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Determining Characteristics of Firms in China that Have Access to Foreign Licensed Technology: An Econometric Approach Using Probit

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Abstract

This paper explores the effect of firm characteristics in terms of licensing foreign technology for firms located in the eastern region of China. Existing studies apply general licensing theory to what might be a factor of regional and industry specific preferences. This paper deploys several probit models based on data gathered by the World Bank to empirically find evidence to support firm attributes and their effect on foreign licensing. The results present us with insights that seem to support that Joint Ventures are more prone to license foreign technology than wholly owned firms, but only on a general level. When controlling for region and industry, firm size, a dummy variable for being a subsidiary and a fractional variable R&D/sales show positive and significant effects on predicted probability of using a foreign license. Significant effects were also found in certain coastal and hinterland regions, as well as in two industry sectors.

Keywords: Licensing, FDI, China, Joint Ventures, Ownership, Probit

Figures:

Tables:

1. Introduction

1.1 Background

With China continually showing unprecedented economic growth numbers, one might wonder how it all came to be. The governments incremental approach to opening up the economy after a long period communist rule autarky meant that western business standards slowly but gradually came into effect. Yet, the fundamental institutional adjustments were constantly one step behind, being pushed by a bottom-up process of development.

In China as well as any other developing country, there was indeed a need for technological advancement. There are however conditions under which technology transfers tend to occur. In the typical case where advanced economies invest in developing countries under foreign direct investments (FDI), protection of the technology holder in terms of legal frameworks or intellectual property rights tend to determine the willingness to invest. If the technology holder chooses to instead share their technology as a licensor, there has to be adequate enforcement of intellectual property laws in order to incentivize licensing (Bosworth & Yang, 2000).

When it comes to technological development, there is however a rivalry between using research and development (R&D) to innovate and to license the innovation. Industry leaders could either choose to focus on major innovations that would replace current production technology, or minor innovation that would only act as a compliment to the current technology. The latter of the two is the one that typically gets licensed out (Katz & Shapiro, 1987). For firms that have previously licensed technology, their R&D expenditure has been shown to be more effective in generating future patents. This also explains the core feature of licensing, which is a spillover effect that has a great impact on future technology development (Johnson, 2002). While the effects of licensing and technological spillover have been widely discussed in economic literature, who the typical licensee might be is not as evident.

1.2 Purpose and Research Question

The purpose of this study is to examine how the probability of using a foreign licensed technology changes depending on properties of Chinese firms. Defining ownership structure as a function of voting shares held by domestic, foreign or state actors, this study is limited to survey data gathered on behalf of the World Bank. Limitations of the study also excludes large parts of mainland China, as a result of the survey used. All data used will refer to the fiscal year of 2011 and exclusively represent manufacturing firms active in China.

Any findings in this study should theoretically give insight to where foreign firms seeking to license their technology should set their focus to. This becomes essential for diversification strategies used by both multinational enterprises (MNEs) and foreign firms looking towards China. Implications of any robust findings would also in essence imply a potentially reduced transaction costs, in terms of lowering the search costs affiliated with licensing.

As shall be presented in the summary of previous studies, there is a wide array of studies covering the topic of licensing. On the other hand, there seems to be a gap needing to be filled explaining what types of firm actually acquires foreign technology. Therefore, this paper seeks to answer the following research question:

- How does ownership and specific characteristics of Chinese firms affect the predicted probability of licensing foreign technology?

To answer the research question, a probit model analysis will be conducted in line with applicable theory.

1.3 Outline of the Thesis

This paper is structured in the following manner: Chapter two will sum up previous studies conducted on the topic. The third chapter will present and discuss applicable theories for the study. Chapter four aims to describe the data set used as well as the construction and description of applicable variables. Chapter five includes a more detailed methodology with regards to econometric quality. The sixth chapter presents the reader with the results of the empirical study. The last chapter of this paper seeks to link the theories presented with the result, to ultimately conclude the study.

2. Previous Studies

The topic of licensing is a well discovered field, in which contributions have typically been focused on either FDI or how foreign licensing affects indigenous R&D. Still, while there has been research specifically aimed to shed light on the licensing situation in China, there is none to my knowledge seeking to empirically determine which firms tend license foreign technology.

2.1 Studies Focusing on China

Using similar data from a prior World Bank survey on Chinese manufacturing firms, Okura (2008) uses probit models to determine characteristics of firms who have access to commercial bank loans. The findings include lesser developed regions and smaller firms being less probable to be able to obtain bank loans. Enhanced probability of acquiring bank credit comes from government assistance agencies, availability of legal and accounting services and export rights of regions.

In one of the first empirical studies focusing on spillover effects in China from foreign direct investment, Cheung & Lin (2004) provide robust finding using provincial data from 1995 and 2000. The study suggests that a crowding-out effect of domestic innovation caused by inwards FDI is either non present or dominated by the positive effects of FDI, at least on a provincial level. The authors also find that the economic development of provinces, as measured in GDP per capita, shows great impact on how effective R&D activities are. This relates to the Chinese coastal regions, which typically are more developed when compared to hinterland regions.

In a study by Bosworth & Yang (2000), the authors explain the relationship between intellectual property rights and licensing activities in China. The paper examines China’s previous insufficient legislature in terms of intellectual property rights and how licensing activities rose as implementation and enforcement of such laws increased. In another paper seeking to explore variations in licensing portfolios for Chinese indigenous firms, Wang, Roijakkers & Vanhaverbeke (2013) found that prior licensing activities resulted in several benefits for the firm. The first realization was that there is an inverted U-shape relation between prior licensing and firm’s innovation performance. Yet, the most interesting finding of the paper was that firms who licensed foreign technology showed to outperform firms who predominantly licensed domestic technology.

2.2 Studies Focused on Licensing Outside of China

In a study focused on licensing in the chemical industry, Fosfuri (2006) tests panel data covering large chemical firms during the period 1986-1996. The author finds that the market for technology plays a crucial role in the licensing strategy of a firm. This implicates that analyzing licensing activities within certain industries without regard to market dynamics is problematic. The author also presents a framework to which could be used as a compliment in addition to the transaction cost theory of licensing. The framework presented states that the rate of technology licensing for a firm is dependent on a comparison between the profit dissipation effect and the revenue effect. In another study conducted by Arora (1997), the author details the increase in licensing activities that was prominent in the chemical industry after the second world war. The increase was a result of a vast number of firms entering the market, which in turn led to more innovators being present. The key takeaway from the paper is that the ability to license technology in either processes or products becomes crucial to advance markets. This is due to patents being efficient transferrers of technology as well as incentivizing R&D investments.

In an empirical study analyzing licensing activities and patent use in Japanese firms, Motohashi (2008) found evidence supporting a high propensity for licensing in smaller as well as larger firms. Firm size and propensity to license shows a nonlinear relationship, were smaller firms highly prone to license and larger firms relatively highly prone. Also showed in the study was a variety of licensing strategies between industries, mainly relating to the technological complexity of the industry.

3. Theory

3.1 Transaction Cost Theory

The transaction cost theory is based upon dividing joint ventures into equity joint ventures (hereafter JVs) and non-equity joint ventures (hereafter contracts). The former of the two is a legal entity in which the funding comes from at least two different partners, or when partial ownership is acquired in a firm, by another firm. The latter of the two includes a large amount of contractual agreement between two firms, without any ownership stake being acquired or lost by any of the firms. Licensing agreements categorize as non-equity JVs but are not exclusive to said JV. Furthermore, JVs can be categorized as either scale or link JVs. Scale JVs are created when at least two firms join forces to enter a new market, combine production or set up new distribution solutions. Typical for these types of ventures is to allow vertical and horizontal integration for the parent companies while also being able to diversify. The case for link JVs is rather different, as the partners are initially in asymmetrical positions. This means that one firm can seek to diversify whilst the other is merely interested in vertical integration (Hennart, 1988).

