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Abstract

Analyzing a unique, previously unavailable, government patent database, this study investigates the determinants of transaction modes (namely to sell, license or retain) of invention and utility model patents in China. The results suggest that there is an inverted U-shaped relationship between an invention patent's quality and the probability of it being licensed out while no relationship exists between a utility model's quality and the probability of it being transacted. We also find that a firm with economically-motivated patent strategies is less likely to sell its invention patents while a firm with administratively-motivated patent strategies are more likely to transact its patents.
Keywords: Patent; Licensing; Sale; Transaction Mode; Technology Transfer; China

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1. Introduction

Licensing and selling patent represent two important forms of technology transfer. The central research question of this study is what are the main factors that affect corporate patent transaction mode decisions (i.e., licensing, sale or internal use) for commercialization in technology marketplace. Scholars have long realized that licensing or sale of patent is not only for obtaining monetary revenue but also for executing corporate strategies (Lichtenthaler, 2011). Kollmer and Dowling (2004), Lichtenthaler (2007), and Bianchi et al. (2014) have argued that unique position in market, different capabilities as well as distinctive resources of a firm influence its choice on licensing, sale or internal exploitation of the patents through new product development. Previous studies have examined patent-, firm- and market-level factors that affect the probability of a patent to be licensed or sold. Factors at the patent-level include technology generality (Gambardella, 1998; Gambardella et al., 2007), economic value or quality of patent (Gambardella et al., 2007), strength of patent protection (Gallini, 2002; Arora and Ceccagnoli, 2006). The firm-level factors include firm size (Gans and Stern, 2003), competition strategy (Gambardella et al., 2007), IP management capabilities (Srivastava and Wang, 2014), corporate transaction experience, transaction partner relationship (Kim and Vonortas, 2006). The market-level factors are enforcement of patent right, difficulty in reaching licensing deal and intensity of competition (Kani and Motohashi, 2012).

While the previous studies have examined the choices of licensing versus internal use of patent or sales versus internal use separately (Wang et al., 2014; Wang et al., 2015a, 2015b), there are few studies of examining the transaction modes, i.e. licensing, sale, internal use altogether. The study by Jeong et al. (2013) is an exception, as the authors found firms licensed patents when uncertainty is low or transaction cost is high, whereas firms sold patent under opposite conditions. We contribute to this line of research by taking into account patent commercialization (technology transfer) decisions as a spectrum of modalities rather than segmenting patent licensing and sale from each other as featured in most of the abovementioned literature.

In addition, in many of the previous studies, the scholars were not able to distinguish between the different reasons why a patent is not licensed or sold: namely whether it is because the value of a patent is too low to be licensed or sold, or whether it is because the value of the patent is so high that the owner keeps it for internal use. In this study, we are able to overcome this difficulty in differentiation by using R&D cost of patents reported by the company participating in the Chinese Inventor Survey as a proxy of patent quality.

A unique feature of the Chinese patent system and its recent development is the patent subsidy given by various levels of governments, which contributes to the patenting surge in China in the last decade (Li, 2012; Dang and Motohashi, 2015; Boeing and Mueller, 2015). Scholars found that one of the direct effects of government subsidy is generating low-quality patents. However, we know little about the impact of subsidy policy on the technology market and the patent transaction activities. By analyzing patent applicants' motivation of applying for and maintaining patents which is documented in the Chinese Inventory Survey, we are able to quantitatively measure the impact of government subsidy on the transaction of patent.

The novelty of this study is that we analyze a novel Chinese Inventor Survey Database, constructed by the State Intellectual Property Office of China, which provides rich information on corporations as patent applicants and the patents they own and matches it with a commercial patent database incoPat, where the full history of the licensing and sale of patents is available. Matching these two databases, we are able to investigate the factors such as patent quality, corporate patent strategy and corporate IP management in the Chinese context which are rarely examined in the previous studies.

We find that there exists an inverted U-shaped relationship between an invention patent's quality and the probability of it being licensed out while only a positive relationship exists between its quality and the probability of it being sold. We also find that a firm with economically-motivated patent strategies, such as cross-licensing, blocking competitors or protection of early-stage R&D, is less likely to sell its invention patents while a firm with

administratively-motivated patent strategies, such as obtaining government subsidy and certification, are more likely to transact its patents.

The rest parts of this paper is organized as follows: the second section develops hypotheses based on strategy and organization theory; the third section describes the data, method and variables of the empirical study; the fourth presents regression results for inventions and utility models respectively; the final section discusses the results and concludes.

2. Theory and Hypothesis

2.1 Patent quality

We identify patent quality as a primary factor that patent owners consider when making decisions of keeping, licensing, selling, or adopting a combination of tactics to maximize short-term economic returns and long-term returns (achieving technological leadership in the market). Patent owners often face high search and transaction cost when engaging in patent licensing and sale activities (especially in an immature technology market (Srivastava and Wang, 2014)). They encounter difficulty in locating potential buyers, acquiring information about potential negotiators and may be harmed by potential buyers' opportunism during the negotiations (Agrawal et al., 2014). Transaction cost theory suggests that if transaction cost is too high, a firm will choose to exploit a patent internally. Thus the likelihood of licensing or selling a patent may increase with quality of patent (Shane, 1994; Kim and Vonortas, 2006; Jeong et al., 2013).

The resource-based view theory, however, suggests that the willingness of companies to trade patents may decrease with patent quality because firms prefer keeping valuable patents for internal use. On the one hand, an invention or utility patent must satisfy statutory criteria, i.e., novelty, non-obviousness or industrial applicability, to be granted (Zuniga et al., 2009). Therefore, every patent is unique to some extent and is of certain value (current value and potential value). Moreover, the value of patent is context dependent. As the technological or market condition of a firm changes, the value of the patent it possess may also alter (Sherry and Teece, 2004). Improper transfer may cost patent owner an opportunity of extracting future value. On the other hand, the tacit knowledge associated with a patent, which is not revealed in the patent document or may even be hidden intentionally by patent applicants, makes the patent inimitable and difficult to be utilized efficiently without the inventors' help. Therefore, patents, especially those of high quality, are hardly substitutable and become sources of sustained competitive advantages of a company (Barney, 1991; Rumelt, 1997). Given that licensing or sale of high-quality patents may result in knowledge leakage and provide current or potential competitors an opportunity to acquire important technology

assets, companies are less likely to transact, especially sell their own high-quality patents (Grimpe and Hussinger, 2014).

