.0148	0.9335
Prior patents	0.0037**	0.0001	0.0104**	0.0021
Pre-experiences	1.0977**	0.0645	0.5952*	0.2992
Other alliances	0.7088**	0.0584	0.7192*	0.3220
Partner patents	0.0008**	0.0001	0.0006	0.0005
Partner-big	0.1326*	0.0645	0.6984*	0.3322
Same nation	− 0.6857**	0.0531	− 0.6150*	0.2827
Same industry	0.0419	0.0605	0.0695	0.3041
Year1990s	1.1211**	0.1446	0.3937	0.4246
Constant	0.6574**	0.1618	0.4955	0.5306
SIC28	− 0.5135**	0.0879	0.1316	0.4485

[4] [Prob. > $\bar{\chi}_{01}^{2}$] << 0.01, where $\bar{\chi}_{01}^{2}$ = 2(Log likelihood of NBRM – Log likelihood of PRM) and its limiting distribution is a 50:50 mixture of χ_0^2 and χ_1^2 distributions, see Gutierrez et al. (2001) for more details

SIC36	−0.1317	0.0890	0.7473	0.5814
SIC38	0.2252*	0.1111	0.8781*	0.5155
SIC73	−0.5180**	0.1939	−0.0153	0.7206
SIC80	−0.1183	0.1766	0.5340	0.8264
SIC87	0.2421*	0.1080	−0.2220	0.6783
Number of observations	118		118	
Log likelihood	−1733.926		−388.628	
Over-dispersion Test	$\bar{\chi}^2_{01}$=2690.60,	Prob > $\bar{\chi}^2_{01}$ = 0.000		

Notes: *Statistically significant at the 10% level
** Statistically significant at the 1% level

In NBRM, the results show that *ongoing* positively affects licensee firms' patenting, which is consistent with the expectation in hypothesis 1[5]. The significantly positive coefficient of *ongoing* indicates that a payment scheme including ongoing payments is better than a payment scheme with only fixed fees in terms of *ex post* performance. The output-contingent payment more effectively induces the inventor's non-contractible efforts and the licensee's active participation, which facilitates knowledge sharing and transfer and accordingly increases the licensee's innovation rates. Although compensating with only fixed fees may elicit sincere efforts from the licensee, the results suggest the limitation of developing alone. The ongoing payments in technology licensing contracts that make it possible to sustain a relationship with the alliance partner revealed better performance.

The results found in control variables are interesting. All variables related to the licensee firm's internal capabilities positively influenced firm patenting after the beginning of an agreement. *Prior patents*, a proxy for the firm's innovative capacity, showed a particularly significant impact on performance. Moreover, the ability to apply external-sourcing strategies, the *pre-experiences* dummy and *the other alliances* dummy, also positively affected the innovative performance. These results confirm that the success of technology licensing relies on the licensee firm's internal technological capabilities and the absorptive capacity of external knowledge that is developed through cumulative learning and experiences.

On the other hand, the variable *partner patents* was insignificant, while the size of the partner firm, *partner-big*, marked a significantly positive coefficient. The former result is consistent with Sampson (2007), where the interpretation was that the benefits of

[5] The estimates at sample means of explanatory variables show about 117% increase in innovation performance when ongoing payments are used.

collaborative activities depend more on a firm's absorptive capacity (such as *pre-experiences*) than on the stock of the partner's technological resources. However, the latter could imply the broader extent of the partner's production and marketing capacity available for *ex post* development. Since big companies can afford other types of aid—such as monetary support, management counseling, manufacturing support, and marketing channels—as well as technical assistance, SMEs tend to benefit more from them than from relatively small companies.

The inter-partner market commonality, *same nation* and *same industry* dummies, revealed no positive effects on alliance performance. Further, when partners are headquartered in the same nation, the performance was worse than in international licensing alliances. Although closely market-positioned partners more easily share information, it appears that concerns for potential competition may prevent them from collaborating intimately (Das and Teng 2003). Finally, there is no significant result for industry dummies except *SIC 38* ("Measuring, Analyzing, and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks"). It seems that the data for each industry are not significant enough to reveal industrial differences in propensity to patent.

To sum up, the empirical results suggest that the existence of a relational partnership after the agreement with an ongoing payment scheme plays an essential role in harvesting more. In addition, an SME's technological performance highly depends on the firm's own innovative capabilities and the partner's production capacity. Once an SME has the ability to utilize the internal and external resources, the link connected to the advanced partner would accelerate innovative performance.