The theory presents a tradeoff between full ownership, JVs and contracts, where JVs are considered the best strategy when intermediate inputs are only available on an inefficient market. One interesting aspect of the theory is the model presented on link JVs.

Figure 3.1. Creation of Link JVs

		Firm A	
		Marketable know-how	Non-marketable know-how
Firm B	Marketable know-how	Indeterminate	B licenses A
	Non-marketable know-how	A licenses B	A JV with B

Source: (Hennart, 1988)

As displayed in figure 3.1, the choice of choosing to license is dependent on the firm's ability to achieve marketable know-how. The transaction cost of know-how by contract is the same as the cost of licensing. The figure makes it clear that if both parties have the same initial conditions, i.e. marketable or non-marketable know-how, the result will be either undetermined or a JV. The choice of licensing only becomes a solution when there is a disparity in initial conditions. Furthermore, any firm's choice to license is conditionally determined by having marketable know-how whilst the other party does not.

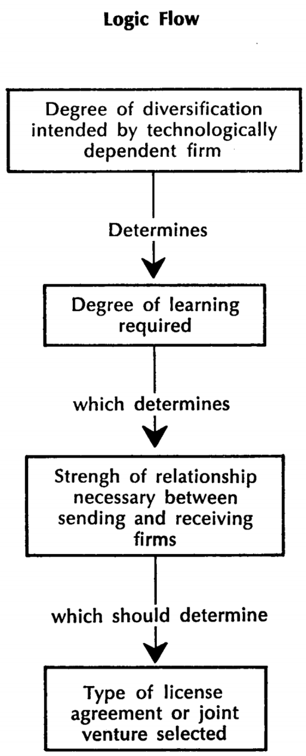
More intuitively, the transaction costs can be explained as the way in which a firm chooses to tackle their lack of local know-how. A firm could either turn to the market and hire domestic personnel or firms to contribute with expertise or turn to internal channels by venturing into a JV with one or more local firms. The costs of these will depend on how much knowledge that is required by the foreign party. Would there be a severe lack of knowledge, the cost of hiring domestic firms could outweigh the cost of a scale or link JV. While the cost of sharing equity increases with the growth of the JV, there it can still be a considered a first-best strategy due to the limited resources being spent ex ante as opposed to contracting (Hennart, 1988).

3.2 The Choice Between Licensing and Joint Venture

In a study which aimed to present the conditions of whether a technologically deficient firm should either license technology or enter a joint venture, Killing (1980) introduces an alternative theory. The author presents a descriptive model of the topic relying on a proposition that the relationship between the licensor and licensees' personnel depends on how much learning the technology dependent firm is in need of. The essence is that know-how is an intangible asset where the transmission of it has to be transferred by personnel.

In the model, the correct choice between licensing only current or current and future technology, as well as the choice between majority and equal joint venture follows a logic flow. The reasoning behind it is that the first stage classifies if a firm is seeking diversification, which in its turn determines how dependent the firm will be on learning. Depending on how much learning is required in turn determines what sort of relationship will be necessary between the two parties. Here a high degree of learning, this grants for much stronger relationship between the parties, as the know-how only is transferable by human resources. The last stage of the logic flow explains that whether licensing or a JV is a preferable strategy depending on how extensive the relationship between the two firms has to be. During the last stage, licensing is presented as the solution for firms who do not intend to create or already has a strong relationship with the technology supplier, and the opposite is true for an equal joint venture (Killing, 1980).

Figure 3.2. The Logic Flow of Firm Choice

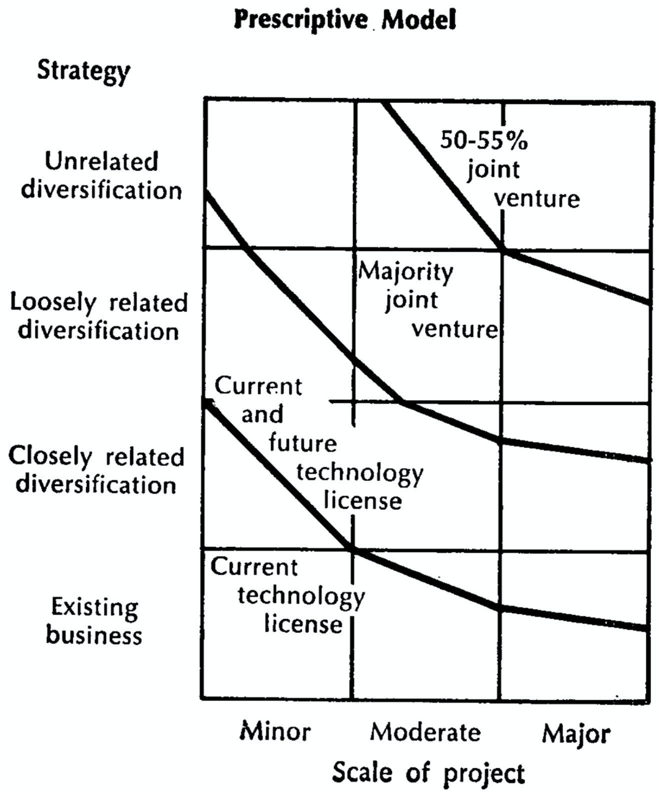


Source: Killing (1980)

Licensing only current technology refers to a contract where the licensee has no obligation to share any developments or new technologies with the licensor. Current and future technology contracts on the other hand refers to that any advancement or improvements in aforementioned technological field will be transferred to the licensee as long as the contract still is valid. The latter of the two is clearly favorable, but it also comes at a higher cost and requires more frequent contact between the two parties. For the two different types of JVs in the model, the majority JV is characterized by the technologically dependent party having an ownership stake in regard to voting rights of at least 70 percent and is less constrained by the relationship between the two parties than the equal JV.

The equal JV is described as a JV between the technology dependent party and the technology supplier, where the dependent party has an ownership share in the JV in the interval between 50 and 55 percent (Killing, 1980).

Figure 3.3. Killings Prescriptive Model



Source: (Killing, 1980)

As depicted in Figure 3.3, a firm ought to choose the solution with the lowest strictly necessary relationship required. The reasoning behind it is that as the technology dependent party increases its linkage with the technology supplier, the cost of the agreement increases. This increase is not solely based on increased royalty rates, which for example occurs when a firm goes from having a current license contract to a current and future contract. The increased cost also derives from managerial fees that comes with a JV, as well as restrictions that can be imposed when committing to a current and future license agreement, often restricting the licensee's ability to export.

3.3 Role of Host Governments

When Multinational enterprises (hereafter MNEs) seek to diversify or enter new markets, their preferable choice of ownership for a subsidiary does not solely depend on their own preference. While any given firm will try to minimize the transaction costs of such a venture, the government of the host country might be prone to negotiate towards a JV with a domestic firm (Gomes-Casseres, 1990).

