CHALMERS
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Chinese University Patent Transfer

- The Effectiveness and Its Determinants

Master's Thesis in the Master's Programme
Entrepreneurship and Business Design

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2016
Report No. E 2016:099

MASTER'S THESIS E 2016:099

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Abstract

University has become an increasingly important role in China's innovation system. The successful patent transfer from universities to private sectors is extremely important for converting academic research into industrial applications throughout the transition of China's economy from imitation-based to innovation-based. Firms, on the other hand, also begin to adopt an open innovation paradigm, which no longer merely relies on internal technology development, but also absorbs external knowledge to escalate the product development process.

Though the university patenting activity has been enhanced over the past several years, the patent transfer is not increasing at a similar pace. Along with the ineffective transfer rate is the ambiguity in the legal definition, complicated institution structure and skepticism over the university patent quality. This thesis made an attempt to clarify the hindrance in Chinese university patent transfer.

A qualitative analysis of the legal environment and institutional structure is presented. Based on patent records from the top 51 Chinese universities, a descriptive statistic analysis is conducted to depict the status quo of university patenting activity, and further to indicate the trend of patent quality change over time. The main finding in this part indicates an improving legal environment for promoting the university technology transfer, but yet the TTOs remain a low level of involvement in the transfer process. As for the patent quality, it is proved to have been increasing along with the rise of patent filings.

In order to investigate the effectiveness of patent transfer, a quantitative analysis utilizing the survival model is conducted to explore the propensity of patent transfer, its determinants and the effects. Additionally, patent selling and patent licensing are distinguished to investigate the different impacts of related factors. The results show that while patent quality has a stronger impact on patent selling, the generality of invention and the involvement of TTOs are more beneficial for increasing patent licensing likelihood.

Beside the patent-level analysis, firm-level incentives are also discussed to explain how the patent acquisition strategy is correlated to the choice of patent transfer form. A four-step workflow is described to include the primary considerations that need to be taken into account when scouting university patents.

Key words: university patent transfer, effectiveness, determinants, patent strategy

Acknowledgement

This thesis has been pursued as the last part of my education in the Intellectual Capital Management program. The two years' study is with no doubt one of the best times of my life and to have the opportunity to work on this project has been exciting since the very beginning.

This research is conducted under the supervision of Prof. Bo Heiden, whose wisdom and intelligence has inspired me throughout the whole education. I would like to express my greatest gratitude to him for his support and encouragement. This project is investigated primarily based in Zhejiang University, in collaboration with Prof. Can Huang. I would also like to thank him for stimulating me and being there whenever I had a problem. I also want to thank Ms. Laure van Oudheusden for the many discussions we had during the project and all the help she generously provided. I shall also acknowledge Mr. Ruud Peters for his kindness and invaluable suggestions and insights. Special thanks to Prof. Ulf Petrusson and all the other lecturers at the ICM program for their knowledge imparted during the lectures.

I would further like to thank all the people that I interviewed and discussed with, without whose input this project would not be completed. I am also grateful to meet so many friends from the ICM program and Prof. Huang' research group. It is their help that keeps me motivated to overcome the obstacles along the way.

Lastly, I would like to thank my brother and parents for their support.

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1 Introduction

1.1 Background

As China is undergoing a transformation from an imitation-based economy to an innovation-based one, the stakeholders in its innovation system, such as state-owned enterprises and high education institutions are presumed to hold great responsibility to enhance the country's innovation capacity. Among other things, universities, due to their public interests and governmental funded characteristics, are of great importance in transferring research results to industrial utilizations (Fisch et al., 2014).

University-industry technology transfer (UITT) has been studied to a great extent with regards to its complicated process, various transfer channels, and the determinants in successful transfer. Though UITT may be established through indirect approaches such as collaborative research, university spin-off, or university science park, patent transfer has been a prevailing channel for a long time due to its proprietary claims. According to Megantz (2002), there are two problems in relation to university patent transfer. Firstly, most of the research funds are provided by the government to create value for the public interest. Therefore, it is arguable with regards to the balance between public interest and university technology commercialization. Secondly, the university research outcomes have been commonly criticized for being too distant from industrial applications, which deactivates the private sectors from acquiring patents from universities.

On the other hand, firms from private sector have been inclined to open innovation, in which internal R&D activities are no longer the only way to strengthen a firm's accumulated knowledge base. In contrast, inbound IP activities are increasingly becoming an important way of absorbing external research results and accelerating the product development process. The source of external IPs could be competitors in the same sector, partnering with universities and public research organizations, and much more other players in the value chain. Universities, among others, are especially interesting due to the pioneering technologies and massive research activities.

Despite all these incentives, UITT in China has not kept pace with rapid growth of the country's overall technological endeavors. There are many speculations on why the commercialization of university patents are not effective yet. This phenomenon is partly induced by the disconnection between academic research and industrial applications, but also due to the low quality of university patents. Meanwhile, the absence or the inadequate capabilities of TTOs has also been identified as one of the main reasons. These reasons are vague and to some extent correlated, which makes it difficult to prioritize an action plan.

Existing literature on the effectiveness of UITT could be categorized into two directions: 1) the analysis of UITT process, and 2) the determinants of effectiveness/success of UITT.

Bozeman (2000; 2015) proposed a "contingent effectiveness model" for UITT, which holds the assumption that parties to technology transfer have multiple goals and effectiveness criteria. He identified five dimensions of determinants in the technology transfer, i.e., transfer object, transfer media, transfer recipient, transfer agent, and demand environment. The definition of effectiveness, depending on the interest of each

party, was summarized into seven criteria, including: 1) out the door (was anything transferred?) 2) market impact 3) economic development 4) political advantage 5) development of scientific and technical human capital, 6) opportunity cost, and 7) public value. Though many studies were based on the value-oriented definition of effectiveness, the "out-the-door" definition of effectiveness will be adopted in this thesis, of which the goal is to successfully transfer IP from university to external parties regardless of the subsequent economic results.

The acknowledgement of disparate desired output from different stakeholders in UITT is also presented in Siegel et al. (2004), which discussed three perspectives from research scientists, university TTOs, and enterprises. In their work, a linear process of UITT from scientific discovery and invention disclosure to final licensing was illustrated. Instead of a linear procedure, Jensen et al. (2003) constructed the discovery and invention disclosure process as a game-theoretic model, which revealed the dual agency role of TTOs who measure success based on both faculty and central administration objectives. Comparatively, Chang et al. (2015) also presented a game theory model with regards to scientific disclosure and commercialization mode selection, however, from the faculty's perspective. These studies gave a thorough analysis on the early stage of UITT, and focused on the choices made by TTO and faculties. However, according to Siegel's model (2004), given a grant patent invention, enterprises, TTO and professors are all engaged in the late part of UITT process, from negotiation to finalization of a transfer deal. This later part of UITT process is less covered in previous studies and will studied in our research. After a general discussion on how the transfer process looks like and the existing problems, the later part of UITT process will be the primary focus in this project.

A vast of literature studied the determinants of a successful technology transfer from university. One of the predominant topics is related to university invention ownership under the Bayh-Dole Act of 1980 (Kenney & Patton, 2009; 2011). There have been debates over whether it hurts or helps technology utilization by granting governmental funded research results to university. The debates are further extended to the discussion of professor ownership versus university ownership in terms of the efficiency of knowledge transfer process (Crespi et al., 2010). In China, the patent subsidy program is mostly studied to determine its effects on patent quantity and quality (Fisch et al., 2014).

Except for policy factors, another branch of determinant research is devoted to institutional and management elements. Friedman & Silberman (2003) found that universities which provide greater rewards for faculty involvement in technology transfer will generate more licenses and royalty income, and the regions with strong entrepreneurial climate are also positive for licensing. Similarly, Thursby & Kemp (2002) also recognized the federal and regional encouragement to be a key factor in promoting university licensing productivity, in addition to other factors such as TTO size, the applied nature of science and university size.

Nerkar & Shane (2007) studied the likelihood of academic inventions to be commercialized, indicating that the scope, pioneering nature and age of technological inventions are preeminent attributes that enhance the appropriability of the returns to innovation. Kotha et al. (2013) presented the concept of science distance to represent the interdisciplinary research, as well as the coordination costs arising from technology

transfer.

