Patent Thickets and Licensing: Empirical Findings from Japanese Listed Companies

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Abstract

This paper employs licensing contract information disclosed in the "Important Technology Contracts in Business" section of the Annual Securities Reports of Japanese listed companies to construct a licensing dataset. We propose alternative methods of measuring patent thickets using patent statistics from the Patstat database and examine the effects of patent thickets on licensing contracts and patent portfolio races of Japanese companies.

Our empirical results show that patent thickets are positively associated with licensing activities, and the patent applications of both licensors and licensee. However licensing activities help to alleviate patent portfolio races both for licensors and licensees.

Keywords: patent thickets; licensing; patent portfolio race.

JEL classification: L10, L20, O34

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1 Introduction

A patent thicket is a dense web of overlapping intellectual property rights (IPR) that a company navigate or break through to commercialize new technology (Shapiro (2001)). In a patent thicket, rival firms hold patents protecting components of a modular and complex technology. The term modular implies that different sets of components that can be assembled to yield a variety of technological products, and complex means that products composed of many such modular components (Hall et al. (2012)). The patents protecting the components may overlap because the functionality of the components are often partial or complete overlaps. Thus, whenever a firm uses such overlap technology, it is vulnerable to the risk of hold-up, namely the danger that the new products will inadvertently infringe on rival firms holding blocking patents (Grindley and Teece (1997), and Shapiro (2001)).

As indicated in Siebert and Graevenitz (2011), patent thickets raise the cost of using complex technology and increase incentives to acquire marginal patents. Some literature investigated the effects of patent thickets and exploited a measure of patent thickets and solutions for hold-up problems in patent thickets, particularly, addressing whether patent licensing is an effective solution for the hold-up problem.

Ziedonis (2004) introduced the first measure of hold-up potential into the literature (Hall et al. (2012))[1]. The measure uses patent citations from focal firm's patents to prior patents owned by other firms, and calculates fragmentation of these patent citations to prior patents. Ziedonis (2004) argued that if a firm faces a more fragmented set of prior patents, it will build a larger portfolio of patents in order to insure itself against the hold-up problem.

[1] Hall et al. (2012) noted that the measure proposed by Ziedonis (2004) does not identify the "web of overlapping patent right.". Clarkson (2005), and Graevenitz et al. (2011, 2012) built measurements based on social network analysis to identify the web of overlapping IPR.

Nishimura and Nagaoka (2012) developed a unique measure of the patent thicket, which employs a size of patents jointly utilized in the commercial application of inventions by their inventors, for 1,200 Japanese firms. The authors' findings show that patenting propensity increases more with firm size in industries with greater patent thicket. The findings also suggested that cross–licensing is often a response to the patent thicket problem for Japanese manufacturers.

Siebert and Graevenitz (2011) investigated whether patent licensing provides a mechanism to either avoid or resolve the hold-up problem. Particularly, they distinguish between ex ante and ex post licensing, and examine the effects of choice between ex ante and ex post licensing on hold-up. Applying a sample selection model of licensing derived from a theoretical model to a dataset for the US semiconductor industry, the authors show that licensing helps to resolve blocking: high expected blocking leads to ex ante licensing, whereas ex post licensing arises if expected blocking is low but realized blocking is high. Moreover, a expected ex ante licensing allows reductions in a firms' patenting level.

The measure of thicket or blocking used in Siebert and Graevenitz (2011) is defined as the interaction of the share of patent citations and a measure of technology proximity on patents proposed in Jaffe (1986).

This paper employs methods used in Clarkson (2005) and Zhang et al. (2013) as two alternative methods for measuring patent thickets and to investigate the relationship between patent thickets and licensing in Japanese companies. We build indexes of patent blocking both for licensor and licensing, and draw on a dataset of licensing contracts from Annual Securities Reports for Japanese listed companies from the year 1990 to 2007. We also utilize a treatment regression model to examine the effects of patent thickets on licensing as well as patent portfolio races of Japanese listed companies.