Due to the above two opposite effects of patent quality on patent transaction, it is logical to suspect that there may exist a curvilinear (inverted U-shaped) relationship between patent quality and transaction (Haans et al., 2015). In other words, at a low level of patent quality, the probability of transaction may increase with patent quality. However, at a high level, the probability decreases with patent quality. We develop the following three hypotheses to investigate the relationship between patent quality and patent transaction modes.

H1a: There is a positive relationship between the probability of patent transaction and patent quality.

H1b: There is a negative relationship between the probability of patent transaction and patent quality.

H1c: There is an inverted U-shaped relationship between the probability of patent transaction and patent quality.

2.2 Corporate patent strategy

As a subset of overall corporate strategy, patent strategy refers to strategic arrangement to gain competitiveness through acquisition and effective management of patents (Somaya, 2012). Sasak et al. (2001) argued that corporate patent strategy includes three sub-strategies, namely patent application, exploitation and organization strategy. Somaya (2002) classified corporate patent strategy into aggressive and defensive ones. The aggressive patent strategies in his view include strategic enclosure (Lerner, 1995; Lanjouw and Schankerman, 2001), harvesting licensing revenue (Arora and Fosfuri, 2013) and patent troll (Bessen and Meurer, 2008). The defensive patent strategies consist of strategic isolation (Lerner, 1995), strategic defense (Somaya, 2002) and multi-invention organization choice (Somaya and Teece, 2001) and combined strategies such as patent portfolio (Ernst, 2001). Apparently, a company can develop multiple patent strategies simultaneously and execute them accordingly with regard

to different products, technologies and markets. The corporate patent strategy thus determines corporate behavior concerning patenting activities and choice of patent transaction modes (Caviggioli and Ughetto, 2013).

Applying for patents to negotiate cross-licensing deals and mitigate royalty payment is a common corporate patent strategy, especially for companies operating in a complex technology industry such as the electronics industry (Köhler, 2011). To gain bargaining power in cross-licensing negotiations, patents are considered strategic assets and less likely to be sold to other parties than to be kept for internal use (Edvinsson and Sullivan, 1996). Similarly, if a firm develops strategies to use patents to prevent others imitating its technology, enhance corporate image, set product standard, block competitors or protect the early-stage R&D, the patents have lower probabilities of being transacted as well. We categorize these strategies based on the intrinsic principle of market-oriented economy instead of on responding to governments' incentive or administrative requirements as the economically-motivated patent strategies.

As a part of institutional environment, governmental policy has an influence on corporate decisions related to transactions (North, 1990; Williamson, 1991). Research also shows that institutions affects enterprise's behavior including IP transactions (Gans et al, 2008; Kostova and Dacin, 2008). In China, the past decade has witnessed a remarkable growth of patenting activity and government policy has played an important role in this surge (Li, 2012). It is estimated that about 30 percent increase of number of patents application has been driven by government policy (Dang and Motohashi, 2015). If a firm's patenting activities are incentivized by government subsidy on patent application fee, or to meet criterion of high-technology company to enjoy tax reduction[1], or to fulfill the administrative requirements set up by government agencies, the firm would be rational to transact the patents after the objective is fulfilled. Otherwise, it has to bear the cost of maintaining the patent. We dub this type of corporate patent strategies as administratively-motivated patent strategies, which are

[1] From January 1st, 2008, the companies in China which are certified as high-technology companies can enjoy a reduced tax rate of 15% in comparison to the regular tax rate of 25%. To pass the certification, a high-technology company has to present evidence that it owns intellectual property, which includes patents (Ministry of Science and Technology, Ministry of Finance and State Administration of Taxation, 2008).

not determined by market force, but rather influenced by government intervention. In line with the above reasoning, we develop the following two hypotheses.

Hypothesis 2a: A firm with economically-motivated patent strategies such as cross-licensing, imitation prevention, enhancing corporate image, setting standard, blocking competitors or protection of early-stage R&D are less likely to transact its patents than keep the patents for internal use.

Hypothesis 2b: A firm with administratively-motivated patent strategies such as obtaining government subsidy and certification are more likely to transact its patents than keep the patents for internal use.

2.3 Corporate IP management

Scholars argued that "Learning by transacting" is an effective way for companies to accumulate knowledge and experience in IP management. (George, 2005; Clarysse et al., 2009; Srivastava and Wang, 2014). Firms with lower IP management capabilities can take part in transactions to improve existing competence. However, the likelihood of completing transactions would be lower for them than for the firms with higher IP management capabilities. A company with specialized IP department is considered to have superior capabilities than a company which manages its IP activities through a part-time organization or no organization at all, because a specialized IP department would have its own budget, staff and work process and can be engaged in more patent transaction activities than otherwise do. However, a competing hypothesis would be that if the patenting activities and strategies of a company are managed by a specialized organization, the company would have better structure and capability to create patents as strategic assets, have higher probability of retaining the assets and exploiting their value internally. Then we would observe that the company's patents are less likely to being transacted. Therefore, we develop the following two hypotheses.

H3a: The probability of patent transaction is higher for the patents managed by a specialized IP department than those managed by a part-time IP department or no IP department at all.

H3b: The probability of patent transaction is lower for the patents managed by a specialized IP department than those managed by a part-time IP department or no IP department at all.

2.4 Other factors

Technological characteristics including generality and scientific nature of technology, corporate characteristics such as firm size, as well as external environment, for instance, weak or strong IP regime, can also influence firms' decision on technology transfer modes. Previous studies showed that large firms are less likely to license technology than small firms, especially start-ups (Arora and Fosfuri, 2003; De Rassenfosse, 2012; Holgersson, 2013). Corporate ownership can impact transaction modes of patents as well (Teece, 1981; Wang et al., 2008; Gaur and Lu, 2007). In Chinese context, state-owned enterprises have the mandates of maintaining economic and social stability at the expense of its economic viability, while private and foreign companies aggressively pursue commercial opportunities for economic gain (Aharoni, 1981). Past literature [give specific citations of the "past literature"] has depicted state-owned enterprises as less innovative and more sluggish in reacting to environmental changes, which has resulted in fewer patents to be transacted in technology market. While private and foreign firms are relatively more active and therefore have economic motivation to apply for patents and transact these patents in marketplace. We study these additional factors by adding them as control variables in the regression models.

3 Data, Methodology and Variables

3.1 Data

To test the above hypotheses, we construct a novel database by merging data from two patent databases: The State Intellectual Property Office's (SIPO) Inventor Survey Database and the incoPat Patent Database (incoPat).