Apart from the nature of inventions, involvement and coordination between stakeholders are also studied to analyze the organizational indicators in the transfer process. Agrawal (2005) concluded that the engagement of faculties, who are the factual inventors, has a positive correlation to the likelihood of successful licensing and latent knowledge transfer. Contrarily, Dechenaux et al. (2011) pointed out the inventor moral hazard, in which the firms are faced with risks of inventors not fully perform obligations. They proposed that this discouragement of involvement from inventors could be mitigated by employing milestones in contracts. Lai (2011) focused on the wiliness-to-engage by TTOs, which emphasized the incentives and capabilities are two primary motivators in successful university industry collaboration. Further, enterprises, as the recipient of university knowledge, have also been analyzed by Wang & Lu (2007). Four modes of university-industry interactions are discussed in different stage of UITT, which emphasize the close interaction between enterprises and universities helps to close the gap in knowledge transfer.

In the context of China's university knowledge transfer, many literatures are focused on examination of patenting activity and thus show a lack in deeper analysis. Li (2012) analyzed the institutional reason behind the surge of patents in China, i.e., the patent subsidy program implemented on province-level. Fisch et al (2014) also addressed the subsidy program and its impact on the patent quality. Novelli & Rao (2007) gave a descriptive analysis of patenting activity and licensing activity in Chinese universities. Dang (2015) uses number of nouns in claims to identify the scope of patent quality. Gao et al. (2013) added an analysis on collaboration situation in Chinese ICT sector, suggesting that U-I-R collaboration needs to be reinforced to utilize university innovation. Though there is an increasing trend in analysis of China university innovation, most of those literature still stay on the surface of patenting and licensing activities.

1.2 Purpose

Following Bozeman and Thursby, the purpose of this thesis is to examine the propensity of patent transfer in the setting of China, the selection of transfer forms, and the primary determinants of a patent transfer deal.

The study is intended to on one hand provide suggestions for universities to guide future work in reaching out to the firms; and on the other hand, for the firms, to provide information in choosing the right form of patent transfer, i.e., selling or licensing a patent.

1.3 Research Questions

To fulfil the purpose of this study, the following research questions are designed to investigate the viability and effectiveness of Chinese university patent transfer.

RQ1: How is the overall environment for university intellectual asset transfer in China?

The first research question is further divided into three parts: legal environment, institutional factors, and patent activity, as depicted in three sub questions. While legal environment and institutional factors explained the external circumstance, the patent activity centers on internal analysis of university research results. The first research question will be discussed by qualitative analysis, and sub questions include:

a) Is the current legal system in China supporting or holding up the transfer from university to industry?
b) Are there any hurdles caused by institutional factors?
c) What is the patent activity trend in Chinese universities?

RQ2: What is the propensity of a given patent to be successfully transferred from university to firm and the determinants in an effective university patent transfer?

This research question is based on a patent-level discussion on the probability of a university patent to be transferred. Four hypotheses are developed to investigate:

a) the timing of a university patent to be transferred, which is presumed to be affected by the uncertainty of patent right and patent lifespan in a patent transaction;
b) the effect of the generality nature of invention embodied in a patent on the likelihood of a patent to be transferred, further distinguished by patent licensing and patent selling;
c) the effect of the involvement of TTOs, which is presumed to be positively connected to the patent transfer by reducing coordination cost;
d) the effect of patent quality on the propensity of a patent to be licensed or sold.

RQ3: What considerations should a firm take into account before acquiring a university patent?

This research question will be approached by analyzing the enterprises' motivations to explore the various factors affecting a firm's decision on patent acquisition. An empirical analysis on the licensees/assignees of the patent transaction records will also be conducted to answer this research question.

1.4 Scope and delimitations

The focus of this project will be centered on the university patent transfer in China, and to be more specific, an analysis on the effectiveness of patent transfer and its determinants.

1. Transfer is limited to patent transfer. The author fully understands that in addition to patent, university spin-offs and collaboration research are also essential alternatives to commercialize university research outcomes, but will limit the scope of this topic to patent transfer;
2. Due to the lack of details on patent transfer contracts, the definition of a successful patent transfer is limited to a closed deal, taking no account of the transfer result in terms of economical benefits or collective social value;
3. The university patent transfer dataset comes from China, which may present characteristics that are not applicable in another country due to its specific setting.

1.5 Thesis Outline

Chapter 1 gave a short introduction on the background of the project and introduced the main thread that will be followed in the rest of this thesis, which is organized as

following:

In Chapter 2, a theoretical framework will be developed to provide as a guiding umbrella under which the methodology and methods will be chosen in order to answer the research questions. A discussion on the validity and reliability of the study will also be included in this part.

In Chapter 3, a qualitative analysis centered around three factors – the legal environment, the institutional structure and the patent quality will be presented to answer the first two research questions.

In Chapter 4, a quantitative analysis on the effectiveness of university patent transfer will be discussed in order to analyze the propensity of a patent to be transferred and its primary determinants.

In Chapter 5, a further analysis on firm-level consideration in patent acquisition is conducted to complement the results from a patent-level discussion in Chapter 4.

In Chapter 6, the key findings and suggested actions will be brought up based on the previous studies. Remarks on the future research will also be included.

2 Methodology and Theoretical Framework

In this chapter, the research design will be presented under which research methods and data are selected respectively to answer the research questions. Also, the theoretical framework will be derived to establish the fundamental basis upon which the research will be built. Finally, a reflection on the validity and reliability of the study will be discussed at the end of this part.

2.1 Overall Methodology

In order to explore the three research questions, this thesis takes a sequential qualitative-quantitative paradigm design to answer both the "what" and "why." According to Onwuegbuzie et al. (2009), such a design helps to overcome 'the limited transferability of findings from qualitative research as well as the initially mentioned hazards of the heuristics of common sense knowledge. By starting the research process with a qualitative study based on second source data, it is attempted to understand how do the legal environment, and the institutional process have laid the foundation for university patent transfer. In addition, an analysis of patent quality trend will also be conducted to help prepare the constructs for later quantitative research. Then, a positivism paradigm will be applied to investigate the statistical phenomena in university patent transfer, as well as the causal relationship among several potential variables with the socio-cultural knowledge gained in the previous qualitative research. Further, a case study will be elaborated to capture the essence of the choices of patent transfer based on the quantitative analysis. By drawing on statistical material about the determinants in university patent transfer, the minimum requirements for qualitative sampling could be easily captured, and may be well advised to downsize the research question and research domain (Bryman, 2001; Onwuegbuzie et al., 2009).

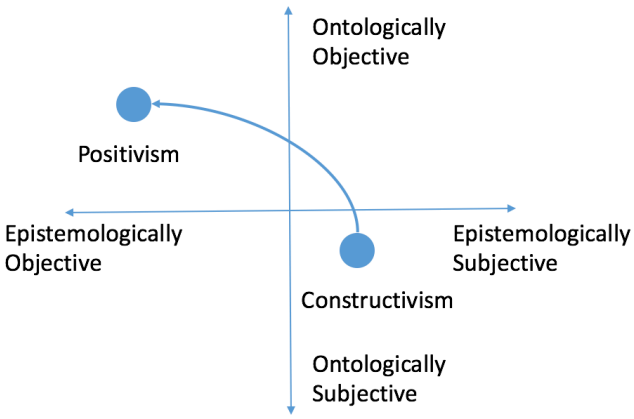


Figure 1 Research Paradigm

There are two reasons to apply a combined research paradigm. Firstly, because the patent transfer situation stays obscure in Chinese universities, it is necessary to use a qualitative analysis method to understand the external environment. One example of such complexity is the ownership of an academic patent, which may hinder or even eliminate the possibility of transfer if it stayed centrally controlled by the government. Therefore, it is important to look at the legal environment to understand whether this transfer from public research to the private sector is allowed or not (legitimacy/viability). Another example would be how the institutions in universities handle the patent transfer procedure will imply its effectiveness and thus incentives for firms if the process does not take long or require rigid scrutiny. On the other hand, after a general understanding of the status quo, an empirical study will help to analyze the internal relationship between the effectiveness of university patent transfer and its determinants based on statistical analysis. This statistical result, in return, will guide

the selection of a suitable case and avoid being focused on distant and marginal cases. Overall, these two complementary paradigms are expected to establish a well-rounded basis for analysis.