The case for the preferred ownership structure of a subsidiary is a result of the MNEs intention to maximize net economic benefits. The choices are, as in previous theories, a wholly owned subsidiary or an equity JV with firms or individuals from the host-country. Also noted in previously mentioned theories is that the transaction costs vary for these ventures, depending on the relationship required between the parties. These costs arouse mainly due to the need of monitoring, negotiating and enforcing of agreements between affected partners (Gomes-Casseres, 1989).

However, there are cases where there is a discrepancy between what the MNEs prefers and what becomes viable. Host country governments pays a crucial role in how much they chose to restrict foreign firms entering the domestic market. In instances where restrictions do occur, they are a result of the firm entering the markets negotiation power relative to the government. This means that the actual ownership structure of a subsidiary is determined by two factors: a) the intensity of preferred ownership structure, and b) the bargaining power of the MNE relative to the host country government. What determines a government's bargaining power can mainly be attributed to the attractiveness of the domestic market. The attractiveness is not, in contrast to popular belief, determined by market size, but instead based on the growth rate of the market (Gomes-Casseres, 1990).

Western enterprises entering the Chinese market are prone to face vast difference in how involved the Chinese government is in the domestic market in contrary to many western governments. The reason is that while China has continually grown towards a market economy, the Communist Party of China is still the only and reigning party. A result of this is that institutions in many cases are less developed and that the government de facto can intervene in local business by controlling and defining the rules of the game. Foreign firms, either JVs or wholly owned, are said to be welcomed while they still need government approval in order to commence business on the domestic market. During and leading up to the first decade of the 21st century, most of the new JVs were comprised of a state-owned enterprise party. Additionally, Chinese political influence may later occur when the state-owned JVs are forced to set certain extensive demands towards the foreign partner. In some cases, the Chinese government might even find a new interpretation of a law that leads to a major impact on business, or suddenly enforce laws or regulations that prior to that instance had been obsolete (Sanyal & Guvenli, 2000).

3.4 Indigenous Technology and the Case for R&D

While previous theory has presented compelling solutions to coordination efforts between different firms, there is still a case to be made about how firms independently seek to advance in their technological competence. There is evidence provided that confirm that research and development (R&D) acts as a substitute for technological purchases made by firms (Basant & Fikkert, 1996). This means that when a firm is lacking technological knowledge, it can either choose to develop technology inhouse or seek out alternatives available for contracting or purchasing.

Consider a foreign firm who is willing to advance into a foreign market. With regards to minimizing technology spillover to domestic firms and therefore optimizing the competitiveness of its products, the foreign firm can either create a wholly owned subsidiary or license its technology to a domestic firm for a fee. If the foreign firm chooses to become a licensor, the upside of the initial period will be that it limits competition with domestic firms. In the following period, the downside is that more proprietary knowledge is transferred to the licensee relative to if the foreign firm would have created a subsidiary. This leads to an increase in R&D productivity for the licensee in the second period, since alterations and improvements made to the technology licensed is owned by the licensor (Saggi, 1999).

Empirical evidence has also been presented to support that the likelihood of transferring technology is determined by how much R&D is invested to the specific field where the firm acts as a transferor. Additionally, the age of the technology that is being licensed has an effect on the probability of it being transferred, where older technologies tend to be licensed out whilst newer and more complex technologies tend to be internalized by the firm (Davidson & McFetridge, 1984). The implications of the latter are that proprietary knowledge transferred to domestic firms will be less relevant to the licensor, as the technology lacks the latest and with that most efficient solutions.

3.5 Flying Geese Model and Industry Effect

The flying geese model explains how less developed countries form their industrial sectors to withstand international competition. The flying geese model is supposed to metaphorically illustrate how geese fly in an inverted V shape and creates a model where three inverted V shapes cross each other in a subsequent matter. The theory explains the conditions under which a country that has been excluded from the international market begins to open up its trade ports. The core of the theory states that an underdeveloped country must first import consumer goods and their technology, to then be able to learn how to produce it, to lastly be able to export it. The same pattern repeats itself when the country approaches a developed stage, where capital goods instead are interchanged (Akamatsu, 1962). While the model does not present a perfect picture of China and its domestic industries as of 2010, there is still something to be said about the natural pattern of indigenous industrial growth in sectors that are underdeveloped.

There is however evidence showing licensing preferences are vary between industries. The chemical industry has been shown to preference licensing on a significantly higher level than foreign direct investment, but the reason might be due to the ability to codify process knowledge into patents rather than product innovation. The food industry as well as the manufacturing industry has also been shown to be prefer licensing. While the reasons for the preference for the food industry might be a result of it providing rather simple consumer goods which can be marketed in different ways by agents, the reason for the manufacturing industry is rather different. Instead there tends to be more licensing with older technologies, which in turn more easily can be absorbed by the licensee for further technological knowledge (Shane, 1994).

3.6 Regional Differences in China

Under the assumption that technology can be considered a free flowing good, the absorption of technology still tends to vary. In order to be able to absorb new technology, firms need to be engaged in the adaptation of new technology as well as being able to create it themselves. If these two activities are left unrealized, being able to absorb new technology will become increasingly more challenging. There also is a large amount of clustering for high end technology firms (Silicon Valley strikes as a perfect example).

What this suggests is that the geographical location matters to a great extent when it comes to where R&D is employed (Pack & Saggi, 1997)

Two general propositions to explain how inter-regional differences may occur are a) innovation to be thought of as an interactive process and b) innovation is shaped by a wide array of social conventions and institutional routines (Morgan, 2007). With these two propositions interpreted in conjunction, it is highly plausible that technological development and innovation differ between regions. In China, there is a great amount of economic and developmental disparity between different regions, which his has led to an immensely uneven distribution of foreign JVs across the country (Li et al, 2011). What can be considered more explanatory is that clustering of high-end technology firms occurs often adjacent to labor-intensive mass production agglomerations (Nee & Opper, 2012). This all points towards significant regional differences in both capability and opportunity of absorbing tacit knowledge.

4. Data

4.1 Data Set

In order to present empirical results for the presented research question, a vast amount of data had to be used. The data set used for all empirical testing consists of 2700 surveys conducted on commission from the World Bank between 2011 and 2013 (World Bank, 2012), and was only conducted on managerial staff, owners or directors of manufacturing firms. The survey was outsourced to several private contractors who had to conduct the face-to-face interviews in the local language. The sampling is limited to establishments who operate and base their operations in 25 different metro areas in China. Controlling for rejection of participation and ineligible firms, the response rate of the survey (contacted establishments in relation to completed interviews) amounted to 7.54. Three types of stratification were used for the random sampling, which consisted of industry, size and region (World Bank, 2013).

4.2 Dependent Variable

For all deployed models the dependent variable is a binary choice between either using or not using a foreign licensed technology at the time of the survey. The data collected from the World Bank is coded to allow a binary model by setting the value of observations using said license to 1 and otherwise 0.

4.3 Explanatory Variables

Ownership variables

The explanatory variables used for all models are based on ownership structure and divided into three different categories: wholly owned firms, majority ownership firms and minority ownership firms. Each category is then matched with domestic, foreign and state owners, giving us a total of 8 different explanatory ownership variables. Due to the lack of wholly state owned firms in the data set, the particular variable for such firms are excluded from all models. According to theories presented, the preferred ownership structure might not always be the case as JVs are sometimes forced. The effect this might have on foreign licensing agreements is expected to be positive for foreign firms and domestic firms who are not wholly owned, while being negative for any firm with state ownership.