Our empirical findings suggest that patent blocking faced both by licensor and licensee has a significant effect on promoting Japanese firms' licensing activities. At the same time, licensing helps to alleviate the patent portfolio race both for the licensor and licensee while patent blocking is positively associated with the patent portfolio race, say, increasing the number of patent applications both by licensor and licensee.

Our contributions to the literature are twofold. As an index for patent blocking, the alternative method proposed in Zhang et al. (2013) is statistically more appropriate than the indexes used in Siebert and Graevenitz (2011) and in Clarkson (2005). Different to the latter two, Zhang et al. (2013) identified a degree of IPR overlap between citing and cited patents. On the other hand, as pointed out by Kim and Vonortas (2006), empirical literature on technology licensing has been less forthcoming because of limited data on licensing contracts. Our study complements the literature by building a dataset for licensing contracts from "Important Technology Contracts in Business" from the Annual Securities Report for Japanese listed companies. The data sources are all open to access by researchers and the results can be replicated.

The remainder of the paper is organized as follows. Section 2 describe the dataset employed in our empirical analysis. Section 3 explains the measurement of patent thickets and the definition of variables. Section 4 presents our empirical results. Section 5 concludes the paper.

2 Data

2.1 Dataset of Licensing Contracts

Japanese listed companies report to shareholders the "Important Technology Contracts in Business" that they sign every year in their Annual Securities Reports. The information consists of the new licenses contracted during the year, the names of licensors and licensees, and the contents of the license[2]. We identify a total of 621 licensing contracts with 470 unilateral licenses and 151 cross–licenses between approximately 440 Japanese listed companies during the period between 1990 and 2007.

We treat a cross license as two unilateral licenses, and treat the two firms in the firm pair as licensor and licensee simultaneously. We also exclude the licensors or licensees that did not apply for patent application from Japan Patent Office (JPO) during the period between 1990 and 2007. This provides 653 contracts between the licensors and licensees over the whole time span. Figure 1 shows that the number of new licensing contracts among Japanese listed companies in our sample grew slightly during the sample period. Table 1 reveals that the majority of licensors or licensees of new licensing contracts are concentrated in chemicals, pharmaceuticals, machinery, and electrical and electronic machinery industries.

2.2 Patents and Citation Data

We collect data on patent application filing and publication date, name of patent applicants, and information for patent citations on patents applied for in the JPO, from a database released by Japanese Institute of Intellectual Property (IIP)[3]. Because the IIP database did not provide complete information for the international patent classification (IPC) assigned

[2]This information was also used in Nagaoka and Kwon (2007).

[3]See Goto and Motohashi (2007) for details of the IIP dataset.

to each JPO patent, we use the Patstat database (Patstat, April 2011 version) released by the European Patent Office (EPO) to obtain all of the information on the IPC for the JPO patents. The Nikkei Company Code is used to match the name of of the JPO patent applications with the name of the Japanese listed companies in the Annual Securities Report.

On the one hand, a complete classification symbol for the IPC comprises the combined symbols representing the section, class, subclass, main group, and subgroup in descending order of hierarchy. The majority of inventions patented to the JPO are diversified across different categories of subject matter, or technical characteristics. This is because the invention information is often associated with different categories of subject matter, i.e., processes, products, apparatus or materials, or the case that the technical characteristics of the subject of the invention are concerned both with function-oriented places and application places[4]. We then use this information to measure patent thickets in our empirical analysis.

[4]To the patent with application code 2000009115, for example, the full list of IPC assigned is C12M 1/24, C12M 1/26, C12M 1/34, C12N 11/00, C12N 11/04, C12Q 1/00, C12Q 1/06, C30B 15/00, G01N 33/18, G01N 33/48, H03H 9/02.