2.2 Theoretical Framework

In order to disentangle the issue of university patent transfer, three levels of theories are provided as the foundation for the research, which include assumptions based on the knowledge-based economy, intellectual property management in three areas, and the technology transfer. The following section will discuss the underlying assumptions of each theory and their relevance to the research topic. At the end of this section, a proposed model of the research process will be introduced to serve as the guidance for the entire study.

1) Knowledge-based Economy

Foray (2004) in his book "The Economics of Knowledge" described that the economy is transitioning from production-based to a knowledge-based one. In his perspective, this new economy is characterized by the properties of knowledge, which is non-excludable and non-rival. The blurring of the line between production and the use of knowledge, together with the demands of the mature technology market, imposed the necessity to discuss the knowledge transfer between both intro- and inter- organizations.

The trend of the knowledge-based economy is not only participated by developed countries, but also happens in latecomers such as China, which is making effort to shift from imitation to innovation. Universities, as one of the key innovation unit, are believed to play significant roles in contributing to the country's economic development (Hu et al., 2008). Luan et al. (2010) argued that in a knowledge-based economy, the university as a leading producer of new knowledge is increasingly prominent in regional innovation, social development and economic growth, as a key element of the "triple helix for innovation" with industry and government. When it comes to university-to-industry knowledge transfer, there are four research streams as identified by Agrawal (2001), which include firm characteristics, university characteristics, localized spillovers and the channels of knowledge transfer. This study will mostly focus patent-level and firm-level analysis.

In general, there exist several transfer pathways between universities and companies, such as know-how, patents, etc. As indicated by Foray (2004), in principle, the codification of knowledge can reduce the costs of knowledge acquisition, which leads to the prevalent use of patents as a media for knowledge transfer. Despite the criticism over the adverse effect of patents on hindering innovation, Cohendet (2009) argued that the patent system can help solve the coordination problems encountered by firms which emerge during search and exchange process of external knowledge. This positive side of patents in knowledge transfer is also exemplified by Chesbrough (2003) in his coined term "open innovation". As depicted in Fig 2, Chesbrough argues that the innovation process is no longer a closed one. By contrast, projects may enter or exit at various points and in various ways. For the technology sources, it is no longer necessary to start the research in-house, but instead, projects could be launched from external technology sources. In addition, technology may be commercialized in many ways as well, such as out-licensing or technology spin-offs. Under this new framework, patents played a dual role of not only increasing incentives to innovate but also facilitating coordination between inter-organizations to create markets for technologies. Therefore, it is

reasonable to view a patent as a critical instrument of technology transfer from the perspective of a knowledge-based economy.

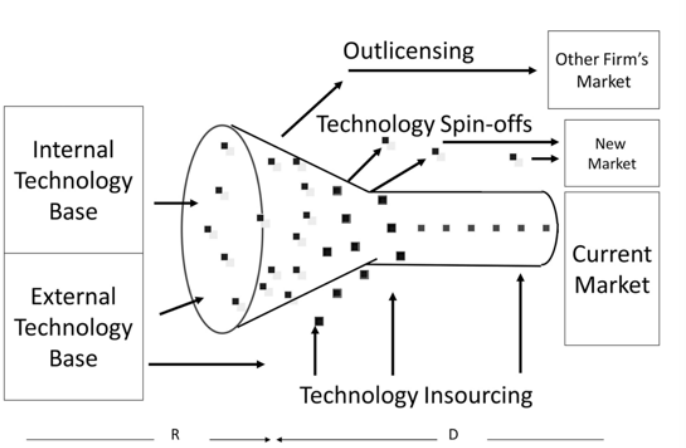


Figure 2 The open innovation model

2) Knowledge Assets Valuation

In order to analyze the patent transfer in the technology market, the first thing is to understand the dynamic nature of knowledge. According to Boisot et al. (1998), the flow of knowledge assets is dependent on two dimensions, which are codification and abstraction. The degree of codification can be measured by the amount of data processing needed to categorize the knowledge. According to Teece (1986), regarding the codification nature, there is a distinguish between the tacit versus codified nature of the knowledge base, where the more codified the knowledge base is, it holds more chances to be absorbed for excluding competitors or to be traded on technology markets. On the contrary, the more tacit the underlying knowledge is, it will be increasingly difficult to be transferred or exchanged. The codification of knowledge is further explained by Cohen and Levinthal (1989), who posited that the degree of spillovers and imitation depends on the nature of knowledge and the absorptive capacity of firms. All things being equal, the level of codification of knowledge has a positive effect on its absorption. Abstraction, on the other hand, describes the degree of association in technology. This could be interpreted as the simplicity versus complexity of the technology base. The more complex one technology is, it tends to include more components in its knowledge, and the less abstract it will be. In conclusion, on Boisot's framework, the simple premise is that structured knowledge flows more readily and extensively than unstructured knowledge.

Beside the nature of knowledge, the role of the patent also needs to be discussed to understand the incentives of patent transfer. Patents are used not only for defensive purposes but also offensive objectives (Cohendet et al., 2009). Further, the value of a patent is also dependent on its industry environment. As Kingston (2001) asserts, in complex sectors, firms tend to use patents defensively (to secure operating freedom) while in simple sectors they tend to use patents offensively (to exclude imitators). According to Somaya (2012), there are two main themes within patent strategy research, generic patent strategies, and the strategic patent managements. Generic patent strategies include proprietary, defensive, and leveraging strategies. Strategic patent managements, on the other hand broadly encompass issues relevant to implementation that follow from the generic strategies. Within the context of

university patent transfer, both topics are relevant and worth to be addressed comprehensively beforehand. In the domain of generic patent strategies, three concepts are developed, namely, leveraging, proprietary, and defensive strategies.

Proprietary strategy: This strategy of using patents originated from the conventional resource-based view to create competitive advantage from intellectual property, thus preventing the technology from being imitated. In this case, a patent fence is favorable to be built to cover a range of technical solutions, such as substitute and follow-on technologies (Granstrand, 1999). With this proprietary strategy, a rigorous and consistent management of patents is needed to maintain and reinforce the patent rights carefully. When necessary, the patent fence needs to be strengthened through the acquisition of interlocking and substitute patents from secondary market (Somaya, 2012).

Defensive strategy: Contrary to the active use of patents to exclusively exploit technologies, a defensive strategy is primarily developed to ensure freedom to operate and mitigate the risk of being held up by other patent owners. This is fundamentally caused by the essence of a patent only confers the right to exclude others, not right to use. Therefore, firms could be constrained from using their own technologies if they read on other owners' patents. Unlike proprietary strategy which relies on core patents to guarantee the use of technology, defensive patent strategy typically requires a strategic patenting portfolio and preemption. For instance, one viable approach is to obtain ex-ante licenses to related patents.

Leveraging strategy: Compared to the previous two strategies, the leveraging strategy is a more proactive way to capture value out of patents by patent licensing. A typical example of context for this approach is the cross-licensing of patent portfolio where patents are viewed as valuable tools for providing more bargaining power during negotiation. According to Somaya (2012), because the end goal of the leveraging strategy is to create value from patents, there is no need to create as watertight a patent protection as in the proprietary strategy.

The patent strategy will be reflected on a micro-management level to the decisions on patent management. The activity in patent transfer takes two primary forms: acquiring and maintaining patent rights, and licensing of patents. The patent acquisition could take in the form of granted patent right reassigning and patent application right transfer. The acquisition of patents may help create patent fences, which is intended as a proprietary strategy to impede imitation, or patent thickets, which will be used as a bargaining chip in cross-licensing negotiations as a defensive strategy (Reitzig, 2014). Patent licensing, depending on the terms of licensing contract, may be exclusive licensing or general licensing in relevant to the exclusivity and scope of the licensed rights (Annan & Khanna, 2000).