An alternative way to present the ownership structures would be to allow the variables to take any value represented in the sample of specific ownership percentages. While this would have given continuous explanatory variables, any predicted marginal effects would only explain the change with an increase of one percent, and still fail to include the effects given by voting rights.

Firm size

Firm size is measured depending on how much personnel the firm employed at the time of the survey. Small firms are categorized as having between 5 and 19 employees and accounted for roughly 25.8% of the total sample used with 431 observations. Medium sized firms were those who employed between 20 and 99 people and accounted for 41.7% of the sample. Large size firms were all remaining firms with at least one hundred employees. The variable is coded at values one, two and three for small, medium and large firms respectively. This leads to a more viable interpretation of predicted coefficients, as the coefficient will allow us to see a general increase or decrease when the firms size increases by one size.

Subsidiary

A dummy variable for if a specific firm is part of a larger organization, or a subsidiary, is thought to have explanatory value. The variable is expected to come out as positive in applicable models. It reflects the possibility of a firm relying on their parent company for either licenses, R&D or funds.

R&D / Sales

There is a theoretical conflict to whether or not R&D acts as a compliment or substitute to technology purchases. To test the impact on R&D, controlling for the amount spend in total values becomes correlated with the scale of the firm and therefore becomes unsubstantiated. Instead a ratio of R&D in relation to total sales revenue becomes a viable option to test the impact of R&D on licensing agreements.

4.4 Control Variables

Presented control variables are representative of factors that might determine the ability or choice of licensing foreign technology. The variables were chosen in accordance to either previous studies or the theory presented.

Industry

That industries tend to differ complexity of technology used is to be considered a certainty. What is more important to look at is how they differ in terms of ability to obtain licenses relevant to their specific field. Given that the evolution of domestic industries follows a flying geese pattern, the industries will evolve somewhat independently of each other. Therefore, controlling for industries can explain differences in technological development in industries, as well as portraying license-intensive industries.

Region

A traditional way to control for region effects would be to set dummy variables for if the region is classified as a coastal region. There is a reason for this, as China historically have favored coastal regions in terms of economic governance in ways such as introducing many of them as special economic zones long before hinterland regions were given the same opportunity. Instead of creating one coastal dummy variable for all regions, each region has been given an individual dummy. The reasoning being that while coastal regions tends to have an advantage in industrial development, estimating fixed effects gives a more precise reflection of each region. Therefore, all regions will be controlled for instead of using a single dummy for coastal regions.

4.5 Descriptive Statistics

Presented in table 4.1 is a summary of all variables used with the exception of control variables. There is a clear overrepresentation of wholly domestic owned firms, which should be expected considering the data used. Additionally, there are no continuous variables in any model used, instead they are all discrete or binary with the exception of the factor variable R&D/sales. Furthermore, the table exhibits that all foreign ownership variables have a higher mean value if they are using a foreign license compared to if they are not. Firm size, subsidiaries and R&D/sales also represents higher means if they are using a foreign licensed technology.

Table 4.1: Descriptive Statistics

Variable	Uses foreign licensed technology			
	Mean if No	Std. Dev.	Mean if Yes	Std. Dev.
Wholly Domestic	0.894	0.308	0.784	0.412
Domestic Majority	0.030	0.171	0.097	0.296
Domestic Minority	0.055	0.228	0.047	0.212
Wholly Foreign	0.016	0.125	0.067	0.250
Foreign Majority	0.006	0.074	0.040	0.196
Foreign Minority	0.024	0.154	0.057	0.232
State Majority	0.049	0.216	0.010	0.099
State Minority	0.004	0.063	0.004	0.070
Firm Size	1.995	0.769	2.295	0.687
Subsidiary	0.087	0.282	0.186	0.390
R&D/Sales	0.013	0.048	0.040	0.091

5. Methodology

5.1 Data Cleansing

In addition to coding data values into appropriate values for the binary models used, the World Bank data set comes with a few issues. The fact that the survey uses a particularly large questionnaire means that not all questions will be answered. Considering our ownership explanatory variables, any sort of inconsistency in those reported values raises a red flag. Therefore all “don’t know”-answers to domestic, foreign or state ownership were excluded from the data used in next chapters presented results. This procedure can be classified as a listwise deletion of data, where the unsatisfactory data is omitted from the results. While this is fairly common practice, in particular for large data set, it still might introduce bias to estimated parameters (Kang, 2013).

5.2 Model Specification

To be able to answer the research question, firm specific factors noted in the theory and explained in the data section are used in relation to firms using foreign licensed technology. Four different models are used to explain the probability of a firm using said foreign licensed technology depending on the explanatory variables. This leads to four generic probit model specified as follows:

$$y_{1,i} * = \beta_1 x_{1,i} + \varepsilon_{1,i}$$

$$y_{2,i} * = \beta_2 x_{2,i} + \varepsilon_{2,i}$$

$$y_{3,i} * = \beta_3 x_{3,i} + \varepsilon_{3,i}$$

$$y_{4,i} * = \beta_4 x_{4,i} + \varepsilon_{4,i}$$

Where $y^*_{k,i}$ is representative of latent (unobserved) variables in the model. For $k = 1 \dots 4$, we have $y_{k,i} = 1 \text{ if } y^*_{k,i} > 0 \text{ and } y_{k,i} = 0 \text{ if } y^*_{k,i} < 0$. Given the probit model, $Var(\varepsilon_{k,i})$ is assumed to follow a normal distribution. This leads to the following log likelihood function of the model:

$$\ln \mathcal{L}(\beta_k) = \sum_{i=1}^{n} \left(y_{k,i} \ln \Phi \left(x'_{k,i} \beta_k \right) + (1 - y_i) \ln(1 - \Phi(x'_{k,i} \beta_k)) \right)$$

In presented probit models, $x_{\mathrm{k,i}}$ are vectors containing the explanatory variables, β_k represents vectors of estimated parameters and $\varepsilon_{k,i}$ is referring to the residuals. In the first model, $x_{1,\mathrm{i}}$ strictly includes firm ownership variables. $x_{2,\mathrm{i}}$ sees an addition of firm size, a subsidiary dummy and the factor variable R&D/sales, and $x_{3,\mathrm{i}}$ includes interaction variables between the added variables in $x_{2,\mathrm{i}}$. $x_{4,\mathrm{i}}$ uses the variables from $x_{2,\mathrm{i}}$ while also including control variables for industry and region.

A choice between either deploying logit or probit models was made, favoring the latter. The reason being that no assumption of a cumulative distribution function of the logistic distribution in the residuals could be justified. Instead, the probit model uses a cumulative distribution function of the normal distribution for residuals. Further reasoning behind choosing probit over logit include the dichotomy given by the dependent variable used for all models. While dichotomous dependent variables favor probit, the general method of choice polytomous dependent variables is logit (Aldrich & Nelson, 1984). What the difference between the two models would have been can be described by their distributions. Both models are symmetrical and has a mean value of 0, but the normal distribution has a variance of 1 while logistic distribution has a variance of $\pi^2/3$. This leads to both distributions being quite interchangeable while in the middle section of the distribution, but the logistic distribution has heavier tails (Amemiya, 1981). What it would imply for the results is higher p-values as we approach the tails, meaning that it would be harder to distinguish the estimated coefficients from zero. Additionally, using the probit model grants an advantage due to the normal distribution's relation to the central limit theorem, where larger sample sizes trends towards a standard normal distribution.