3 Measurement of Patent Thickets and Definition of Variables

3.1 Empirical Framework

Our prime interest is in investigating the relationship between patent thickets and licensing in Japanese companies. Thus, we focus our regressions on the following equation[5],

$$Licensing_{it} = \beta_0 + \beta_1 Block_{it} + \beta_2 Fragmentation_{it} + \beta_3 MarketShare_{it} + u_{it} \tag{1}$$

where $Licensing_{it}$ equals a unit if a new license is signed between the i^{th} pair of firms in year t, and zero otherwise. $Fragmentation_{it}$ represents the fragmentation of patent citations, and $MarketShare_{it}$ refers to production competition in market shares for the i^{th} pair of firms in year t. As argued by Siebert and Graevenitz (2008), if the (realized) blocking is sufficiently high, firms will prefer to enter into a (ex post) licensing contract to resolve blocking. Thus, we expect $\beta_1 > 0$.

We estimate Equation (1) by ordinary least squared (OLS) regression, and Logit regression as well. To test the relationship between patent thickets and the patent portfolio race, we employ a treatment regression model augmented with an endogenous binary-treatment variable, say, *Licensing* in our empirical analysis.

3.2 Measurement of Patent Thickets

To measure patent thickets, we employ a series of indexes that measure patent blocking and capture the strength of technological rivalry between firms and the potential for hold-up. First, we follow Siebert and Graevenitz (2008) to build two types of indices for patent thickets as follows,

[5]The equation owes much to Siebert and Graevenitz (2008) in their specification of the model for the relationship between blocking and ex post licensing contracts.

Fragmentation: As in Ziedonis (2004), the fragmentation of patent citations can be measured as,

$$Fragmentation_{kt} = 1 - \sum_{m=1}^{M} \left(\frac{C_{kmt}}{\sum_{m=1}^{M} C_{kmt}} \right)^2 \tag{2}$$

where C_{kmt} represents number of backward patent citations made by firm k to the patents of firm m during year t. We measure it for the licensor firm and the licensee firm respectively. We expect that firms' propensity to enter into licensing contracts would increase if they face higher hurdle due to more firms holding them up.

Blocking of SG: Siebert and Graevenitz (2008) proposed an index of patent blocking as follows,

$$Blocking\ of\ SG_{kmt} = RC_{kmt}^{SG} Prox_{kmt} \tag{3}$$

where RC_{kmt}^{SG} is measured as the share of patent citation on the patents of firm k that point to patents belonging to firm m given a total of M firms cited by firm k.

$$RC_{kmt}^{SG} = \frac{C_{kmt}}{\sum_{m=1}^{M} C_{kmt}}$$

$Prox$ represents technological proximity between firm k and m measured as,

$$Prox_{kmt} = \frac{P'_{kt} P_{mt}}{\sqrt{P'_{kt} P_{kt}} \sqrt{P'_{mt} P_{mt}}}$$

where P_{kt} represents vector of patent class shares of firm i's JPO patent applications in year t. We measure $Prox$ by four-digit IPC classification both for licensor and licensee firms.

In addition to the RC_{kmt} discussed in Siebert and Graevenitz (2008), we also propose two alternative methods from Clarkson (2005) and Zhang et al. (2013) to measure patent thickets as follows,

Blocking of adj Clarkson: For each patent n in firm k, the propensity for that to cite preceding external patents (held by other firms) within the same market is calculated as $C_{kn} =$

$\sum_{j=1}^{N} \frac{C_{knj}}{N}$, where C_{knj} equal to one if patent n cites external patent j, and zero otherwise with both patents belonging to the same market, and N represents the total number of possible citations to external patents. The market is defined by the four–digit IPC classification. We then obtain an adjusted index discussed in Clarkson (2005) as,

$$RC_{kt}^{adjClarkson} = \frac{\sum_{n=1}^{P} \sum_{j=1}^{N} C_{knj}/N}{P} \tag{4}$$

where P represents the number of markets where the firm k engages in business. Thus, $Blocking\ of\ adj\ Clarkson$ would be defined as,

$$Blocking\ of\ adjClarkson_{kmt} = RC_{kt}^{adjClarkson} Prox_{kmt} \tag{5}$$

$Blocking\ of\ adj\ Clarkson$ reflects the cumulative nature of innovation within the same market, and reveals the extent to which hold up occurs in the same technology or product field.