Based on the previous argumentation, the propensity of university patent transfer could be researched from two angels. The first is based on a patent-level to understand how the nature of technology, the patent quality, and coordination cost will effect the likelihood of a university patent to be transferred. It will be further distinguished in terms of transfer form of being acquired or licensed. The second perspective is to observe from firms' lens to illustrate the motivations in obtaining patents in relation to the generic patent strategy as discussed before. This firm-level strategic motives will help strength the prediction of specific characteristics of patents that will stand higher

possibility to be transferred.

3) Understand Patent Transfer in Three Arenas

Patent as a social construct has rooted its fundaments in three arenas – judicial, administrative and business (Petrusson, 2004). Knowledge transfer using patent as a media, therefore, should also follow this framework. First, the patent transfer is submissive to the legal requirement to claim for a patent right, which consists of laws and policies to not only facilitate but also regulate the transfer activities with formalistic procedures. Because the patent transfer is connected with the shift over ownership and right to use, it is vital to understand the legal system beforehand. Second, the transfer process involves multiple parties and lengthy procedure; the administrative setup is also proved to be an important supportive platform. TTO as a prominent actor in the process, together with its influence on patent transfer from university to private sectors, has been studied by a significant amount of literature (Nelson & Byers, 2010; Crespi, 2010; Elfenbein, 2007). Third, the value of patents need to be put in a business context, as its ultimate purpose is to serve the business development. Therefore, the analysis of patent transfer should not be a standalone study without incorporating a business perspective. Following this logic, this thesis will discuss from these three arenas to shine a light on the current situation of Chinese university patent transfer, the effectiveness, and its determinants.

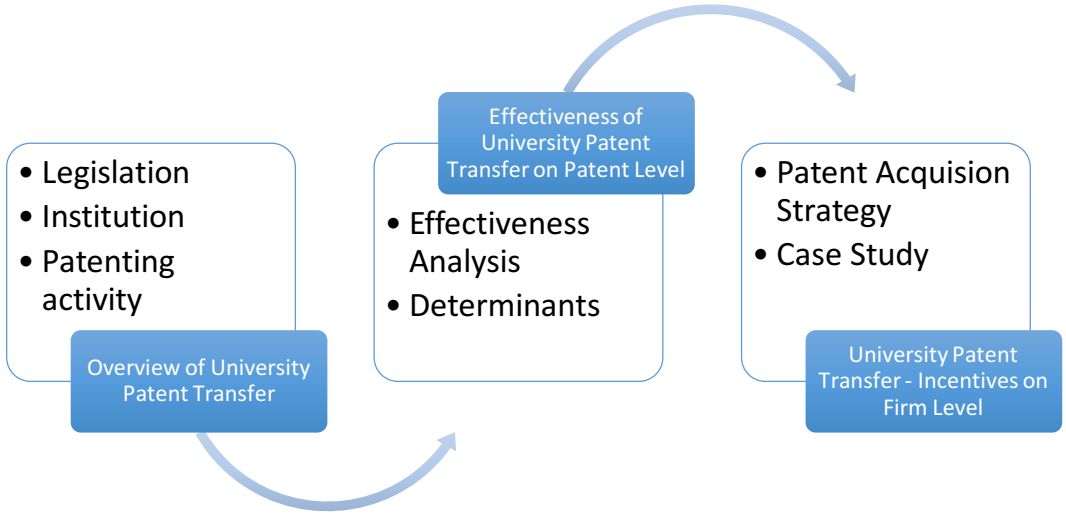


Figure 3 Theoretical Framework

Fig 3 depicts the workflow of this project, which starts from an overview of the university patent transfer.

Table 1 Research Design

Research Topic	**Hypotheses**	**Research Paradigm**	**Research Methods**
Overview of University Patent Transfer	a. The legal system in China plays a positive role in promoting university patent transfer b. The TTO institution is trending in actively involved in patent transfer	Positivism	Secondary data collection Interviews Data Analysis

	c. The university patent activity is increasingly becoming active		
Effectiveness of University Patent Transfer on Patent Level	a. The effectiveness of university patent transfer is related to patent quality b. Nature of technology is the second determinant c. The TTO environment is the third determinant	Positivism	Quantitative Analysis
University Patent Transfer – Incentives on Firm Level	a. Firms' decision on acquisition of university patents depending on its patent strategy b. An effective decision-making procedure needs to be developed based on the previous findings	Constructivism	Interviews Case Study

2.3 Data Collection

Secondary Data: Secondary data has mostly gathered during the research on legal environment and institutional structure. The data source includes laws, policies, reports, and journal articles. Because the ownership of university patents used to be assigned to government, secondary data on the revision of the patent law, latest legislation on university technology transfer and other policies are collected to clarify the viability of university patent transfer. Besides, the government patent subsidy program also has implications for the university patent quality. For the institutional structure on university technology transfer, data is also compiled from university's official websites to show the institutional policy and its governing offices with regards to patent transfer.

Interviews: Interviews are conducted as a prominent approach to comprehend the underlying situation and reasons for university patent transfer. The interviews were held with TTO officers, inventors, and firm representatives in a semi-structured way. The goal is to simultaneously getting answers for specific questions and discovering opinions on the questions in the matter from different perspectives. In total, around ten interviews were conducted to form a comprehensive view by gathering different parties' insights.

Patent Database: A database for Chinese patents is utilized to extract university patent information. Overall, patents of 51 top Chinese universities that were filed from 2005 to 2015 are integrated to form the original data set. For each patent record, a set of general information, such as inventors, owners, IPC codes, and so on are listed. In addition to those fundamental registration information, for each patent that has been transferred through licensing or reassigning, information such as licensees/assignees, date of assignment etc., is also accessible. This patent database is primarily applied for the quantitative analysis in Chapter 4. However, in Chapter 3 where the quality of university patents is analyzed, this database has also been used for exploring the patenting trend in Chinese universities, thus giving a brief idea of how the quality has changed along with the legal set up.

Case Study: The cases were selected from typical examples from university patent transfer records to exemplify the results from quantitative analysis and provide additional thoughts on improving the transfer process.

2.4 Validity and Reliability

Validity is used to indicate whether a research accurately measures research subjects and gives resilient answers. For the quantitative part of research, the validity of results is examined by p values. For the qualitative part of research, trustworthiness instead of validity is more applicable, which could be reinforced by well-designed research questions and investigation process. In this study, opinions from different parties are collected to complement with each other and avoid biases.

Reliability refers to the resilience of investigation results which present some degree of generality in a broader scope. The reliability of this project is guaranteed by incorporating multiple stakeholders' points of view. The combination of quantitative and qualitative analysis is also helpful in forming a comprehensive picture while keeping the underlying reasons in place.

The chapter described the methodology, consisting of theoretical framework, literature and research design. The resulting theoretical framework will form the basis for the empirical study.

3 Overview of Chinese University Patent Transfer

This chapter is aimed to explore the external environment where Chinese universities lie in as well as the patent activity trend in universities. Through analysis, the following sections are attempted to answer three sub-questions:

- *Sub Question 1:* Is the current legal system in China supporting or holding up the transfer from university to industry?
- *Sub Question 2:* Are there any hurdles caused by institutional factors?
- *Sub Question 3:* What is the patent activity trend in Chinese universities?

3.1 Policies and Municipal laws on UITT

3.1.1 University in national innovation system

The notion of national innovation system in China was coined along with the establishment of patent law in 1985. Around 35% of the R&D expenditure in universities comes from industrial partners, thus making universities an important force of innovation in China. It has also witnessed several attempts guided by the government to commercialize the resulted technologies from university research. Since 1990, there was a trend in university-founded enterprises. However, due to the poor management skills and central administration procedure, most of these academic research enterprises did not make significant achievements and had been gradually closed (Hong, 2008). In parallel to the Bayle-Dole Act introduced in the United States in the 1980s, the Chinese government also set up the technology transfer law, according to which, the ownership of patents generated from university research funded by the government no longer belongs to the government, but instead is assigned to each university. These changes emphasized the primary role of universities in innovation whereas industrial firms take responsibilities to commercialize these innovations.