The inventor survey has been conducted annually by the SIPO and provincial Intellectual Property Bureaus since 2008. It uses a Probability Proportionate to Size sampling technique, and contains vast and highly-reliable information on sampled patents. The sampling framework of each year's survey includes the patents granted in last year. In this study we analyze the data of the 2012 survey, which accordingly represent the patents granted in 2011. In the 2012 survey, 44,850 questionnaires were sent out and 38,837 were returned with a response rate of 86.7%. Among the returned questionnaires, 26,204 were answered by 9,568 companies, 10,673 by 994 universities or research institutes and 1,702 by 1,508 individual inventors. We focus on patents owned by companies in this study, and draw on the rich firm- and patent-level information related to the invention from the questionnaires (that is, the cost of invention protected by the patents in question, patent strategies and IP management of companies, firm size, ownership, technology field of the patents, and so on).

IncoPat is a commercial patent database, containing global patent information drawn from 102 countries and territories all available in Chinese. Its database collection contains more than 105 million patents from around the world, and is updated on a weekly basis. IncoPat contains all the Chinese invention, utility, and design patents applied for from September 1985 when the modern Chinese patent system was established until today. The information which can be retrieved and downloaded contain patent title, abstract, application date, grant date, legal status, citations, patent family information, licensing and sale history and so on.

According to the Chinese Patent Law, a contract of patent sale can only be effective upon registration of the contract in the SIPO. According to the SIPO Regulation on Registration of

Patent Licensing Contract (SIPO Regulation No. 62 and 18), the parties signing a patent licensing contract should register the contract in the SIPO within three months after the contract becomes effective. The parties involved in patent licensing and sale deals therefore have legal obligation to register their transactions in the SIPO. The registration information obtained by the SIPO and collected by the incoPat becomes the basis for this empirical study.

By matching the patents' unique application number, we are able to merge both the 2012 data of the inventory survey and the whole incoPat Patent Database, and have access to a comprehensive array of information of 19,518 patents, including 11,320 invention and 8,198 utility model patents granted in 2011. We exclude design patents because they do not represent technological innovation and are not directly comparable to invention and utility model patents. Among the invention patents, 9,759 (86% of 11,320) have yet been transacted by October 2015 when this paper was written, but 327 (3%) have been licensed and 1,234 (11%) have been sold. Among the utility model patents, 7,665 (93% of 8,198) have yet been transacted, 131 (2%) have been licensed and 402 (5%) have been sold.

3.2 Regression model

We assume that firm managers' choices over transaction modes are based on their assessment of patent quality and corporate patent strategies and are constrained by the IP management structure of the companies and so forth. The appropriate model to investigate the relationship between transaction modes and above factors is a multinomial logit, shown in equation 1, where the bold characters represent vector or matrix.

(1) $\text{Prob}(\boldsymbol{Y_i} = j|\boldsymbol{X}_i) = \frac{e^{\boldsymbol{X_i\beta_j}}}{1+\sum_{k=1}^{J} e^{\boldsymbol{X_i\beta_k}}}$, for j=0, 1, 2,…,J, where $\boldsymbol{\beta_0} = \mathbf{0}$, and $\boldsymbol{\beta_j} = \begin{pmatrix} \beta_{j0} \\ \beta_{j1} \\ \vdots \\ \beta_{jm} \end{pmatrix}$

(2) $\boldsymbol{\delta_j} = \frac{dP_j}{d\boldsymbol{X_i}} = P_j[\boldsymbol{\beta_j} - \sum_{k=0}^{J} P_k\boldsymbol{\beta_k}]$

(3) $\text{Relative Risk (Odds Ratio)} = \frac{P_j}{P_k} = \frac{e^{\boldsymbol{X_i\beta_j}}}{e^{\boldsymbol{X_i\beta_k}}} = e^{\boldsymbol{X_i\beta_j}}\ if\ k = 0$

$$(4)\ \frac{\text{Relative Risk}_{[\beta_{j0}+\beta_{j1}x_1+\cdots+\beta_{jm}(x_m+1)]}}{\text{Relative Risk}_{[\beta_{j0}+\beta_{j1}x_1+\cdots+\beta_{jm}x_m]}} = \frac{e^{[\beta_{j0}+\beta_{j1}x_1+\cdots+\beta_{jm}(x_m+1)]}}{e^{[\beta_{j0}+\beta_{j1}x_1+\cdots+\beta_{jm}x_m]}} = e^{\beta_{jm}}$$

It is difficult to interpret the coefficients $\boldsymbol{\beta_j}$ of the multinomial logit model estimated from equation (1) because it does not provide the marginal effects. There are two options. The first is to provide the marginal effects $\boldsymbol{\delta_j}$, i.e. $\frac{dP_j}{d\boldsymbol{X_i}}$, for each variable (Equation 2). The disadvantage of this method is that it gives the change in the absolute probability of being each mode of transaction due to a one-unit change in the explanatory variable. Since the patents are not equally distributed across the three modes, the absolute marginal effects vary by the number of patents in each mode. The alternative method, which is used here, is to provide the ratio of relative risk. Relative risk (odds ratio) is defined as the ratio of the probability of a patent being licensed or sold to the probability of not being transacted (the reference mode) (Equation 3). The ratio of relative risk is the change of relative risk given a one-unit change in the explanatory variable (the exponent of β_{jm}, Equation 4) (Stata, 2015). Since the relative risk is calculated through dividing the probability of a patent being licensed or sold by the probability of not being transacted, it is possible to compare the ratio of relative risk across the different modes.