$Blocking\ of\ Zhang$: Because the most of JPO patents are assigned by two or more IPC classifications, our last alternative method can be defined as,

$$Blocking\ of\ Zhang_{kmt} = RC_{kmt}^{Zhang} Prox_{kmt} \tag{6}$$

and RC_{kmt}^{Zhang} is measured as,

$$\frac{\sum_p CSame_{kmpt}/C_{kmt}}{\sum_m \sum_p CSame_{kmpt}/C_{kmt}} \tag{7}$$

where $CSame_{kmpt}$ is an index of IPC's overlap in p^{th} citation between citing firm k and cited firm m during year t, and measured as,

$$CSame_{kmpt} = \frac{CI_{kmpt} CI_{kmpt}}{CI_{kpt} CI_{mpt}}$$

where CI_{kmpt} is the number of IPC classifications appearing simultaneously both in the citing patent and cited patent for the p^{th} citation. CI_{kpt} and CI_{mpt} are total number of

IPC classifications assigned to citing patent and cited patent respectively, related to the p^{th} citation. Full IPC is used for the measurement. Thus, $CSame_{kmpt}$ has a value between 0 and 1, representing the extent to which the citing and cited patents overlap with respect to technical characteristics.

We expect that $Blocking\ of\ Zhang$ could identify the "web of overlaping patent right", and capture the extent of patent thickets. If it is the case, $Blocking\ of\ Zhang$ should be positively associated with licensing contracts.

3.3 Definition of Other Variables

We also include other variables in our empirical analysis.

$Average\ Market\ Shares$ and $Difference\ Market\ Shares$: Larger firms are more likely to have production facilities and are therefore more susceptible to hold-up (Hall and Ziedonis (2001)). On the other hand, firms with larger market shares are less willing to sell their technologies because of the rent dissipation effect (Arora and Fosfuri (2003).

Licensing Experience: Previous experience with licensing reduces the costs of each subsequent contract (Siebert and Graevenitz (2008)).

4 Results

4.1 Sample Selection and Descriptive Statistics

We construct a sample for all firm pairs of approximately 440 Japanese listed companies during 1990 and 2007, which leads to a cross section of more than 180,000 observations. Of the firm pairs with no record of license contracts, we select 10% of observations randomly. This provides approximately 19,100 observations, of which there are 653 pairs with licensing contract records.

Table 2 presents the descriptive statistics of covariates used in our regressions. It also shows that the values of the blocking measures, i.e., *Blocking of SG*, *Blocking of adj Clarkson* and *Blocking of Zhang*, are higher for the firm pairs that chose licensing than for the firm pairs that did not license at all.

4.2 Estimated Results for Effects of Blocking on Licensing

We first estimate Equation (1) by using OLS. Table 3 shows the estimated results. The OLS estimations include licensor and licensee industry fixed effect, and year dummies.

As shown in the table, the coefficients of *Blocking of SG* and *Blocking of Zhang* are all positive and highly significant, and those for *Blocking of adj Clarkson* reveal significantly positive in column 4 and 7. This implies that higher blocking is positively associated with firms' higher propensity to enter into a (ex post) licensing contract, then to resolve the blocking.

The coefficients of *Fragmentation* are negative and significant in most cases both for licensor and licensee firms.

Galasso and Schankerman (2010) reported that patent disputes litigated in the U.S. district courts are settled more quickly when infringers require access to fragmented external rights. Thus, fragmentation of patent rights is positively associated with the speed of technology diffusion through licensing. On the other hand, however, Ziedonis (2004) noted that firms exposed to technology competition with more rival firms increase their patenting efforts. Siebert and Graevenitz (2008) argued that the firm's propensity to enter into licensing contracts could decrease if the number of firms that might hold it up increase. And the estimated results of Siebert and Graevenitz (2008) suggest that the trend towards greater fragmentation of patent citations undermines licensing significantly. Our results are consistent to the findings of Siebert and Graevenitz (2008) concerning fragmentation patent citations made both by licensor and licensee firms.