4.2. Additional effects of equity grants and fixed fees

The finding on the effect of equity grants shows a significantly negative coefficient. Although it is commonly expected that equity grants build closer relationships between partners, the influence of equity grant was less efficient than the effect of other forms of ongoing payment—including royalties and milestone payments. Furthermore, the negative value in the sum of coefficients for the two variables, *ongoing* and *ongo×equity,* indicates that licensing agreements that include equity grants tend to generate worse performance than alliances with only fixed-fee payments.

This can be interpreted from several perspectives. First, as mentioned in section 2, the additional monitoring and coordination required because of the licensor's equity ownership makes the decision-making process of the licensee complicated and impedes faster responsiveness to unforeseen challenges that arise over the life of SMEs. The stronger relationship with the external partner would dampen innovative performance by decreasing the SME's flexibility (Oxley 1997; Pisano 1989). These negative effects offset the positive effects of knowledge sharing, reduction of opportunism, and collaboration between partners. Additionally, since equity is usually used as a method of compensation for riskier technology by the licensor (Elfenbein 2004), it might not directly improve the licensee's innovative performance. Because stocks are marketable whenever their owner wants to sell off, licensors can hedge the risks of the alliance and break off the relationship in the middle of development.

Meanwhile, the additional effect of fixed fees was insignificant. Although the mixed effect of fixed fees and ongoing payment was expected to increase the licensee firm's patenting in hypothesis 3, no significant influence has been found. Because the proportion of fixed fees considerably decreases when combined with output-contingent payments, the commitment effect for further innovation could not be conspicuous. Fixed fees mixed with royalties or milestone payments would be considered by a licensee to be sunk costs, which are inevitably required for concluding the contract. The effect of ongoing payments, therefore, remains unchanged even if it includes fixed fees.

Finally, the insignificant effect of *ongo×equity×fixed* reveals that there is no additional effect of combining equity grants and fixed fees. Considering the additional effects of equity and fixed fees respectively, the insignificant joint effect is not surprising.

5. Conclusion

This study examined payment mechanisms in technology licensing contracts functioning as catalysts to elicit the inventor's effort, knowledge sharing, and further innovation. While considerable previous works have recognized that complex payment mechanisms in technology licensing serve to reduce risks, deal with moral hazard problems, and successfully complete contracts, this paper has explored the role played by the payment mechanism in augmenting the licensee firm's innovative performance. Even though the payment mechanism may depend on the business condition of the licensor and the licensee at contract time, licensees can collaborate intensively with outstanding partners for a considerable time and expect to make *ex post* progress based on this connection through ongoing payments.

Given the positive effects of ongoing payments, this study has also examined the possible influence of various combinations of payments, focusing on equity grants and fixed fees. The empirical results revealed that equity grants negatively affect SMEs' innovative performance, though equity is generally considered to strengthen the partnership between the contract parties. Although this study attempted to explain the diverse reasons behind this negative effect, the study's research framework was limited in that it did not allow for investigation of the influence of partnerships with differentiated levels of intensity. Admittedly, if the intensity of a partnership were determined with respect to the contractual terms or other types of measures, it might convey greater implications to this research. Moreover, it would be meaningful to extract the separated effect of each payment mechanism, such as royalties and milestone payments.

To conclude, technology transfer is an important goal in inter-firm alliances. Sharing knowledge, which is achieved through favorable resource flows, is one of the critical factors for innovative success (Sampson 2007; Thursby et al. 2005). In this sense, many works weighted the relational governance mode of alliances for increasing knowledge flows between partners. Then, should SMEs always seek to enter into relational alliances with technology owners? The findings of this paper showed that even in contractual alliances, licensee firms could derive knowledge from inventors and utilize it for further innovation by carefully organizing the contract structures. Investigation of the payment mechanism in a contract can shed light on this question.

References

[1] Arora, A. (1996). Contracting for Tacit Knowledge: The Provision of Technical Services in Technology Licensing Contracts. Journal of Development Economics, 50(2), 233-256.

[2] Arora, A., Ceccagnoli, M. & Cohen, W. M. (2008), R&D and the patent premium. International Journal of Industrial Organization, 26 (5), 1153-1179.

[3] Bessy, C. & Brousseau, E. (1998). Technology Licensing Contracts Features and Diversity. International Review of Law and Economics, 18 (4), 451-489.