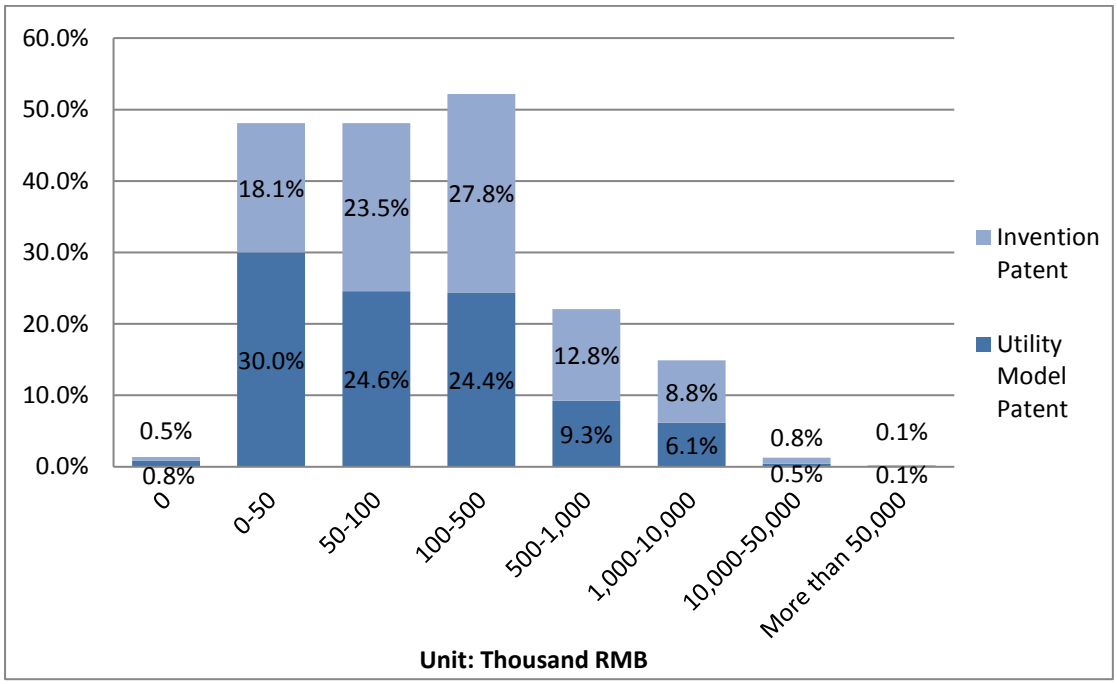
The ratio of relative risk can be interpreted as follows. When a ratio of relative risk is greater than 1, a one-unit change in the explanatory variable increases the relative probability of being a specific type of transaction modes versus the probability of no transaction, while a ratio of relative risk below 1 reduces this probability. A ratio of relative risk of 1 occurs when the two probabilities are identical, so that the presence of the explanatory variable has no effect on the outcome.

3.3 Independent variables

We use logarithmic *R&D cost* of a patent reported by the respondent in the inventory survey as a measurement of patent quality[2]. The question regarding R&D cost provides nine options for respondents to choose, starting from no cost, less than RMB 50,000, between 50,000 and 100,000, between 100,000 and 500,000, between 500,000 and 1 million, between 1 million and 10 million, between 10 million and 50 million, more than 50 million and don't know. We take mid-point value between lower bound and upper bound of every band as the approximate cost of the patent. For the patent with a R&D cost above RMB 50 million, we take 70 million as the approximate value. We also add 10 thousand to the value of R&D cost having a unit of 10 thousand in order to avoid taking logarithm of 0. For example, if the respondent chose "between RMB 10 million and 50 million", then the value of R&D cost for the patent is 3001 with a unit of 10 thousand. Figure 1 shows distribution of R&D costs of invention and utility model patents. The percentages of invention patents falling into the high cost categories are greater than those of the utility model patents, which demonstrate that the average quality of invention patents are higher than that of the utility model patents. We also calculate square term of logarithmic R&D cost (*Qua_R&D cost*) to test the hypothesis 1.

[2] In empirical studies, a few other indicators of patent quality are used such as citations, number of claims, family size, ratio of granted to filed patents and so forth (Squicciarini et al., 2013). Citation information is not available for the Chinese patents [Why is citation information unavailable for Chinese patents?]. We have included the number of claims in the regression as a proxy of patent quality. However, the coefficients of this variable are not statistically significant. The reason may be as what Dang and Motohashi (2013) argued, the applicants in China tend to draft narrow claims in order to have the patents granted [this suggest that the "administrative" reasons predominate rather than the "economic" reasons], which compromised the quality of the patent in the end. Based on our interview with patent agents and attorneys in China, we can confirm that quantity of claims is not an accurate indicator of patent quality in China [we can/should say more about this: why quantity of claims is not an accurate indicator of patent quality in China. Furthermore, why does this insight come from patent agents and attorneys?].

Figure 1: Distribution of R&D cost of Invention and Utility Model Patents (Unit: Thousand RMB)



A set of dummy variables reflecting firm- and patent-specific strategies are constructed to test hypothesis 2. In the survey, respondents are asked whether the company applied for patents in order to execute the following eight strategies: market expansion, *cross-licensing*, *imitation prevention*, enhancing *corporate image*, *standard setting*, *blocking competitors*, *protection of early-stage R&D*, or meeting the *administrative requirement*. We take the strategy of market expansion as the reference group and construct seven dummy variables to represent the rest seven strategies, respectively. The names of dummy variables will start with *Firm* to reflect these are firm-level strategies. In addition, respondents are also asked about their motivation of applying for and maintaining the patent in question. The options include *revenue generation*, production *cost reduction*, patent *portfolio building*, obtaining *government subsidy* and *qualification certification*, promoting *corporate image* and others. We construct six dummy variables to represent the six patent-specific strategies, respectively, and take the option of "others" as the reference group. The names of these dummy variables will start with *Patent* to reflect these are patent-level strategies.

We use the questions in the survey related to intellectual property management practice to test hypothesis 3. We construct a dummy variable *specialized department*, which equals 1 if the firm has a specialized department to manage intellectual property and 0, otherwise. We generate dummy variables *general administration department, legal department, R&D department,* which equal 1 if the firm's IP department is under the leadership of general administration department, legal department, R&D department, respectively, and equal 0 otherwise. The reference group for these three dummy variables is the option "others".

3.4 Control variables

We add three sets of control variables into the regression. Firms who answer the questionnaire are classified into large, medium, small and micro companies by their operating revenue and number of employees, though the criteria vary between industries. Based on this classification, we construct three firm size dummy variables *large*, *medium* and *small* and take micro companies as the reference group. To control for the effect of ownership on choice of transaction modes, we construct three dummy variables *state-owned, Hong Kong, Macau and Taiwan-owned (HKMT)* and *foreign* to represent companies' ownership status and take domestic private firms as the reference group. We also construct 31 technology dummies to control for the 32 technologies fields that the patents belong to.[3] The correlation matrices of the variables are presented in Table 1a and 1b, which show no serious multicollinearity among variables.

[3] The technology fields include electrical machine, electrical device; audiovisual technology; telecommunications; digital communications; basic communication procedures; computer technology management methods; semiconductor; optics; measurement; bio-material analysis; control; medical technology; fine organic chemistry; biotechnology; pharmaceuticals; high polymer chemistry, polymer; food chemistry; basic material chemistry; material and metallurgy; surface processing technologies and coating; chemical engineering; environmental technology; handling; machine instrument; engine, pump and turbo machinery; spinning and papermaking; other special machinery; thermal process and appliance; machine parts; transportation; furniture and game; other consumer goods.