5.3 Measure of Fit

While R^2 works as a clear measure of fit in linear regression models, the same cannot be said for pseudo R^2 in binary models. In the results presented during the next chapter, all pseudo R^2 will relate to McFadden's definition of R^2, where it is based on the log-likelihood of the model. Given the general specification of the probit model, the pseudo R^2 measure is computed in the following way:

$$R^2_{McFadden} = 1 - \frac{\ln{(L_c)}}{\ln{(L_{null})}}$$

Where L_c is the maximum log-likelihood value of the fitted model and L_{null} being the log-likelihood for the null model when non-intercept coefficients are restrained to strictly being 0 (Veall & Zimmermann, 1996).

While there still is to be a general assessment of the significance of pseudo R^2, the measure still gives an important indication of how well the model fits the data (Yazici, Alpu & Yang, 2007). Another way to approach the fit of the model is to compare the predicted outcomes from the models with the actual sample results. Demonstrated in table 5.1 is a cross-tabulation of all presented models, showing the difference in predicted and actual outcomes.

table 5.1: Cross-Tabulation of Actual and Predicted Outcomes at ŷ>0.5

		y_i		
		0	1	Correctly Specified
$\hat{y}_{1,i}$	0	0.976	0.859	77.44%
	1	0.024	0.141	
$\hat{y}_{2,i}$	0	0.974	0.853	77.48%
	1	0.026	0.147	
$\hat{y}_{3,i}$	0	0.973	0.840	77.72%
	1	0.027	0.160	
$\hat{y}_{4,i}$	0	0.953	0.623	81.45%
	1	0.047	0.378	

What the table shows is that when comparing actual predictions of the models, the first three models are fairly similar. They all correctly predict roughly 77% of the sample, with most of them being negative predictions. Considerably more important, the first three models' predictions severely misspecifies the dependent variable when the observation actually uses a foreign license, with no model reaching over 20% in correct specifications. The last model sees an increase in correct specifications, reaching a total of over 80%, but this time amounting to almost 40% in cases where the dependent variable is 1 in both prediction and observation.

5.4 Marginal Effects

When deriving variables in order to get their marginal effects, there is a choice to be made about how do derive them. The two typical approaches to obtaining marginal effects are to either chose average marginal effects (AME) or marginal effects at the mean (MEM). When strictly applying them to dummy variables, the two differ in the following computational matter:

$$E(y) = F(\beta x)$$

$$AME_i = \frac{1}{n} \sum_{k=1}^{n} \left[F\left(\beta x^k \mid x_i^k = 1 \right) - F\left(\beta x^k \mid x_i^k = 0 \right) \right]$$

$$MEM_i = F(\beta \bar{x} \mid \bar{x} = 1) - F(\beta \bar{x} \mid \bar{x} = 0)$$

Source: (Bartus, 2005)

The difference then is that AME will estimate the marginal effect for all individuals and thereafter divide it by the sample size, whereas MEM will estimate marginal effects for the average value of the variable. While neither of the two are optimal, one major problem occurs when dealing with dummy variables and computing their marginal effect at their mean is that the variable takes an unrealistic value. Since the variable in reality is binary, calculating the marginal effect at the mean leads to using observations that are not representative of the sample or the variable. Using MEM also results in a high risk of over- or underestimating the AME. Additionally, using AME leads to interpretations that are more realistic of the estimated results when compared to MEM (Bartus, 2005). Therefore, in all presented models, the marginal effect will be a result of estimated average marginal effects.

5.5 Multicollinearity

A viable way of detecting multicollinearity in the data is to control a correlation matrix of all explanatory variables to determine if they are independent. Higher correlation values in the 0.8-0.9 region would indicate that there might be multicollinearity between the variables. Yet, this method presents a limitation, since it cannot detect collinearity between three or more variables. When only comparing two variables, they might indicate a low correlation, but still be collinear in when not compared individually (Kennedy, 2003).

Presented in table 5.2 is the correlation between all explanatory variables. What is noticeable is that there are two correlation values that exceed 0.8, between domestic majority and foreign minority as well as state majority and domestic minority. Why this is the case relates to how these dummy variables must coexist in order to represent full ownership of a firm. Since both correlations are positive, it indicates that a given majority ownership typically occurs with a specific minority ownership, which would be a typical JV. Given that the explanation only is based on inference, any conclusions about multicollinearity not being present cannot be considered verifiable.

Table 5.2: Correlation Matrix

Variable	Dep. Var.	Wholly domestic	Domestic majority	Domestic minority	Wholly foreign	Foreign majority	Foreign minority	State majority	State minority	Firm Size	Subsidiary	R&D/ Sales
Dep. Var.	1.000											
Wholly domestic	-0.141	1.000										
Domestic majority	0.139	-0.561	1.000									
Domestic minority	-0.015	-0.609	-0.052	1.000								
Wholly foreign	0.133	-0.437	-0.037	-0.041	1.000							
Foreign majority	0.126	-0.303	-0.026	0.475	-0.020	1.000						
Foreign minority	0.079	-0.459	0.805	-0.028	-0.031	-0.020	1.000					
State majority	-0.086	-0.521	-0.044	0.814	-0.035	-0.024	-0.037	1.000				
State minority	0.013	-0.154	0.227	0.030	-0.010	0.079	-0.011	-0.012	1.000			
Firm Size	0.170	-0.103	0.109	0.025	0.028	0.044	0.091	0.014	0.034	1.000		
Subsidiary	0.136	-0,113	0.016	0.045	0.126	0.107	0.001	0.018	0.075	0.179	1.000	
R&D/Sales	0.188	-0.096	0.163	-0.012	0.016	0.044	0.045	-0.056	0.014	0.032	0.035	1.000

To look further into the possibility of collinearity in the models, variance inflation factors were computed for each variable. The variance inflation factor (VIF) is a direct result of the R^2 of a linear regression for any given variable, calculated with the formula: VIF = $1/(1-R^2)$. It relates to how much the variance of a given variable will increase, interpreted as for example a variable with a VIF of 1.3 would lead to 30% higher variance than if perfectly uncorrelated with the other variables. This also determines how much larger the standard deviation of the variable will be, due to the variance being equal to the standard deviation squared (Allison, 2012).

Presented in table 5.3 is the VIF for all explanatory variables with and without the domestic ownership variables. Looking at the first part including all explanatory variables, there is a clear issue with high VIF. While the mean VIF is below 10, all domestic ownership dummy variables indicate high collinearity between the variables. Typical values for determining if the VIF value is too high is using either 5 or 10 as a cutoff value, even though none of them are formally determined (Craney & Surles, 2007).

Table 5.3: Variance Inflation Factors of Explanatory Variables

VIF with domestic ownership included		VIF with domestic ownership excluded	
Variable	VIF	Variable	VIF
Wholly Domestic	32.29	Subsidiary	1.07
Domestic Majority	15.22	Firm Size	1.04
Domestic Minority	14.63	Foreign Majority	1.02
State Majority	11.34	Wholly Foreign	1.02
Wholly Foreign	8.67	Foreign Minority	1.01
Foreign Majority	4.72	State Minority	1.01
Foreign Minority	3.33	R&D/Sales	1.01
State Minority	1.21	State Majority	1.01
Subsidiary	1.07		
R&D/Sales	1.07		
Firm Size	1.05		
Mean VIF	8.60	Mean VIF	1.02

Given that the sample heavily favors domestic firms in relative terms to observations, the high VIF numbers could be caused by an unbalanced sample. Another plausible reason for the high VIF in that their variables represent categorical dummy variables. According to Allison (2012), given that the categorical choices for ownership are small, the high VIF could be caused by the small size of the reference category. Since the ownership variables used are dummy variables only representing three choices for domestic and foreign firms, this would result in high VIF, but it does not necessarily mean that the variables are associated with each other. Nonetheless, the impact of these VIF will result in higher standard deviations for the domestic variables and therefore the p-values of said variables will be higher in relation to the other ownership variables.