3.1.2 Policies and Municipal laws

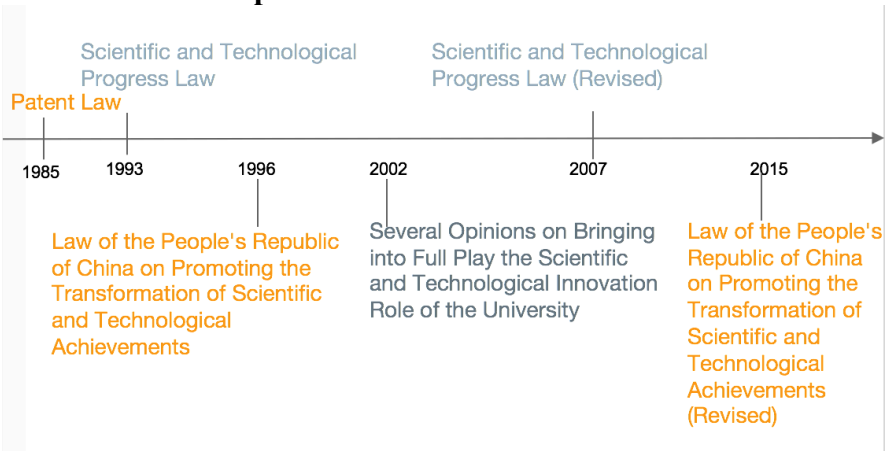


Figure 4 Evolvement of Legal Environment

Patent Law: The national innovation system in China dates back to the year of 1985 when the first legislation related to patent came into force. The first Patent Law was considerably "European", but it has gone through three times of amendments to keep in aligning with international norms. In April 2015, a new round of revision of the Patent Law was initiated with a focus on improving patent quality, enhancing patent right enforcement, increasing patent protection, and promoting patent operation. This

revision escalates the duty for each administration government offices to promote the exercise and functioning of patents to a legal obligation. It signals a strong willing from top to bottom to change the situation of low utilization of patents. Furthermore, with respect to research outcomes from national-funded research institutes and high education institutions, inventors are expected to have more freedom to practice their own patents. They also expect to have claims on the generated profits from within. This encouraging measure is to prevent the reluctance of the administrated universities or research institutes in practicing the service inventions created by the employees. Moreover, to address the problem of information asymmetry between patent owners and potential licensees, an open patent licensing mechanism is suggested in the fourth amendment. Under this suggestion, inventors may add an open licensing tab to their patents so that anyone is entitled to practice the patent with a pre-agreed license. In this way, it is expected to reduce the cost of patent licensing (Lin et al., 2004).

Three Modes of a Patent Transfer: A transfer refers to the activity where the owner of a patent conveys his exclusive right to an external shareholder. Compared to technology consultancy or contract research, a patent transfer is an afterward trade which conveys the exchange of knowledge but also in most cases requires subsequent technological support for the recipients to absorb the technology covered in the patent. A patent transfer encompasses multiple modes, including patent right assignment, assignment of the right to apply for patents and license of patent exploitation.

Patent Subsidy Program: Since 1999, the Chinese government has adopted the patent subsidy policy to encourage the patent applications both domestically and abroad. By the end of 2007, the municipal governments in nearly 30 provinces have established special funds to subsidize costs and fees usually incurred during patent application, substantial examination, and maintenance (Li, 2012). The budget available for patent subsidies is frequently redeemed in two ways, which are reimbursement for actual costs or a fixed amount of compensation for filing a patent application respectively. The compensation for a domestic patent is around 2000~3000 RMB, while an international patent filing may receive from 8000 RMB up to 25,000 RMB reimbursement. Due to this large reimbursement for patent filing, the patent subsidy program has attributed to the surge of patent filing in China. However, because there is no requirement on patent quality, many scholars also argue that the patent subsidy program has to a large extent contributed to the averagely low quality of Chinese patents (Fisch et al., 2014). A more detailed analysis related to the patent quality will be conducted in the subsequent sections (Li, 2012).

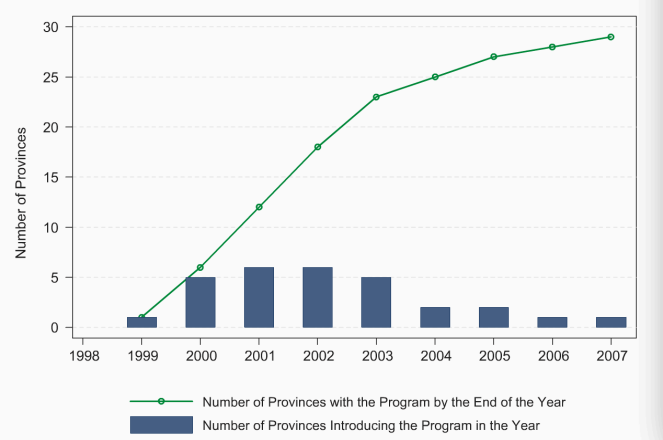


Figure 5 Patent Subsidy Program Trend (Li, 2012)

The Law for Promoting Science and Technology Achievements: The Bayh-Dole Act of 1980 is often considered as a landmark in the university patenting (Leydesdorff etc., 2009). Its presumed effect on university technology transfer has encouraged other countries to introduce similar regulations. In China, the Scientific and Technological Progress Law was first issued as in March 2007, and the latest update was published in late 2015. Under this law, the project administrators, such as scientific institutions, universities or enterprises, who undertake a project are entitled to implement the patent or transfer or license the intellectual property with the corresponding intellectual property ownership in hand. However, there is an additional clause on service invention. Service inventions are inventions created by employees. The ownership of service invention belongs to the employer, but the employee inventor will have the right of first refusal if the patent is going to be transferred to an external party for practice. Under this law, all the inventions created as an outcome of research projects which are conducted by researchers in universities will be owned by universities. However, the inventors will have the priority to transfer the inventions under their names if needed. In aligning with Regulations on the Administration of Technology Import and Export issued by the Department of Commerce, it is preferred to transfer patents to domestic firms and transfer to foreign companies needs to be in conformity with regulations on technology exportation.

In conclusion, the Chinese government encourages and supports the technology transfer from universities to industrial applications based on several policies and laws. However, there is also argumentation around whether the overall practical effect of these measurements is positive or negative. Also, because of the encouragement of domestic transfer, the situation stays obscure for foreign companies who would like to license in or buy patents from Chinese universities, as they may face strict regulatory scrutiny before closing a deal of technology transfer.

3.2 Institutional Organization

3.2.1 Different forms of technology transfer

There are different forms when it comes to technology transfer. Except for the conventional model, other transfer approaches include incubator, technology transfer platform, and university start-up. Table. 2 describes the difference among various technology transfer forms. Patent transfer is mostly handled by TTOs in a technology platform. As of today, the main problem in technology transfer platform lies in a lack

of unambiguous mechanism for profit sharing.

Table 2 Comparison of Technology Transfer

Classification	Model	Disadvantage in Legal Environment
Conventional Model	Technology Transformation	Lack of legislation and policy guidance
Technology Incubator	University Science Park	Ambiguous legal norms
	National Engineering Center	Not officially recognized as corporate
	Provincial Institute	Policy-oriented with weak legal identity
	University-Industry R&D Collaboration	Lack of legislation and policy guidance
Technology Transfer Platform	College and enterprise cooperation committee	Not an independent legal person
	Industry-University-Research Cooperation Office	Not an independent legal person
	Technology Transfer Office	Lack of explicit profit sharing mechanism
Technology Entrepreneurship	High-tech Enterprises affiliated with University	Absence of legislation and policy guidance

3.2.2 Institution organization for technology transfer

Before the introduction of technology transfer law, the science and technology department in universities used to hold the responsibility to administrate the patent transfer. However, with the increase in awareness of commercializing the technologies, many universities have set up a particular office to manage the intellectual property. One prevalent form is called the university-industry collaboration committee, in which a member mechanism is held for private firms to create opportunities for further collaboration. This committee mostly aims at establishing bonds between universities and corporations from a high level while leaving the practical management of cooperation to other managerial offices. Besides, companies taking part in such a committee normally have specific technical problems in need to be solved and therefore focus on collaboration in research and development phase. Similar to the U-I committee, another form of office is Enterprise-University-Research Institute Cooperation Office, a cooperation platform between local government and university. Different from the U-I collaboration board, the collaboration office is mostly related to commercializing technologies with high readiness. Many Chinese universities have established technology transfer offices to further promote the commercialization of technologies. These technology transfer offices go one step further compared to U-I committee regarding marketing technologies. In most cases they are one department designated by universities to concentrate on filtering market-ready technologies and promoting industrial applications.