Table 1a: Correlation Matrix: Regression on Invention Patents

		Mean and Standard Deviation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	Qua_R&D Cost	12.03(12.0	1.00																								
2	R&D cost	3.10(1.56)	0.96	1.00																							
3	Firm_cross-licensing	0.36(0.48)	-0.13	-0.13	1.00																						
4	Firm_imitation prevention	0.63(0.48)	0.12	0.11	-0.10	1.00																					
5	Firm_corporate image	0.29(0.45)	0.01	0.01	-0.33	-0.05	1.00																				
6	Firm_standard setting	0.28(0.45)	0.08	0.09	-0.18	-0.02	0.07	1.00																			
7	Firm_blocking competitors	0.38(0.48)	-0.05	-0.07	0.38	0.00	-0.29	-0.15	1.00																		
8	Firm_protection of early stage R&D	0.60(0.49)	0.02	0.00	0.06	-0.12	-0.14	0.00	0.19	1.00																	
9	Firm_administrative requirement	0.07(0.25)	0.00	0.00	-0.07	-0.07	0.13	-0.02	-0.11	0.02	1.00																
10	Patent_revenue generation	0.62(0.49)	0.11	0.08	0.06	0.08	-0.06	0.02	0.08	0.02	-0.10	1.00															
11	Patent_cost reduction	0.27(0.45)	-0.01	-0.03	0.13	0.16	-0.05	-0.04	0.07	0.02	-0.02	0.01	1.00														
12	Patent_portfolio building	0.55(0.50)	0.00	0.01	0.04	-0.12	-0.08	-0.04	0.10	0.02	-0.03	-0.23	-0.43	1.00													
13	Patent_government subsidy	0.06(0.24)	0.02	0.02	-0.03	-0.01	0.04	0.07	-0.05	-0.03	0.05	-0.03	-0.10	-0.14	1.00												
14	Patent_qualification certification	0.09(0.29)	0.03	0.03	-0.13	-0.03	0.07	0.03	-0.14	0.03	0.16	-0.20	-0.12	-0.12	0.11	1.00											
15	Patent_corporate image	0.22(0.41)	0.02	0.04	-0.18	-0.01	0.17	0.08	-0.12	-0.01	0.06	-0.28	-0.16	-0.12	-0.03	0.03	1.00										
16	Specialized department	0.63(0.48)	-0.09	-0.09	0.33	-0.02	-0.20	-0.05	0.24	0.03	-0.13	-0.05	-0.06	-0.13	-0.12	-0.19	-0.17	1.00									
17	General administration department	0.23(0.42)	0.02	0.03	-0.12	-0.02	0.07	0.05	-0.08	-0.19	-0.03	-0.03	-0.06	-0.03	-0.02	-0.04	-0.05	-0.10	1.00								
18	Legal department	0.23(0.42)	-0.13	-0.15	0.50	-0.07	-0.20	-0.20	0.32	0.17	-0.12	-0.08	-0.13	-0.00	-0.09	-0.15	-0.18	-0.31	-0.30	1.00							
19	R&D department	0.44(0.50)	0.07	0.08	-0.24	-0.06	0.11	0.05	-0.23	-0.03	0.12	-0.05	-0.03	-0.04	-0.05	-0.07	-0.07	-0.13	-0.50	-0.42	1.00						
20	Large	0.52(0.50)	-0.17	-0.17	0.26	0.07	-0.08	-0.12	0.23	0.13	0.05	0.00	0.18	-0.01	-0.12	-0.15	-0.10	-0.30	-0.27	0.35	-0.01	1.00					
21	Medium	0.27(0.45)	0.16	0.16	-0.19	-0.01	0.05	0.11	-0.19	-0.01	-0.01	0.00	-0.10	-0.01	-0.09	-0.12	-0.05	-0.16	-0.03	-0.18	-0.09	-0.64	1.00				
22	Small	0.18(0.39)	0.06	0.05	-0.12	-0.08	0.06	0.03	-0.07	-0.14	-0.04	0.01	-0.11	-0.02	-0.05	-0.06	-0.06	-0.18	-0.28	-0.22	-0.06	-0.50	-0.29	1.00			
23	State-owned	0.19(0.39)	-0.04	-0.03	-0.11	-0.05	0.11	0.01	-0.07	-0.10	-0.18	-0.11	-0.02	-0.05	-0.01	-0.07	-0.09	-0.13	-0.10	-0.22	-0.27	-0.18	-0.07	-0.13	1.00		
24	HKMT	0.06(0.24)	0.03	0.04	-0.05	-0.01	0.03	0.03	-0.07	-0.02	-0.02	-0.01	-0.04	-0.02	-0.02	-0.01	-0.00	-0.00	-0.02	-0.03	-0.04	-0.03	-0.07	-0.04	-0.12	1.00	
25	Foreign	0.16(0.37)	-0.11	-0.08	0.07	-0.01	-0.01	0.01	0.02	-0.16	-0.07	-0.04	-0.05	0.06	0.04	-0.04	-0.01	-0.06	-0.17	-0.05	-0.09	-0.09	-0.01	-0.10	-0.21	-0.10	1.00