5.6 Statistical Software

The data cleansing, coding, creation of new variables, statistical analyses as well as deployment of all models were conducted using STATA/IC 16.0.

6. Results

The purpose of this study is to determine and analyze characteristics and their effect on firms in China who use a foreign technology license. Hereafter the results from multiple probit models set out to determine said characteristics will be presented and interpreted.

6.1 Explanatory Variables and Their Effect on Foreign Licensing

The first model presented is a probit model only accounting for either wholly owned, majority and minority with respect to domestic, foreign and state owners. In the second model, previously mentioned variables will also be included, but with the addition of a subsidiary dummy variable, research and development costs divided by sales revenue, as well as an integer scaling firm size variable. The third model uses the same variables as the second with the addition of interaction variables.

As depicted in Table 6.1, there is no significant effect on wholly domestic firms. Notable is that the ownership group is overrepresented in the sample with 1450 out of 1671 observations. The dummy for domestic majority on the other hand is significantly different from zero on the 5 percent level, giving a strong indication that domestic majority joint ventures (either with state or foreign ownership) is related to foreign technology licensing. The marginal effect of the dummy explains that in model 1, having a domestic majority ownership on average increases the probability of using a foreign license by roughly 45 percent. Domestic minority and wholly foreign owned firms on the other hand show no significance, not even on the 10 percent level. The largest coefficient comes from the foreign majority dummy, which also has the highest significance in the model. With a marginal effect of roughly 55 percent**,** it does not come as a shock that a foreign firm is more likely to be using a foreign license. The reasoning for this will be further discussed in the next chapter. While state majority is insignificant, both foreign and state minority comes out to be significantly negative from zero on the 5 percent level. Considering that domestic majority joint ventures would have to have either a foreign or state minority, the marginal effect of domestic majority does not tell the whole story. While the addition of marginal effects result in a positive aggregate effect for either minority, the effect is much smaller than first indicated. Being a JV with state minority ownership combined with domestic majority ownership results in a lesser probability of using a foreign license compared to having a foreign minority. According to the model, a domestic majority firm having both state and foreign minority ownership would result in a negative probability marginal effect.

Table 6.1: Probability of Using a Foreign Technology License, 2011

	Model 1 Coeff. (std. Dev)	Marginal effect	Model 2 Coeff. (std. Dev)	Marginal effect	Model 3 Coeff. (std. Dev)[1]	Marginal effect
Wholly Domestic Owned	0.068 (0.640)	0.020	0.119 (0.671)	0.033	0.176 (0.680)	0.048
Domestic Majority	1.534** (0.705)	0.452	1.239* (0.737)	0.345	1.230* (0.740)	0.339
Domestic Minority	-0.480 (0.635)	-0.141	-0.383 (0.629)	-0.107	-0.382 (0.629)	-0.105
Wholly Foreign Owned	1.035 (0.665)	0.304	0.991 (0.697)	0.276	1.047 (0.705)	0.288
Foreign Majority	1.883*** (0.705)	0.554	1.646** (0.694)	0.458	1.689** (0.688)	0.465
Foreign Minority	-0.840** (0.348)	-0.247	-0.617* (0.369)	-0.172	-0.525 (0.369)	-0.145
State Majority	-0.262 (0.677)	-0.077	-0.373 (0.666)	-0.104	-0.324 (0.662)	-0.089
State Minority	-1.231** (0.561)	-0.362	-1.076* (0.601)	-0.299	-1.053* (0.603)	-0.290
Firm Size			0.279*** (0.049)	0.078	0.258*** (0.054)	0.071
Subsidiary			0.348*** (0.107)	0.097	0.487*** (0.149)	0.134
R&D/Sales			3.061*** (0.546)	0.851	5.400*** (1.357)	1.488
INTERACTIONS						
Small*Subsidiary					-0.402 (0.403)	-0.111
Medium*Subsidiary					0.068	0.019

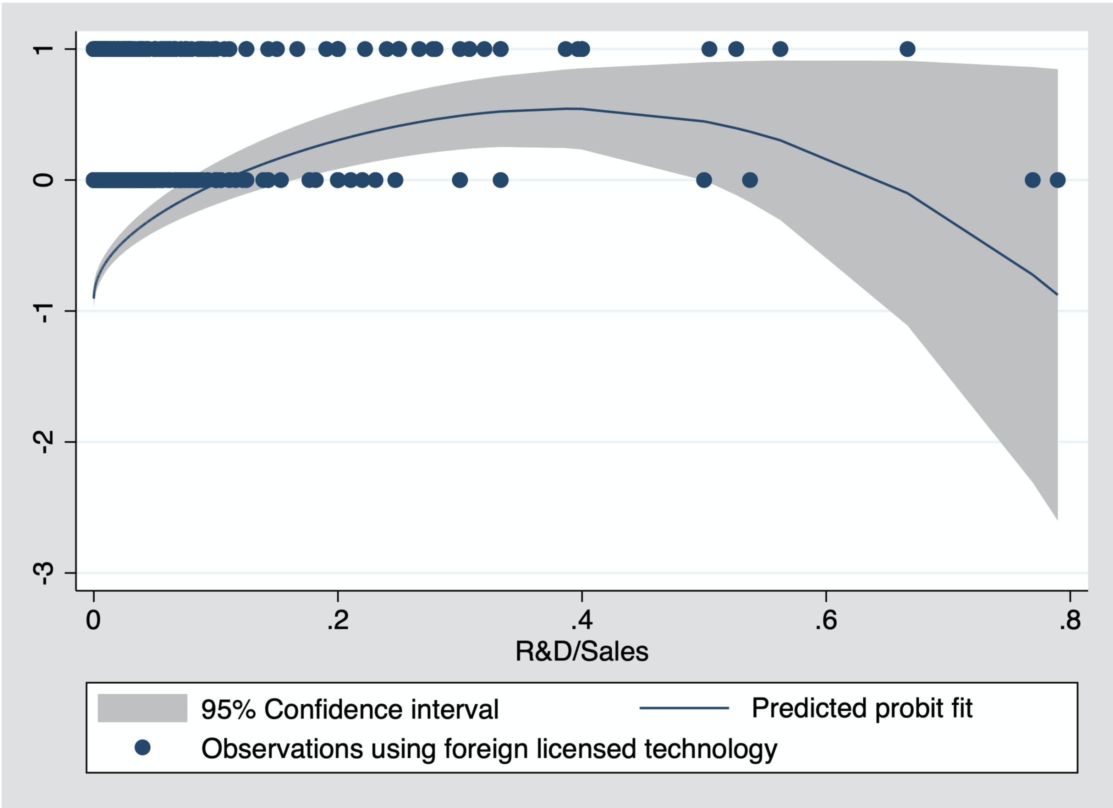
			(0.217)	
Small*R&D/Sales			-0.680 (1.956)	-0.187
Medium*R&D/Sales			-1.162 (0.727)	-0.320
Subsidiary*R&D/Sales			-5.698*** (1.82)	-1.570
Constant	-0.847 (0.639)	-1.590** (0.680)	-1.621** (0.692)	
N	1671	1665	1665	
Log-likelihood value	-873.46	-827.26	-820.09	
Pseudo R^2	0.0538	0.1000	0.1078	

*p<0.1, **p<0.05, ***p<0.01

note 1: Large*subsidiary and large*R&D/sales removed due to collinearity.