3.2.3 Technology transfer process

This section is intended to identify key issues in the knowledge transfer from university to firms. Siegel (2004) presented a generally linear flow model of university-industry technology transfer regarding how technologies are transferred. As shown in Fig. 6, the process consists of three phases all the way from invention disclosure to patenting and

to marketing. The process often the time starts with a research result developed in a university laboratory. Under the Bayh-Dole Act in the US, researchers are obliged to disclose their discovery to TTOs. However, in the Chinese universities, the invention disclosure is not compulsory, which leaves freedom for researchers to decide whether to reveal or not. Chang (2015) studied the incentives for researchers to disclose inventions, which are closely connected to the financial resources and market potential of the technology. There has also been criticism over the low rate of disclosure and patenting as a private asset in Chinese universities (Li, 2012), which impedes the process of university technology transfer. However, according to interviews with the university officers, though it is inevitable to see some researchers privately claims right on the public-funded research results, it remains very uncommon cases.

During the evaluation for patenting, TTOs are responsible for making a judgment over the commercialization potential and deciding whether to patent or not based on such analysis. In the case of US universities, this is a substantial decision, for budgets usually are constrained by universities for filing patents. However, there is a different scenario in the setting of Chinese universities. First, TTOs are not involved in the decision making of patenting. Though there are some exceptions where TTOs have professional patent agencies that can provide consultancy for researchers, it remains the researchers' right to file a patent. Second, because of the patent subsidy granted by government, the expense of filing and maintaining a patent is diminished, which renders researchers motivated to apply for patents regardless of their future payback potential. The researchers also face the choice over domestic patent protection versus global protection. While domestic patent protection comes at a much lower cost, a global patent will generate more values with a broader geographical coverage.

In the marketing phase, inputs from TTOs and researchers are utilized to identify the potential licensees or assignees. A new trend in Chinese universities is the online marketplace where patents are listed for the public to view. Interested companies will then have easier access to the latest technology outcomes. These online marketplaces are similar to patent brokers such as Innocentive, Yet2.com and Ocean Tomo mentioned by Cohendet (2009) which are positioned to assist in diffusing new information and communicating technologies. However, it has also been found that the Chinese university patent online marketplaces are in short of functions such as valuation, auditing and diagnostic tests of technologies. After a firm reaching out to university for a patent, the negotiation process is executed to structure a deal. The TTOs have policies regulating a lower boundary on the licensing income of the contract, but the actual number of royalties are left for discussion between researchers and firms. Since the patent transfer is more than a mere property transfer, it may need more involvement of scientists in its commercialization process to transfer the knowledge and know-how associated with the patent.

There are several implications from the above analysis. Based on Siegel's workflow, several conclusions could be drawn for the current situation of Chinese universities. Firstly, the low awareness to participate early in planning the patenting activity is presumed to be the main issue. Currently, TTOs are mostly engaged in later phases of marketing and negotiation and provide little guidance for researchers on how to patent. This problem may lead to low-quality patents, which has been blamed for long. Secondly, the motive for TTOs to gear up the university patent transfer is increasing, as the latest revision of The Law for Promoting Science and Technology Achievements

has guaranteed that the TTO officers will have a right to claim for a portion of royalties as a service fee. Some researchers proposed that the nature of the competition among universities will affect the incentives of patenting (Leydesdorff and Sun 2009; Persson et al. 2004). For example, if international collaborations and co-authorships are more important in the university ranking system whereas patent or spin-offs are not included in the ranking, the motivation to emphasize patents and patent transfer will be deteriorated. In the case of Chinese universities, patents are listed in the assessment of researchers' achievements and counted as project result. Therefore, the incentives for patenting and patent transfer remain high for all the stakeholders in universities. Thirdly, we have witnessed a catching up in the building of online marketplace. However, most of these university patent market remains as a single catalog of patents, without a professional assessment of the technologies, the potential application industries, and other business oriented information. Therefore, though these marketplaces help circulate patent information, they need more efforts in presenting the listed patents in an attractive way to the firms and thus increasing the chances of patent transfer.

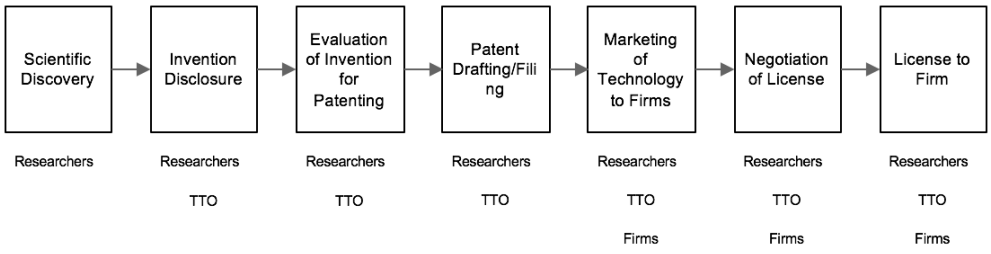


Figure 6 Technology Transfer Process and Stakeholders

3.3 Patenting activity

In this part, we assess the development of Chinese university patenting in terms of patent quantity and quality from the year 2005 to 2015. The objective is to analyze the exploratory and descriptive nature of Chinese university patents. Fisch (2014) gave a distribution of university patents from 1991 to 2009 and used forward citations as a proxy for patent quality. He found that the university patents had witnessed rapid growth in terms of quantity while patent quality did not increase to a similar degree. In this project, we extended Fisch's work by studying the patents from the top 51 universities. Though forward citations and number of claims have been applied in many literatures as an indicator for patent quality, we also included the validity of patents and the PCT patents to analyze the patent quality. According to Svensson (2007), patents with a higher quality stand higher chances to be renewed and be maintained carefully. On the contrary, patents with low quality have a relatively less life span, either being rejected by patent examiners or being abandoned by their owners. PCT patent, on the other hand, costs much more to register, which are normally assumed to be more valuable (Li, 2012).

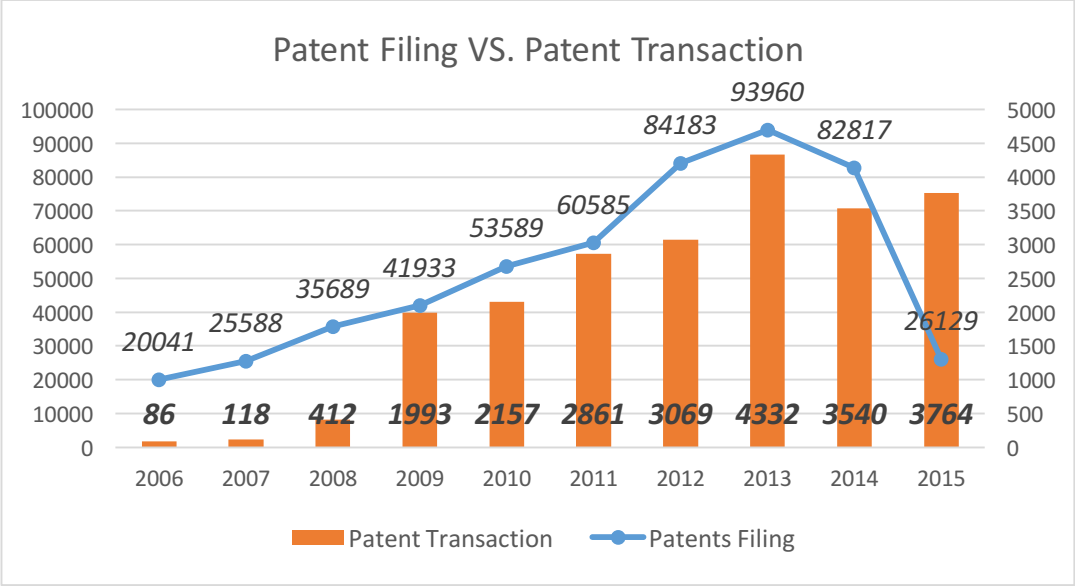


Figure 7 Patent Filing vs. Patent Transfer

Fig. 7 shows the patent filing and patent transfer trend of universities in China. Data is extracted from top 51 universities. There is a boosting of both patenting and patent transactions in the universities over the past ten years. However, a turbulence in recent years has also been witnessed in patent transactions. The average percentage of patents that have been transferred is around 5%. Admittedly, the transfer rate differs across the types of technology, patent quality, and other factors. The analysis of the principal factors of university patent transfer will be covered in Chapter 4 and this section only gives a descriptive statistical analysis to provide a preliminary overview of the university patenting activities.