Table 1b: Correlation Matrix: Regressions on Utility Model Patents

		Mean and Standard Deviation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	Qua_R&D cost	9.46(10.80)	1.00																								
2	R&D cost	2.69(1.49)	0.96	1.00																							
3	Firm_cross-licensing	0.14(0.35)	0.03	0.03	1.00																						
4	Firm_imitation prevention	0.62(0.49)	0.05	0.04	0.02	1.00																					
5	Firm_corporate image	0.43(0.50)	-0.04	-0.04	-0.22	-0.11	1.00																				
6	Firm_standard setting	0.34(0.47)	0.08	0.07	-0.01	-0.09	-0.05	1.00																			
7	Firm_blocking competitors	0.20(0.40)	-0.01	-0.01	0.20	0.13	-0.17	-0.04	1.00																		
8	Firm_protection of early-stage R&D	0.55(0.50)	-0.03	-0.02	-0.03	-0.10	-0.09	0.05	0.01	1.00																	
9	Firm_administrative requirement	0.11(0.31)	-0.03	-0.01	0.06	-0.08	-0.01	-0.07	0.01	0.07	1.00																
10	Patent_revenue generation	0.55(0.50)	0.08	0.06	0.05	0.07	-0.05	0.00	0.07	-0.01	-0.07	1.00															
11	Patent_cost reduction	0.32(0.47)	-0.06	-0.05	-0.05	-0.02	0.01	0.03	-0.04	0.06	0.00	-0.11	1.00														
12	Patent_portfolio building	0.41(0.49)	0.05	0.04	0.10	0.09	-0.05	0.00	0.12	0.06	0.00	-0.18	-0.31	1.00													
13	Patent_government subsidy	0.11(0.31)	0.03	0.03	0.01	-0.05	0.03	0.03	-0.06	-0.04	0.05	-0.06	-0.10	-0.16	1.00												
14	Patent_qualification certification	0.15(0.36)	-0.01	-0.01	-0.04	-0.04	0.03	-0.03	-0.08	0.01	0.12	-0.21	-0.15	-0.10	0.04	1.00											
15	Patent_corporate image	0.30(0.46)	0.01	0.01	-0.05	-0.03	0.12	0.03	-0.04	-0.01	-0.01	-0.21	-0.19	-0.15	-0.07	-0.02	1.00										
16	Specialized department	0.38(0.49)	0.03	0.03	0.12	0.06	-0.10	0.08	0.17	0.04	-0.07	0.05	0.02	0.11	-0.05	-0.10	-0.09	1.00									
17	General administration department	0.29(0.45)	0.04	0.03	-0.08	-0.01	0.06	0.03	-0.09	-0.07	-0.05	0.02	-0.03	-0.05	0.02	0.02	0.02	-0.11	1.00								
18	Legal department	0.05(0.22)	-0.02	-0.01	0.18	0.03	-0.09	-0.01	0.11	0.07	0.05	0.00	-0.04	0.08	-0.04	-0.03	-0.01	0.14	-0.15	1.00							
19	R&D department	0.55(0.50)	-0.03	-0.02	-0.01	-0.01	0.01	-0.06	-0.01	0.06	0.01	-0.01	0.05	0.02	-0.01	0.01	-0.02	0.07	-0.72	-0.21	1.00						
20	Large	0.31(0.46)	-0.11	-0.09	0.12	0.03	-0.10	-0.04	0.15	0.11	0.09	-0.03	0.14	0.03	-0.08	-0.09	-0.07	0.25	-0.24	0.12	0.20	1.00					
21	Medium	0.34(0.47)	0.09	0.08	-0.02	-0.01	0.03	0.00	-0.03	-0.01	0.00	0.00	-0.03	0.04	-0.01	0.04	0.01	-0.03	0.04	-0.01	-0.04	-0.48	1.00				
22	Small	0.32(0.46)	0.03	0.01	-0.09	-0.01	0.06	0.04	-0.11	-0.09	-0.08	0.03	-0.09	-0.06	0.07	0.05	0.05	-0.19	0.17	-0.11	-0.12	-0.46	-0.49	1.00			
23	State-owned	0.17(0.38)	-0.11	-0.08	0.02	-0.06	0.00	-0.09	0.05	0.12	0.13	-0.05	0.09	-0.03	-0.05	-0.02	-0.01	-0.02	-0.15	-0.06	0.16	0.36	-0.08	-0.25	1.00		
24	HKMT	0.06(0.25)	0.03	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.00	0.03	-0.02	0.04	0.00	0.00	-0.06	0.04	0.05	0.05	-0.07	0.00	0.06	-0.05	-0.12	1.00	
25	Foreign	0.09(0.29)	0.03	0.04	0.01	0.04	-0.04	-0.01	0.03	0.02	-0.01	0.01	0.02	0.00	-0.03	0.00	-0.01	0.02	-0.05	0.10	0.01	0.04	0.02	-0.04	-0.14	-0.08	1.00

4. Results

4.1 Regression results

The multinomial logit model results for invention and utility model patents are presented in Table 2a and 2b, respectively. The reference category is patents not being transacted. The regressions in the first column of both tables include only the key explanatory variables and exclude all the control variables. The control variables are added into the regression progressively. The last column of both tables present the full models. In the following discussion, we will focus on the results of the full models, but also taking into account of the robustness of the ratio of relative risk across all the specifications.