The estimated results concerning the transaction costs are somewhat unexpected. We apply previous licensing experience to control the effects of the transaction costs on licensing contract, and expect that firm's previous experience with licensing will reduce the costs of subsequent contracts. Our results, however, imply that licensor firms are unwilling to sell technology to the firms with previous experience of licensing contracts.

The coefficient of $Average\ Market\ Shares$ is positive and significant in column 3, while that for $Difference\ in\ Market\ Shares$ is significantly negative in column 7. These results coincide with those of Siebert and Graevenitz (2008), although the statistical significance is not strong.

Finally, the Akaike information criterion (AIC), Bayesian information criterion (BIC) and Log likelihood in Table 3 suggest that specification of the models with $Blocking\ of\ Zhang$ is more appropriate in the sense of statistics than those for $Blocking\ of\ SG$ and $Blocking\ of\ adj\ Clarkson$. That the specification of the model with $Blocking\ of\ adj\ Clarkson$ reveal inferior statistically may suggest that, hold–up problems do not only occur for firms within the same technology or product field.

Table 4 represents the estimated coefficients of Logit regressions as a counterpart to Table 3. The results are quite coincident with each other.

4.3 Estimated Results for the Effects of Blocking on the Patent Portfolio Race

To investigate the relationship between blocking and the patent portfolio race, we employ patent applications made by licensor and licensee firms to control the patent portfolio race. We utilize a treatment regression as a regression technique, in which *Licensing* is treated as an endogenous variable. The estimated results are shown in Table 5.

In the regression of *Licensing* on $Blocking\ of\ SG$ and $Blocking\ of\ Zhang$, the estimated coefficients for all independent variables are consistent with those obtained in Table 3 and Table 4. With respect to the relationship between blocking and patent applications, the coefficients of $Blocking\ of\ SG$ and $Blocking\ of\ Zhang$ reveal positive and significant both for licensor and licensee firms. On the other hand, *Licensing* appeals a strong negative effect on patent application both for licensor and licensee. This implies that a licensing contract helps to alleviate the patent portfolio race for the licensor as well as for the licensee.

5 Conclusion

In this paper, we employ the "Important Technology Contracts in Business" information from the Annual Securities Reports of Japanese listed companies. We construct a licensing dataset, and propose alternative methods of measuring patent thickets to examine the effects of patent thickets on licensing contracts and patent portfolio races in Japanese companies. Our main findings are summarized as follows.

(1) Patent blocking faced both by licensor and licensee firms has a positive and significant effect on firms' licensing activities.

(2) As an alternative method for measuring patent thickets, $Blocking\ of\ Zhang$ discussed in Zhang et al. (2013) shows more appropriate in the sense of statistics than $Blocking\ of\ SG$ proposed in Siebert and Graevenitz (2008) and $Blocking\ of\ adj\ Clarkson$ that adjust the index discussed in Clarkson (2005). The former identified a degree of IPR overlap between citing and cited patents, and can be related to patent thickets more closely than $Blocking\ of\ SG$ and $Blocking\ of\ adj\ Clarkson$.

(3) Licensing helps to alleviate patent the portfolio race measured by patent application made both by licensor and license, while patent blocking raises propensity for patent applications both in licensor and licensee firms.