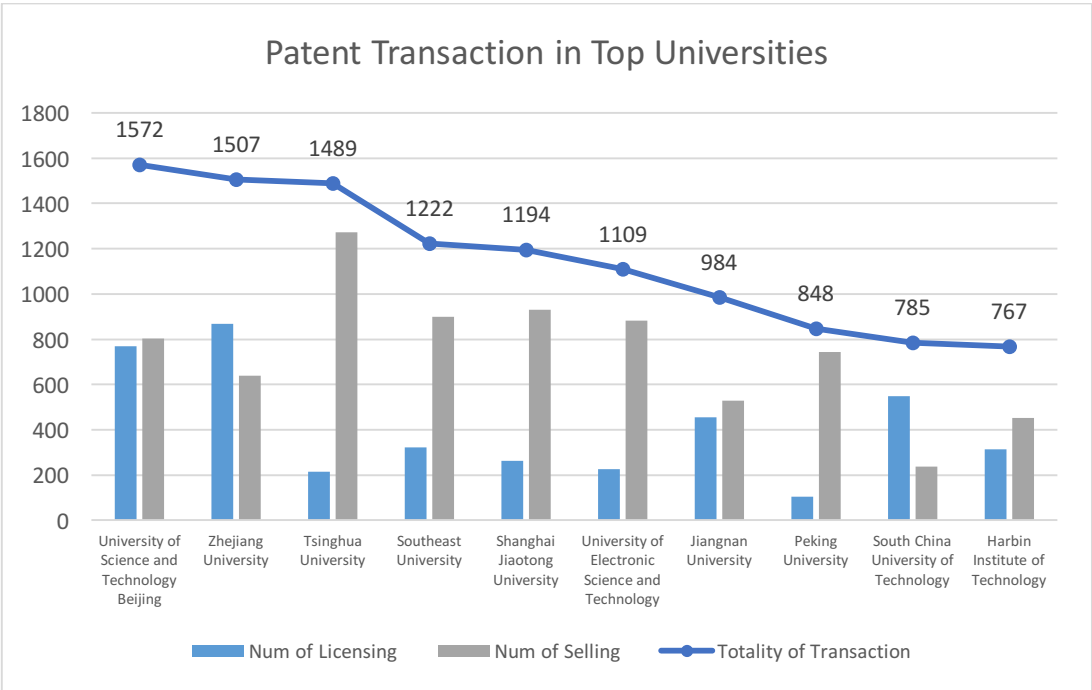


Figure 8 Patent Transaction in Top Universities

Given the increasing trend in university patent filing, the percentage of university patents out of all Chinese patents is decreasing from 7% in 2007 to less than 5% in 2014. However, compared to the 2% of US universities (Love, 2013), it could be inferred that Chinese university patenting is a major component of the Chinese portfolio, which is partly caused by the division of labor between universities and industry. However, the decline also indicates the research concentration is slightly shifting from universities to industry.

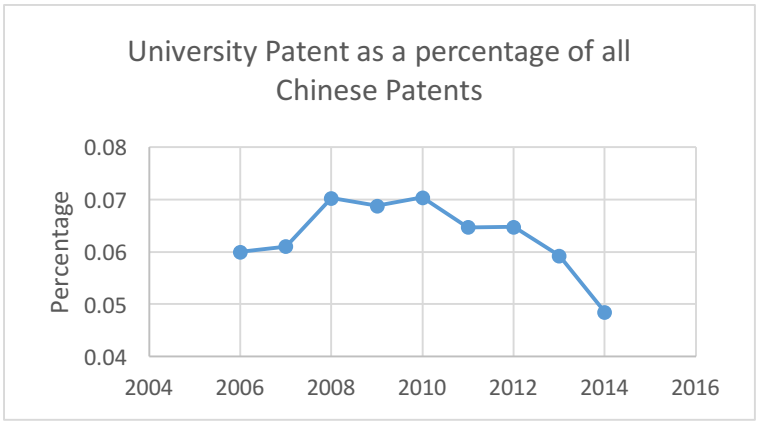


Figure 9 University Patents Percentage

Second, the PCT patent only consist a small proportion of patents, on average only around 1% of all the 51 universities' patents have an international protection. This percentage stays similar in all the Chinese patents, which indicates that university patents do not show a distinctive advantage nor disadvantage regarding PCT patent protection. However, this situation might be improving recently. According to Leydesdorff et al. (2013), among all the assignee countries China accounts for more than 4 % of the university patents at the USPTO in 2012, as against only 1.8 % in 2007.

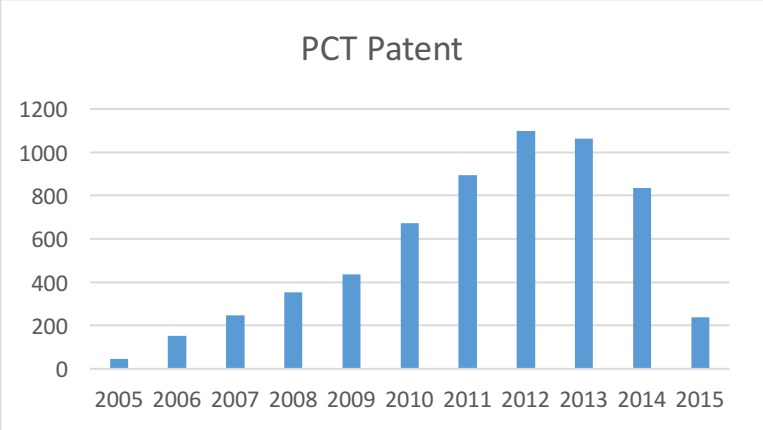


Figure 10 PCT Patent Trend

In addition to the PCT applications, the patent validity is also analyzed to describe the changes in patent quality. In Fig. 11, the patents are categorized by their first public date, and for patents publicized in the same year, the status of validity is summarized. Taking the year 2005 as an example, in total 6983 patents went public this year, among which 4589 patents are invalid on the date of research (Jan

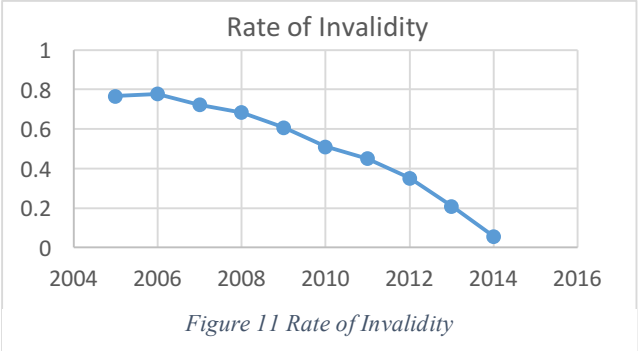


Figure 11 Rate of Invalidity

1st, 2016) and 1393 patents remain active to the time of the investigation. Usually, the probability of a patent of becoming invalid will increase with time moving. From an overall statistical perspective, given the patent quality stays at the same level, the percentage of patents went invalid should decrease proportionally to the time axis. However, from Fig. 11, we found that the decreasing speed of the rate of invalidity turns out to be slower in recent years. Thus, from the ratio of invalidity of university patents, it could be interpreted that the patent quality is increasing in terms of the lifespan. Fig. 12 further divided the validity status of patent into inactive, pending, and active.