Table 2a: Ratio of Relative Risk of Patent Transaction Modes: Invention Patents

	(1)		(2)		(3)		(4)	
Transaction mode	Licensed	Sold	Licensed	Sold	Licensed	Sold	Licensed	Sold
Qua_R&D cost							0.96(0.02)**	1.01(0.01)
R&D cost	1.18(0.04)***	1.04(0.02)*	1.16(0.04)***	1.02(0.02)	1.16(0.04)***	1.04(0.02)**	1.66(0.28)***	0.97(0.08)
Firm_cross-licensing	0.78(0.12)	0.74(0.06)***	0.86(0.14)	0.72(0.06)***	0.90(0.15)	0.79(0.07)***	0.90(0.15)	0.79(0.07)**
Firm_imitation prevention	1.16(0.15)	0.86(0.06)**	1.09(0.14)	0.86(0.06)**	1.12(0.16)	0.97(0.07)	1.10(0.15)	0.97(0.07)
Firm_corporate image	0.90(0.13)	0.96(0.07)	0.92(0.13)	0.95(0.07)	1.01(0.15)	0.83**(0.07)	0.99(0.15)	0.83(0.07)**
Firm_standard setting	0.99(0.13)	0.9(0.07)	1.01(0.13)	0.91(0.07)	1.11(0.15)	0.92(0.07)	1.11(0.15)	0.92(0.07)
Firm_blocking competitors	1.12(0.15)	0.82(0.06)***	1.17(0.16)	0.81(0.06)***	1.19(0.17)	0.66(0.05)***	1.18(0.17)	0.66(0.05)***
Firm_protection of early-stage R&D	1.10(0.14)	0.71(0.05)***	1.10(0.14)	0.70(0.05)***	1.21(0.17)	0.78(0.06)***	1.20(0.17)	0.78(0.06)***
Firm_administrative requirement	0.95(0.23)	0.83(0.11)	0.91(0.22)	0.87(0.11)	0.99(0.25)	0.99(0.13)	0.98(0.24)	0.99(0.13)
Patent_revenue generation	1.12(0.17)	0.98(0.08)	1.09(0.16)	0.97(0.08)	1.00(0.16)	0.90(0.07)	0.99(0.15)	0.90(0.07)
Patent_cost reduction	1.08(0.17)	1.10(0.09)	1.06(0.17)	1.14(0.10)	1.10(0.18)	1.12(0.1)	1.08(0.18)	1.12(0.1)
Patent_portfolio building	0.81(0.12)	1.16(0.09)*	0.79(0.12)	1.12(0.09)	0.78(0.13)	1.11(0.1)	0.78(0.13)	1.11(0.1)
Patent_government subsidy	0.97(0.25)	1.46(0.18)**	1.00(0.26)	1.39(0.17)***	1.03(0.27)	1.31(0.17)**	1.03(0.27)	1.31(0.17)**
Patent_qualification certification	0.88(0.2)	1.16(0.13)	0.84(0.20)	1.10(0.12)	0.82(0.20)	1.01(0.12)	0.83(0.2)	1.01(0.12)
Patent_corporate image	1.07(0.17)	1.21(0.1)**	1.03(0.17)	1.21(0.10)**	0.98(0.17)	1.10(0.10)	0.99(0.17)	1.10(0.10)
Specialized department	1.13(0.15)	1.05(0.07)	1.11(0.15)	1.01(0.07)	1.09(0.16)	0.98(0.08)	1.09(0.16)	0.97(0.08)
General administration department	0.61(0.12)**	1.09(0.12)	0.64(0.13)**	0.99(0.11)	0.74(0.17)	0.67(0.08)***	0.74(0.17)	0.67(0.08)***
Legal department	0.69(0.15)	0.82(0.1)	0.90(0.22)	0.75(0.10)**	0.93(0.25)	0.75(0.11)**	0.91(0.25)	0.76(0.11)**
R&D department	0.81(0.14)	0.98(0.1)	0.83(0.14)	0.91(0.09)	0.96(0.19)	0.80(0.09)**	0.96(0.19)	0.8(0.09)**
Large					0.76(0.34)	0.25(0.05)***	0.75(0.33)	0.25(0.05)***
Medium					0.53(0.24)	0.37(0.07)***	0.52(0.23)	0.37(0.07)***
Small					0.64(0.29)	0.34(0.06)***	0.62(0.28)	0.34(0.06)***
State-owned					0.53(0.10)***	1.04(0.11)	0.54(0.11)**	1.04(0.11)
HKMT					0.81(0.22)	0.72(0.12)**	0.82(0.22)	0.72(0.12)*
Foreign					0.68(0.15)*	1.5(0.14)***	0.71(0.16)	1.49(0.14)***
Technology Dummies	Not included		Included		Included		Included	
Number of Observations	10.464		10.464		10.034		10.034	
Log Likelihood	-4853.93		-4745.60		-4373.40		-4370.3	

Notes：The data in parentheses refer to standard errors. *** denotes a significance level of 1%, ** denotes a significance level of 5%, * denotes a significance level of 10%.

Table 2b: Ratio of Relative Risk of Patent Transaction Modes: Utility Model Patents

	(1)		(2)		(3)	
Transaction mode	Licensed	Sold	Licensed	Sold	Licensed	Sold
R&D cost	0.9(0.06)	0.97(0.04)	0.90(0.06)	0.95(0.04)	0.89(0.06)	0.98(0.04)
Firm_cross-licensing	1.46(0.35)	1.15(0.18)	1.63(0.40)**	1.18(0.19)	1.64(0.42)*	1.09(0.18)
Firm_imitation prevention	0.80(0.15)	1.05(0.12)	0.80(0.15)	1.08(0.12)	0.91(0.19)	1.15(0.14)
Firm_corporate image	0.79(0.16)	1.03(0.12)	0.80(0.16)	1.03(0.12)	0.85(0.18)	1.08(0.13)
Firm_standard setting	0.84(0.17)	1.19(0.13)	0.87(0.18)	1.20(0.13)	0.96(0.20)	1.26(0.15)**
Firm_blocking competitors	1.23(0.27)	0.90(0.13)	1.22(0.27)	0.90(0.13)	1.25(0.29)	0.84(0.12)
Firm_protection of early stage R&D	1.16(0.22)	1.02(0.11)	1.15(0.22)	1.01(0.11)	1.19(0.25)	0.92(0.11)
Firm_administrative requirement	0.94(0.29)	1.08(0.18)	0.98(0.30)	1.14(0.19)	1.04(0.32)	0.97(0.17)
Patent_revenue generation	1.28(0.27)	0.92(0.11)	1.31(0.28)	0.93(0.12)	1.63(0.37)**	0.98(0.13)
Patent_cost reduction	1.35(0.31)	1.16(0.16)	1.31(0.31)	1.18(0.16)	1.36(0.33)	1.10(0.16)
Patent_portfolio building	1.43(0.32)	1.40(0.18)***	1.42(0.32)	1.4(0.18)**	1.43(0.34)	1.45(0.20)***
Patent_government subsidy	1.58(0.45)	0.96(0.18)	1.61(0.46)	0.96(0.18)	1.85(0.54)**	0.94(0.19)
Patent_qualification certification	1.25(0.35)	1.33(0.20)	1.26(0.35)	1.36(0.21)**	1.53(0.44)	1.47(0.23)**
Patent_corporate image	0.97(0.23)	1.11(0.15)	0.96(0.23)	1.14(0.15)	0.79(0.21)	1.13(0.16)
Specialized department	1.46(0.29)*	1.13(0.13)	1.48(0.29)**	1.15(0.13)	1.50(0.32)*	1.10(0.13)
General administration department	0.49(0.14)**	1.33(0.26)	0.51(0.15)**	1.36(0.27)	0.62(0.20)	1.33(0.28)
Legal department	0.37(0.19)*	2.47(0.58)***	0.44(0.22)	2.71(0.64)***	0.48(0.25)	2.78(0.68)***
R&D department	0.57(0.14)**	1.52(0.27)**	0.56(0.14)**	1.53(0.27)**	0.63(0.18)	1.33(0.25)
Large					1.25(0.79)	2.09*(0.86)
Medium					0.99(0.61)	1.42(0.57)
Small					0.83(0.51)	1.51(0.61)
State-owned					0.97(0.27)	1.6(0.24)***
HKMT					1.06(0.41)	0.51(0.15)**
Foreign					1.05(0.35)	0.82(0.17)
Technology Dummies	Not included		Included		Included	
Number of Observations	7,854		7,854		7,541	
Log Likelihood	-2115.16		-2067.26		-1920.40	

Notes：The data in parentheses refer to standard errors. *** denotes a significance level of 1%, ** denotes a significance level of 5%, * denotes a significance level of 10%

The ratio of relative risk of R&D cost of an invention patent is greater than 1 and statistically significant across all specifications (Table 2a), which demonstrates that patent quality is positively associated with the probability of the patent being licensed versus it not being transacted. However, the ratio of relative risk of quadratic term of R&D cost is smaller than 1 and statistically significant, showing that as the quality of invention patent increase, the probability of it being licensed will tip upwards (i.e. increase) and then decrease. There is an inverted U-shaped relationship between invention patent quality and its likelihood of being licensed. Nevertheless, the quality is not correlated with the probability of an invention patent being sold versus it not being transacted (the ratio of relative risk is indeed statistically significant in some specifications, but it is not robust in the others, particularly in the full model). Nor does the quality of a utility model influence the probability of it being transacted (Table 2b). A possible explanation is because utility model patent applications in China are not subject to substantive examination and many of them are used to protect incremental innovation only, its average quality is inferior to that of invention patents. Therefore, quality is not an important factor in determining a firm's choice about the transaction mode of utility model patents.