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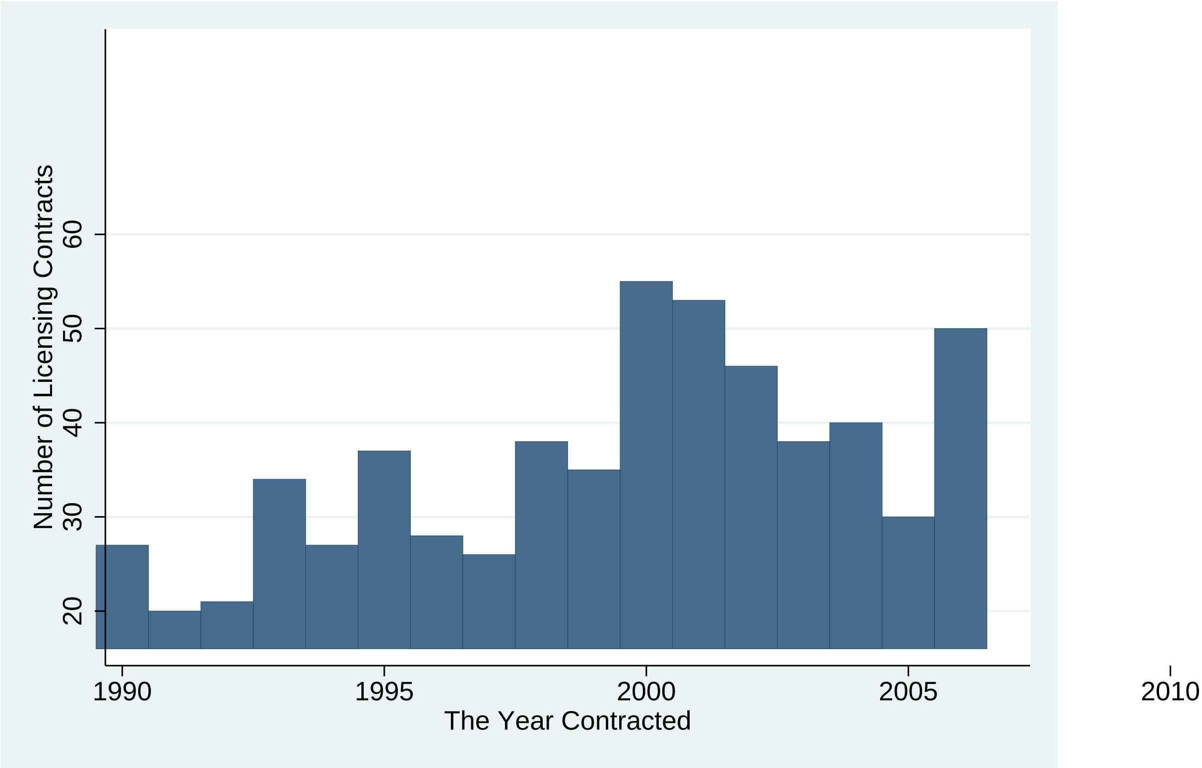

Figure 1: Number of Licensing Contracts during the period of 1990 to 2007

Table 1: Distribution of Licensing contracts across Industries

Industry	licensors	licensees
Food	16	11
Textile	14	15
Pulp and Paper Products	7	8
Chemicals	46	35
Pharmaceuticals	111	113
Rubber	6	11
Ceramics	12	14
Iron and Steel	34	37
Non-ferrous Metals	19	23
Machinery	67	76
Electrical and Electronic Machinery	191	188
Shipbuilding	9	7
Motot Vehicles	28	27
Precision Instruments	32	29
Miscellaneous Manufactures	11	23
Construction	8	1
Trade	13	5
Service	29	30
Total	653	653

Table 2: Descriptive Statistics for Firm Pairs

	Licensing Pair	No Licensing Pair	Full Sample			
	Mean	Mean	Mean	Std.dev	Min	Max
Patent Application for Licensee	851	635	643	1331	0.000	7809
Patent Application for Licensor	395	208	215	694	0.000	7809
Blocking of SB	0.020	0.001	0.002	0.017	0.000	0.550
Blocking of adj Clarkson	0.005	0.002	0.002	0.009	0.000	0.386
Blocking of Zhang	0.263	0.032	0.040	0.208	0.000	1.000
Fragmentation for Licensor	0.527	0.514	0.514	0.399	0.000	0.958
Fragmentation for Licensee	0.444	0.426	0.426	0.405	0.000	0.977
Average Market Shares	0.002	0.002	0.002	0.003	0.000	0.035
Difference in Market Shares	-0.001	-0.001	-0.001	0.005	-0.066	0.003
Licensing Experience for Licensor	0.727	0.683	0.685	0.465	0.000	1.000
Licensing Experience for Licensee	0.652	0.659	0.659	0.474	0.000	1.000
Observations	653	18455	19108			