[4] Bessy, C., Brousseau, E & Sauissier, S. (2008). Payment Schemes in Technology Licensing Agreements: A Transaction Cost Approach. Working Paper, University Paris I. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1259394. Accessed 25 July 2009.

[5] Bousquet, A., Cremer, H., Ivaldi, M. & Wolkowicz, M. (1998). Risk Sharing in Licensing. International Journal of Industrial Organization, 16 (5), 535-554.

[6] Bozeman, B. (2000). Technology Transfer and Public Policy: A Review of Research and Theory. Research Policy, 29 (4-5), 627-655.

[7] Dechenaux, E., Thursby, M. & Thursby, J. (2009). Shirking, Sharing Risk and Shelving: The Role of University License Contracts. International Journal of Industrial Organization, 27, 80-91

[8] Elfenbein, D. (2004). Contract Structure and Performance of Technology Transfer Agreements: Evidence from University Licenses. http://elsa.berkeley.edu/users/webfac/farrell/e221_s04/dan.pdf. Accessed 20 July 2009.

[9] Feldman, M., Feller, I., Bercovitz, J. & Burton, R. (2002). Equity and the Technology Transfer Strategies of American Research University. Management Science, 48(1), 105-121.

[10] Fey, C. F., & Birkinshaw, J. (2005). External Sources of Knowledge, Governance Mode, and R&D Performance. Journal of Management, 31 (4), 597-621.

[11] Grant, R. M. (1996). Toward a Knowledge-Based Theory of the Firm. Strategic Management Journal, 17 (Winter Special Issue), 109-122.

[12] Greene, W. H. (2008). Econometric Analysis. Upper Saddle River, NJ: Prentice Hall.

[13] Gutierrez, R. G., Carter, S. & Drukker, D. M. (2001). On Boundary-Value Likelihood-Ratio Tests. Stata Technical Bulletin, 10 (60).

[14] Hatzichronoglou, T. (1997). Revision of the High-Technology Sector and Product Classification. OECD Science, Technology and Industry Working Papers. OECD Publishing.

[15] Jensen, R. & Thursby, M. (2001). Proofs and Prototypes for Sale: The Licensing of University Inventions. The American Economic Review, 91 (1), 240-259.

[16] Kim, Y. & Vonortas N. S. (2006). Technology Licensing Partners. Journal of Economics and Business, 58, 273–289.

[17] Lee, Y. & Cavusgil, S. T. (2006). Enhancing Alliance Performance: The Effects of Contractual-Based versus Relational-Based Governance. Journal of Business Research, 59 (8), 896-905.

[18] Lim, T. A. & Veugelers, R. (2003). On Equity as a Payment Device in Technology Licensing with Moral Hazard. http://www.univ-paris1.fr/f4_lim.pdf. Accessed 15 June 2009.

[19] Macho-Stadler, I., Martinez-Giralt, X. & Perez-Castrillo J. D. (1996). The Role of Information in Licensing Contract Design. Research Policy, 25 (1), 43-57.

[20] Marjit, S. & Mukherjee, A. (2001). Technology Transfer under Asymmetric Information: The Role of Equity Participation. Journal of Institutional and Theoretical Economics, 127 (2), 282.

[21] Mowery, D. C., Oxley J. E. & Silverman B. S. (1996). Strategic Alliances and Interfirm Knowledge Transfer. Strategic Management Journal, 17, 77-91.

[22] Oxley, J. E. (1997). Appropriability Hazards and Governance in Strategic Alliances: A Transaction Cost Approach. Journal of Law, Economics, & Organization, 13 (2), 387-409.

[23] Pisano, G. P. (1989). Using Equity Participation to Support Exchange: Evidence from the Biotechnology Industry. Journal of Law, Economics, & Organization, 5 (1), 109-126.

[24] Sampson, R. C. (2007). R&D Alliances and Firm Performance: The Impact of Technological Diversity and Alliance Organization on Innovation. The Academy of Management Journal, 50 (2), 364-386.

[25] Trajtenberg, M. (1990). A Penny for Your Quotes: Patent Citations and the Value of Innovations. The RAND Journal of Economics, 21 (1), 172-187.

[26] Vishwasrao, S. (2007). Royalties vs. fees: How do firms pay for foreign technology?, International Journal of Industrial Organization, 25, 747-759.

[27] Vrande, V., de Jong, J. P. J., Vanhaverbeke, W., de Rochemont, M. (2009), Open innovation in SMEs: Trends, motives and management challenges. Technovation, 29 (6-7), 423-437.

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