When adding three more general variables to the model, we see that there is a loss of significance on all ownership type variables while the added variables show significance on the 1 percent level. State and foreign minority as well as domestic majority now only becomes significantly different from zero on the 10 percent level. Firm size on the other hand represents a marginal effect of 0.078, which should be interpreted as when a firm grows one additional size (small to medium or medium to large), the probability of using a license increases by roughly 8 percent**.** The dummy for being a subsidiary has a marginal effect of 0.097, which means that subsidiaries are approximately 10 percent more likely to use a foreign license. The ratio between R&D expenditure and sales revenue comes out to be largest coefficient with a marginal effect of over 0.85. This is a rather unexpected result, opposing theories where R&D acts as a substitute for licensing. Looking closer at figure 6.1, there is a distribution heavily tilted towards a low ratio of the variable. This means that the interpretation should be that if a firm increases their expenditure towards R&D with 10 percent relative to their sales revenue, their predicted probability of using a foreign license increases by an average of 8.5 percent. The few observations with a ratio of over 0.5 are considered to be heavy research dependent firms and should also be classified as outliers. Therefore, the results cannot fully explain what happens after the ratio surpasses 0.5, due to the limited data provided in our sample.

Figure 6.1. Two-way Fractional Polynomial Prediction of Dependent Variable with Regards to R&D/Sales



The final model without control variables introduces five interaction variables out of what was originally seven, but each interaction with large size firms were removed due to multicollinearity. Out of the ownership variables, only foreign majority remains significant on the 5 percent level. Still, state minority as well as domestic majority remain significant on the 10 percent level. All interaction variables were insignificant from zero, except from the subsidiary interaction with R&D/sales (1 percent level). The marginal effect of the interaction, roughly -1.6, cancels out the initial positive marginal effect of R&D/sales. What this means is that an increase in the R&D to sales revenue ratio predicts a negative accumulated effect for a subsidiary. Unprecedented by previous studies, this will be further discussed during the next chapter.

To mention the comparison in pseudo R^2 between the first three models, there is a constant increase in fit as we add more variables. This is to be expected as long as the variables have explanatory value. While the log-likelihood value (and therefore the pseudo R^2) is a function of sample size, the decrease in sample used for model 2 and 3 should not be considered as a plausible explanation for the large increase in goodness of fit.

6.2 Controlling for Industry and Region

The fourth and last model features all explanatory variables while also controlling for industry and region effects.

When controlling for industry and region specific effects, the pseudo-R^2 increases by a substantial amount. Intuitively this looks like the best model for predicting our dependent variable, but yet there are a couple of issues. The first issue that forces us to interpret the result with caution is the limited sample for each control variable. This is mainly problematic in the industry sector, where the cleansed data set has discrepancy in collected samples for each industry. The second issue is that the presented fit might solely be due to the fact that 45 additional dummy variables were added.

Table 6.2: Probability of Using a Foreign Technology License, Industry and Region Controlled

	Model 4 Coeff.	Std. Dev.	Marginal effect
Wholly Domestic Owned	-0.686	(0.753)	-0.157
Domestic Majority	-0.779	(0.844)	-0.179
Domestic Minority	-0.409	(0.741)	-0.094
Wholly Foreign Owned	0.362	(0.695)	0.083
Foreign Majority	0.889	(0.725)	0.204
Foreign Minority	0.505	(0.464)	0.116
State Majority	-0.942	(0.709)	-0.216
State Minority	0.116	(0.683)	-0.27
Firm Size	0.325***	(0.056)	0.075
Subsidiary	0.407***	(0.121)	0.093
R&D/Sales	1.682**	(0.679)	0.386
INDUSTRY			
Textiles	-0.024	(0.190)	-0.005

Garments	-0.139	(0.193)	-0.030
Leather	-0.098	(0.527)	-0.021
Wood	0.251	(0.952)	0.061
Paper	-0.405	(0.518)	-0.079
Recorded Media	0.435	(0.348)	0.111
Refined Petroleum Products	-0.328	(0.861)	-0.066
Chemicals	0.170	(0.184)	0.041
Plastics & Rubber	0.155	(0.179)	0.037
Nonmetallic Mineral Products	-0.061	(0.188)	-0.013
Basic Metals	-0.183	(0.198)	-0.039
Fabricated Metal Products	-0.314	(0.201)	-0.063
Machinery and Equipment	0.082	(0.192)	0.019
Electronics	0.134	(0.183)	0.032
Precision Instruments	0.162	(0.398)	0.038
Transport Machines	0.405**	(0.181)	0.103
Furniture	1.281***	(0.440)	0.377
Recycling	0.684	(0.488)	0.186
Services of Motor Vehicles	0.536	(0.891)	0.141
Wholesale	-0.175	(0.686)	-0.037
IT	0.824	(0.618)	0.230
REGION			
Beijing (Municipalities)	0.146	(0.281)	0.043
Guangzhou City	2.080***	(0.334)	0.638
Shenzhen City	0.486**	(0.228)	0.154
Foshan City	-0.302	(0.247)	-0.076
Dongguan City	0.530**	(0.237)	0.169
Shijiazhuang City	-0.212	(0.247)	-0.055
Tangshan City	-0.617**	(0.269)	-0.136
Zhengzhou City	0.331	(0.238)	0.101
Luoyang City	-0.488*	(0.263)	-0.114
Wuhan City	1.134***	(0.255)	0.384
Nanjing City	-0.208	(0.267)	-0.054
Wuxi City	-0.124	(0.240)	-0.033
Suzhou City	0.021	(0.237)	0.006

Nantong City	-0.183	(0.243)	-0.048
Shenyang City	-0.502*	(0.303)	-0.116
Dalian City	-0.605**	(0.282)	-0.134
Jinan City	-0.604**	(0.282)	-0.134
Qingdao City	-0.236	(0.278)	-0.061
Yantai City	-1.153***	(0.320)	-0.200
Shanghai (Municipalities)	-0.893	(0.572)	-0.174
Chengdu City	-0.391	(0.276)	-0.095
Hangzhou City	-0.274	(0.353)	-0.069
Ningbo City	0.317	(0.225)	0.097
Wenzhou City	-1.055***	(0.324)	-0.191
Constant	-0.892	(0.790)	
N	1660		
Log-likelihood value	-684.47		
Pseudo R^2	0.2533		

*p<0.1, **p<0.05, ***p<0.01

Comparing the second and the final model, the latter predicts that all ownership related explanatory variables become insignificant even on the 10 percent level. The marginal effects of firm size and being a subsidiary remains close to the result from model 2, staying significant on the 1 percent level. R&D/sales loses explanatory value as the coefficient is roughly halved compared to the second model, as well as only being significant on the 5 percent level.

The industry control only presents us with two significant result, being the transport machinery sector (5 percent level) and furniture (1 percent level). These are not industries that previously have been proven to be more license dependent than other and should therefore not be concluded as significant in a general case. Instead, the furniture industry could more likely be explained by being a Chinese catch-up industry that lacks the technological development compared to other industries. The observation of 138 firms being in the transport machine industry is considered sufficient and indicates that the sector might be more technology dependent than other domestic industries.