Table 3: OLS Estimates for Effects of Blocking on Licensing

	I	II	III	IV	V	VI	VII	VIII
Dependent Variable: Licensing								
Blocking of SG	1.261***	2.176***			1.262***	2.178***		
	(4.29)	(8.67)			(4.29)	(8.68)		
Blocking of adj Clarkson	0.269		1.531***		0.268		1.532***	
	(1.22)		(4.69)		(1.22)		(4.70)	
Blocking of Zhang	0.115***			0.187***	0.115***			0.187***
	(5.78)			(11.67)	(5.79)			(11.68)
Fragmentation for Licensor	-0.012***	-0.008*	-0.005	-0.012***	-0.012***	-0.007	-0.004	-0.011***
	(-2.78)	(-1.70)	(-1.18)	(-2.75)	(-2.65)	(-1.49)	(-0.98)	(-2.63)
Fragmentation for Licensee	-0.013***	-0.006	-0.001	-0.014***	-0.013***	-0.006	-0.001	-0.014***
	(-3.35)	(-1.40)	(-0.26)	(-3.46)	(-3.39)	(-1.41)	(-0.20)	(-3.50)
Licensing Experience for Licensor	-0.002	0.001	0.002	-0.002	-0.001	0.001	0.002	-0.001
	(-0.46)	(0.31)	(0.59)	(-0.51)	(-0.37)	(0.43)	(0.69)	(-0.43)
Licensing Experience for Licensee	-0.013***	-0.012***	-0.011***	-0.013***	-0.013***	-0.012***	-0.011***	-0.013***
	(-3.31)	(-2.96)	(-2.67)	(-3.26)	(-3.32)	(-2.95)	(-2.65)	(-3.26)
Average Market Shares	0.937	1.348*	1.299	0.822				
	(1.16)	(1.66)	(1.57)	(1.02)				
Difference in Market Shares					-0.522	-0.679*	-0.567	-0.461
					(-1.28)	(-1.65)	(-1.36)	(-1.13)
Year Effects	yes	yes	yes	yes	yes	yes	yes	yes
Sector Effects for Licensor	yes	yes	yes	yes	yes	yes	yes	yes
Sector Effects for Licensee	yes	yes	yes	yes	yes	yes	yes	yes
AIC information criterion	-10222.61	-10038.57	-9391.29	-10070.56	-10222.98	-10038.6	-9390.61	-10070.86
BIC information criterion	-9719.20	-9550.64	-8903.37	-9582.63	-9719.57	-9550.68	-8902.69	-9582.93
Log Likelihood	5176.30	5082.28	4758.65	5098.28	5176.49	5082.30	4758.31	5098.43
No. of observations	17065	17065	17065	17065	17065	17065	17065	17065

Notes: (a) "***", "**", and "*" denote 1%, 5%, and 10% significance levels, respectively.
(b) Values in parentheses are t statistics.
(c) Robust standard errors are used for t statistics.