As far as the hypothesis 2 is concerned, the ratio of relative risk of several economically-motivated patent strategy variables are less than 1 (Table 2a), showing that if a firm applies for invention patents for the purpose of cross-licensing, blocking competitors and protecting its early-stage R&D, it will be less likely to sell them. These actions clearly indicates the strategic importance of these patents to the firm. The insignificance of the ratio of relative risk of the economically-motivated strategy variables in Table 2b reveals the less important role that utility model patents play in executing the firms' IP strategy, in comparison to invention patents. An exception in this regard are utility model patents applied for and maintained to build patent portfolios (an economically-motivated strategy) are more likely to be sold.

The ratio of relative risk of the administratively-motivated patent strategy variables such as obtaining government subsidy and qualification certification are greater than 1 and statistically significant in Table 2a and 2b. It means that a firm will be likely to

shed out patents if these patents are obtained with government subsidy or they are mainly used for the companies to be certified as high-technology companies to enjoy tax rebates and other government benefits. However, because the patent maintenance fee is usually not covered by the subsidy, once the purpose of applying for these patents is fulfilled, the companies are likely to trade them out. Otherwise, they will have to pay the maintenance fee.

Regarding hypothesis 3, whether a specialized IP department is established has no impact on invention patent transaction mode. However, the utility model patents managed by a specialized IP department is more likely to be licensed than to be kept for internal use. This finding seems to support the hypothesis 3a that a company with specialized IP department has better capability and structure to manage patent transaction activities. However, the effects are limited to utility model patents only. The invention patents managed by a specialized IP department under the general administration department, legal department or R&D department are less likely to be sold versus the invention patents managed by the other departments of the companies. Since in many Chinese companies the three departments are the major organizations managing the IP-related activities,[4] the results seem to point out the practice deviating from the norm will lead to higher likelihood of patent sale. However, the IP management structure exerts different influence on the transaction mode of utility model patents. If the patenting activities are managed by the legal department, it will lead to higher probability of selling utility patents, as compared to design patents.

The results regarding control variables largely conform to expectation. Compared to the reference category of micro-sized firms, small, medium and large firms are less likely to sell invention patents while firm size does not affect invention patent licensing activities. Contrary to the results on invention patents, the analysis on utility model shows that large firms are more likely to sell utility model patents than the

[4] Nearly 50 percent of the invention and utility model patents are managed by specialized IP department under the leadership of the R&D departments. About 25 percent of both types of patents are in the charge of specialized IP department under the general administration departments. 23% of the invention patents are managed by specialized IP department under the legal departments while only 5% utility model patents are at hand of legal departments.

micro-sized firms. When it comes to ownership, state-owned firms are less likely to license invention patents than the reference group domestic private firms. The HKMT-owned firms are less likely to sell invention patents, but foreign firms are more likely to do so, compared with domestic private firms. Compared with domestic private firms, state-owned firms are more likely to sell utility model patents and HKMT-owned companies are less likely to sell utility patents.

5. Discussion and conclusion

In this study, we construct a novel database by merging the SIPO-administrated Invention Survey database and incoPat database to analyze the patent transaction modes in China. We investigate what factors influence the probability of a patent being licensed or sold versus being exploited internally. We use a multinomial logit model to examine how patent quality, economically- and administrative-motivated patent strategies, corporate IP management structure affect transaction modes of patents.

We find that although in general higher quality leads to higher probability of invention patent transaction, there is an inverted U-shaped relationship between patent quality and invention patent's probability to be licensed. The fact that the low-quality invention patents are less likely to be licensed than the medium-quality invention patents may result from high transaction cost associated with the low-quality patent, while the high-quality invention patents are less likely to be licensed may be due to the fact that these patents are valuable, rare, inimitable and irreplaceable resources of the company. We also find that patent quality has no effect on the transaction of utility model patents, which may be due to their inferior quality in comparison to the invention patent's.

The invention patents owned by firms which have strategies to cross-license patents, block competitors and protect early-stage R&D are less likely to be sold than be kept for internal use. The firms need these invention patents to achieve what we call economically-motivated strategies, which are based on the intrinsic principle of market-oriented economy rather than respond to government intervention. An exception in this regard is the utility model patents applied for and maintained to build portfolio (an economically-motivated strategy) are more likely to be sold. In contrast to the economically-motivated strategies, administratively-motivated patent strategies are defined according to the companies' answer in the questionnaires that they are incentivized by government subsidy to apply for and maintain patents or use patents

to pass the certification of high-technology companies to reduce tax rate. We find that the patents are motivated by these strategies are more likely to be sold or licensed. It seems though the companies have made rational choices because they would probably not apply for these patents without incentives from government. Once the objective of obtaining the patents is fulfilled and with the mounting pressure to pay maintenance fee to renew the patents (subsidy does not cover maintenance fee), firms choose to transact the patents.

When it comes to the effect of IP management structure on patent transaction mode, the utility model patents managed by a specialized IP department is more likely to be licensed than to be kept for internal use. If the specialized IP department is under legal department, the utility model patents are more likely to be sold. On the contrary, if an invention patent is managed by a specialized department under the general administration, legal or R&D department, which are mainstream organizations responsible for IP management in China, it is less likely to be sold versus to be kept for internal use.

Last but not the least, results of separate regressions on invention and utility model patents illustrate that firms perceive the two types of patents differently and exploit them in different ways. For example, invention patents seem to be more effective than utility model patents in implementing econometrically-motivated patent strategies such as cross-licensing, blocking competitors and protecting early-stage R&D. Therefore, firms with these strategies are less likely to sell the invention patents. Clearly the difference in quality and also in protection period of the two types of patents are in mind of corporate managers when they consider transaction choices.

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