When controlling for region, eleven out of twenty-four regions predicts a firm’s probability on licensing foreign technology on a significant level of at least 10 percent, represented by five on the 5 percent level and four on the 1 percent level. Only looking at the firms with the highest level of significance, Guangzhou, Yantai and Wenzhou are all coastal regions while Wuhan is classified as a hinterland region. In contrast to only looking at only a dummy variable for coastal regions, this presents us with an insight that coastal regions experience vastly different effects on licensing. In this case, Guangzhou shows a positive marginal effect of 64 percent while both Yantai and Wenzhou predicts a negative marginal effect of roughly 20 percent. Even looking at the 5 percent level of significance, there seems to be region specific effects on licensing that results in positive as well as negative marginal effects.

7. Discussion and Conclusion

7.1 Discussion

Referring back to the transaction cost theory, there is much left to be explained in the presented results. If anything, the proposition that there is a tradeoff between either licensing or turning to a JV is not supported by our results. Since both domestic and foreign majority firms have a positive effect on licensing, it instead might indicate that there is lack of intangible know-how in link JVs that occur with time, resulting in the choice to license over expanding owners in the JV. This would imply that once a link JV is created, the cost of letting more ownership groups in would be much less cost-effective from the current owner's perspective than to turn towards licensing technology instead.

Under the assumption that the logic flow presented in table 3.2 and the prescriptive model presented in table 3.3 holds, the licenses used by any firm already being a JV should be either within or closely related to the existing business. Since a strong relationship between the two or more ownership groups in a JV already exists, it implies that the costs of adding additional owners would largely offset the benefits of transferable know-how by shared managers. It is still hard to determine whether JVs choose to prefer licensing only current or current and future contracts, as the increased relationship and therefore learning often comes with a constraint on export activities. Further studies on this topic would be necessary in order to fully explain the preferred choices when it comes to licensing for already formed JVs.

With respect to domestic majority being the largest marginal effect for ownership variables in the first three models, this cannot be considered a major insight. As long as we are testing for the probability of licensing a foreign technology, there still remains unexplored theories of firm and personal bias towards cultural similarities untouched by this paper. Yet, when controlling for industry and region effects, domestic majority becomes insignificantly different from zero. State and domestic minority ownership both resulted in a reduced predicted probability for any firm to license foreign technology. One explanation to this could be that the Chinese host government is forcing foreign firms to turn to a JV instead of a wholly owned subsidiary. On the other hand, having a smaller probability of using a foreign license would be an indicator that the JV has sufficient marketable know-how and has made a cost minimizing choice to join forces instead of relying on licensed technology.

The R&D/sales variable shows significant explanatory value on all four models, while still raising a few questions. Especially during the results from model 3, we see that there is an unusual effect caused when interacting with the dummy for subsidiaries. This effect is interpreted as follows: While higher relative spending on R&D on a general level results in a higher probability of using a foreign license, the effect is cancelled out if the firm is a subsidiary. This means that only independent firms are more likely to license foreign technology if they are spending relatively high amount on R&D, while the opposite is true for subsidiaries. Why this is the case can be explained by two different types of subsidiaries. The first reason is applicable for subsidiaries (including JVs) who license technology from their parent company, and therefore is not dependent on any sort of intra-firm R&D. The second reason is that if a subsidiary is heavily tilted towards generating its own in-house R&D, it can either transfers progress made to the parent company or simply license it out, which reduces the need for licensing foreign technology to practically zero. Yet comparing model 2 and 4, it is still a surprising result that R&D acts somewhat similarly to a complement of licensing, which is unprecedented in the theory presented. Although great caution should be taken into account when trying to applicate these results to a more general case, it still calls for further research.

Largely untouched by the theory presented in this paper, all models present results indicating that the size of a firm is a determinant of the probability of being a licensee of foreign technology. Yet, the explanation might relate to Killings (1980) prescriptive model. As firm grow larger in size, there is a natural inclination to broaden the market share of the company, and therefore expanding into new areas. As this requires knowledge previously unknown to a firm who seeks diversification, licensing technology would seem to be a reasonable choice instead of expanding R&D expenditure to a previously untested market segment.

Looking at the control for industry effects, only the furniture and transport machine sectors had a significant effect on licensing foreign technology. According to the flying geese model, this indicates that these industries are in a catch-up phase, trying to advance their core technology. That would mean that these industries are in need of importing technology in order to imitate and absorb the intricate knowledge that comes with licensed technology. When enough knowledge is absorbed, these industries should theoretically be sufficiently independent to develop their own production technology and be able to export their goods without importing licensed technology. On the other hand, this could also be a result of intangible patents created for the production technology by foreign firms, more or less forcing the domestic Chinese firms to adapt to the technology via licensing.

Regional effects, even though only controlled for by dummy variables, strikes as a major determinant for how licensing activities unfolds within China. If this is the cause of institutional or technological development differences between regions cannot be determined by the testing done is this paper. The intensive clustering that is evident throughout China might also be a determinant for which regions are able to continually improve institutional conditions for firms, which in turn could warrant regional firms to be self-sufficient when it comes to technology deployed. It could also be that intellectual property rights are enforced by different means depending on region, which would force licensing as opposed to replicating intra-industrial technology.

7.2 Implications of the Results

The data set used only presents us with a snapshot of the current situation at the times of the survey, and therefore limits our ability to control for robustness over time. Additionally, presented results are in no way transferable to a context outside of regions and industries controlled for. Yet, the variables for subsidiary and firm size stayed significant on the 1 percent level throughout all models. To fully uncover the causation effect on the use of foreign technology licenses, both size and subsidiaries need to be further investigated.

7.3 Improvements

To improve the reliability of the results, using panel data to be able to test the effects over time would give a more accurate prediction of actual effects of the variables. A more precise way of measuring firm size would also be appropriate. Another valid point to make is that using dummy variables almost exclusively as independent explanatory variables indeed has it flaws. While the aim of the study was to determine characteristics of firms who were using a foreign license, a more thorough selection of suitable data could have been accomplished. Furthermore, this study does not take domestic licensing into consideration. This is only one of the problems associated with the survey data used. Another major complication of the data set is that the stratification used heavily favors domestic firms, and therefore small wholly domestic owned firms. This makes the data heavily imbalanced when it comes to ownership structures. Lastly, the models used are only specified to cover a few explanatory variables. Most likely, there are additional factors that plays an explanatory role in this case. Therefore, the probit models used cannot be considered correctly specified.

7.4 Conclusion

This paper has predicted and analyzed the effects of certain firm attributes in relation to the probability of firms using a foreign licensed technology. The emphasis in explaining the variations in foreign licensing activities has been ownership structure, size and research expenditure. To sum up the results, the ownership structure that is most likely to be licensing foreign technology is a firm with a foreign majority. Even though only significant on the 10 percent level when adding interaction variables, domestic majority has a positive and state minority has a negative effect on foreign licensing. When controlling for industry and region specific effects, ownership becomes insignificant. Larger firms were also more likely to be using foreign technology licenses, as well as subsidiaries. R&D over sales showed an unforeseen positive marginal effect, but the implications remain undetermined due to the confined sample used. While the significant results indicate a causation effect on the probability of licensing foreign technology, it is not to be considered conclusive evidence. Any variable with plausible effect from the results presented can neither be transferred to cases outside of the eastern regions of China, nor to firms outside the manufacturing sector.

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