Table 4: Logit Estimates for Effects of Blocking on Licensing

	I	II	III	IV	V	VI	VII	VIII
Dependent Variable: Licensing								
Blocking of SG	5.994***	18.410***			6.028***	18.454***		
	(2.85)	(7.74)			(2.86)	(7.77)		
Blocking of adj Clarkson	4.892*		16.849***		4.874*		16.873***	
	(1.74)		(4.90)		(1.74)		(4.91)	
Blocking of Zhang	1.525***			1.980***	1.527***			1.983***
	(8.45)			(15.69)	(8.49)			(15.76)
Fragmentation for Licensor	-0.334**	-0.201	-0.108	-0.326**	-0.304**	-0.169	-0.080	-0.298**
	(-2.31)	(-1.45)	(-0.81)	(-2.26)	(-2.13)	(-1.23)	(-0.60)	(-2.08)
Fragmentation for Licensee	-0.340**	-0.109	0.043	-0.347**	-0.344**	-0.109	0.051	-0.349**
	(-2.50)	(-0.83)	(0.34)	(-2.54)	(-2.53)	(-0.83)	(0.40)	(-2.56)
Licensing Experience for Licensor	-0.015	0.061	0.082	-0.021	-0.004	0.074	0.093	-0.010
	(-0.14)	(0.58)	(0.78)	(-0.20)	(-0.04)	(0.70)	(0.88)	(-0.09)
Licensing Experience for Licensee	-0.389***	-0.341***	-0.307***	-0.385***	-0.390***	-0.341***	-0.305***	-0.386***
	(-3.36)	(-2.97)	(-2.73)	(-3.32)	(-3.36)	(-2.97)	(-2.71)	(-3.33)
Average Market Shares	38.196*	43.398**	40.309*	37.905*				
	(1.69)	(2.02)	(1.85)	(1.69)				
Difference in Market Shares					-20.208*	-21.754**	-17.826	-19.677*
					(-1.77)	(-1.99)	(-1.58)	(-1.73)
Year Effects	yes	yes	yes	yes	yes	yes	yes	yes
Sector Effects for Licensor	yes	yes	yes	yes	yes	yes	yes	yes
Sector Effects for Licensee	yes	yes	yes	yes	yes	yes	yes	yes
AIC information criterion	4894.98	5002.08	5178.65	4910.71	4894.66	5002.09	5179.42	4910.51
BIC information criterion	5390.43	5482.05	5658.62	5390.67	5390.11	5482.06	5659.38	5390.47
Log Likelihood	-2383.49	-2439.04	-2527.33	-2393.35	-2383.33	-2439.05	-2527.71	-2393.25
No. of observations	17007	17007	17007	17007	17007	17007	17007	17007

Notes: (a) "***", "**", and "*" denote 1%, 5%, and 10% significance levels, respectively.

(b) Values in parentheses are t statistics.

(c) Robust standard errors are used for t statistics.

Table 5: Treatment Regression for Patent Applications and Licensing

	Licensor's Applications			Licensee's Applications		
	I	II	III	IV	V	VI
Dep: Log Patent Applications						
Licensing	-7.642***	-7.625***	-7.612***	-9.737***	-9.668***	-9.817***
	(-35.46)	(-37.11)	(-34.78)	(-37.26)	(-37.85)	(-38.29)
Blocking of SG	26.578***			41.157***		
	(10.43)			(10.40)		
Blocking of adj Clarkson		41.511***			72.068***	
		(8.09)			(8.03)	
Blocking of Zhang			2.874***			4.688***
			(18.91)			(20.64)
Log R&D Sales for Licensor	1.164***	1.161***	1.160***			
	(147.73)	(147.01)	(147.61)			
Log R&D Sales for Licensee				0.972***	0.966***	0.963***
				(94.46)	(92.67)	(94.05)
Dep: Licensing						
Blocking of SG	8.640***			9.777***		
	(9.04)			(9.08)		
Blocking of adj Clarkson		11.686***			13.592***	
		(7.74)			(7.47)	
Blocking of Zhang			0.987***			1.173***
			(16.31)			(19.71)
Fragmentation for Licensor	-0.805***	-0.790***	-0.847***	-0.029	-0.003	-0.077
	(-11.81)	(-11.90)	(-12.19)	(-0.57)	(-0.06)	(-1.43)
Fragmentation for Licensee	-0.007	0.030	-0.083*	-0.773***	-0.729***	-0.870***
	(-0.16)	(0.68)	(-1.70)	(-14.33)	(-13.77)	(-15.56)
Licensing Experience for Licensor	0.091	0.101*	0.069	-0.024	-0.019	-0.051
	(1.63)	(1.86)	(1.23)	(-0.56)	(-0.46)	(-1.18)
Licensing Experience for Licensee	-0.110**	-0.106**	-0.122***	-0.103**	-0.095**	-0.122***
	(-2.50)	(-2.47)	(-2.74)	(-2.35)	(-2.19)	(-2.74)
No of observations	18430	18430	18430	17696	17696	17696

Notes: (a) "***", "**", and "*" denote 1%, 5%, and 10% significance levels, respectively.

(b) Values in parentheses are t statistics.

(c) Robust standard errors are used for t statistics.