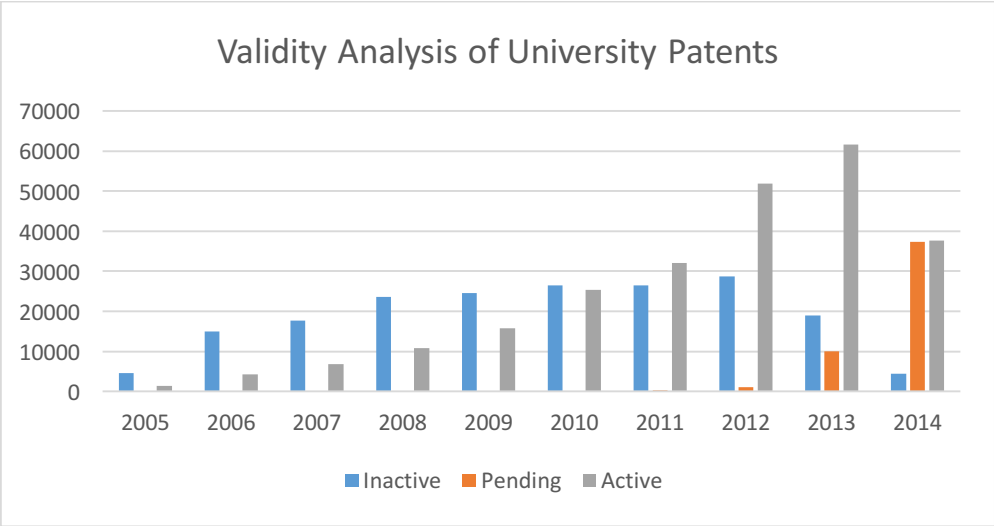


Figure 12 Validity Analysis of University Patents

3.4 Discussion

Based on the three arenas' analysis of intellectual property management by Petrusson (2004), this chapter mainly examined the legal environment and institutional structure to answer the three research questions listed at the beginning of this chapter. The answer to the first question is that the legal system in China plays a very positive role in patent transfer. There are constant changes undergoing to loosen the legal requirement with relation to the ownership and the right of disposition to fasten the efficiency of patent transfer. With regards to the institutions such as TTOs, though many efforts have been made to facilitate the university patent transfer, a lack of professionals and expertise has also been identified, which needs to be improved towards a business-oriented approach to managing and marketing university patents. Besides, both the patent filing and patent transfer activities have been increasing over recent years. Though there are lots of criticism over the low patent quality from China, a descriptive analysis of patent quality based on patent invalidity rate has shown an improvement trend in patent quality filed by Chinese universities.

4 Effectiveness of Chinese University Patent Transfer

Based on the previous discussion around the legal and administrative environment, together with an analysis of the trend in university patent quality, this chapter will focus on the effectiveness of Chinese university patent transfer. Through analyzing a university patent database, this chapter investigates the effectiveness of Chinese university patent transfer and its determinants. The timing of university patents to be transferred is explained in relation to the effect of uncertainty of patent right and patent lifespan on a patent transaction. This is followed by a quantitative analysis of the determinants of patent transaction, and a comparison of licensing and selling patent. This chapter is mostly focused on patent level to examine the factors that affect the propensity of a patent to be licensed or reassigned from university to the private sector.

The rest parts of this chapter are organized as follows: After an introduction and literature review, hypotheses will be developed based on knowledge-based economy theory and organization theory. The next section will describe the definition of variables, data set collection, and data analysis method for the empirical study. The regression results will be analyzed to understand how the propensity changes over time and the factors that affect the patent transfer and differences in patent transfer forms. Finally, there will a discussion around the results and conclusions.

4.1 Introduction & Literature Review

The university patent transfer has previously been studied from different angles. In general, there are three primary chains of literature. The first is characterized in developing an efficient framework for knowledge transfer from university to industry, where Siegel (2004) and Bozeman (2000; 2015) have both presented representative models for the understanding of effectiveness in university technology transfer. A second perspective starts from a more practical point by analyzing the choice of licensing management, as well as incentives of different stakeholders. Thursby (2001) discussed the objectives, characteristics, and outcomes of university licensing based on a US university database. The third division begins with a micro management point of view to investigate the propensity of a university patent to be transferred. In this vein, scholars such as Gambardella (2007; 2008) and Arora (2006;2011) took factors like quality of patent, economic value, and technology nature and so on into consideration, and analyzed the likelihood of technology transfer based on the patent level. In this project, the previous two chapters have conducted a qualitative analysis based on the understanding of the first two chains of literature. This chapter will follow the third perspective and focus on the university patent transfer in the setting of Chinese universities.

While there are already previous studies concentrating on Chinese university technology transfer, most of them stayed on the aspect of the patenting activity. Hong (2008) studied the knowledge diffusion process and the geographic variations in university-industry collaborations. His result showed a decentralizing trend in knowledge flows from university to industry, suggesting that the geographic constraints on knowledge exchange are becoming salient in China. Li (2012) explained the patent subsidy programs taking place at the province-level has induced an increase in patent propensity, but it did not reduce the patent quality unless the criteria used for patent examination have been lowered. This conclusion is also acknowledged by Fisch (2014)

who showed that university patents witnessed rapid growth regarding quantity while patent quality failed to keep a similar pace of improvement. Fisch also compared the effects of the subsidy program and other innovation policies that were aimed to stimulate R&D excellence and proved the former one less effective on increasing patent quality. Fong et al. (2015), through analyzing patent assignment, revealed that Chinese faculty prefers to assign high-quality patents to non-university assignees, and further provided insights on university licensing policies. Luan et al. (2010) proved a global increase in Chinese academic patents, but the rate of utilization of Chinese academic patents remains weak. The reasons were attributed to the encourage of quantity instead of quality, the university technology transfer mechanism, industry's constrained capacity to absorb and a mismatch between industry expectation and academic research. Although these scholars have discussed the university patents and expressed concerns over the low average level of quality, there is no explicit analysis on the drivers in promoting patent transfer. Through utilizing a large amount of data set, this project is intended to complement an internal analysis of the determinants on patent transfer.

A unique characteristic of Chinese universities lies in that the establishment of TTOs has a relatively short history. Historically, it is the S&T division that acts as an administrative office with regards to patent management. Apart from the patent management, many other activities that are related to research management also fall into the scope of responsibilities of S&T division, which inevitably causes excessive workload for the officers (Cao et al., 2009). However, with the advent of TTOs, this drawback in insufficient resources allocated to IP management is to some extent offset because TTOs are positioned as promoting the commercialization of research outcomes. However, there are also arguments on the negative impact of TTOs primarily caused by its mechanism inefficiency, which is reflected in the lack of professionals and rigid procedures over contract management. In this project, the function of TTO is examined to clarify whether it brings more benefits or disadvantages in the respect of the patent transfer.

Another feature that sets this project apart from previous studies is that the transaction mode is examined more carefully, whereas most of the previous literature only focused on the comparison between licensing and other ways of commercializing research results. Little is known about the difference between patent licensing and patent selling in the market for technology. Some exceptions differentiated the transaction types. Caviggioli (2010;2012;2013) investigated the primary drivers of companies' patent transaction decisions, including strategic, monetary, managerial, patent specific and transaction cost. Through qualitative analysis, Caviggioli filled in the gap of understanding the determinants of licensing and selling from a firm's perspective. This provides a comprehensive overview of those individual factors that are assigned to the choice of companies' decision on the patent transaction. Jeong & Lee (2015) applied an empirical study to analyze the determinants of the decision on whether to license out or to sell. His work focused on the transaction cost, the same as proposed in Caviggioli's work, which indicates that low transaction cost makes licensing a patent more appealing. Contrarily, in the case of high transaction cost, a patent is more likely to be sold. To add on to the previous study, we contributed with a quantitative examination on the patent level and focused on analyzing the determinants of academic patent transfer.

In summary, this chapter first discusses the propensity of Chinese university patent transfer. Secondly, it is attempted to distinguish different motivations for the choice of

patent commercialization. Based on the quantitative results, recommendations will be given to improving the effectiveness of university patent transfer.

4.2 Hypotheses

As discussed before, the patent transfer is more than a mere transition of ownership or right to use. Instead, it involves a more complicated process of knowledge diffusion and technology absorption. Gans (2008;2010) proposed that there are several factors to explain the deviations from the socially optimal timing of technology transfer, including search costs, asymmetry of information, and uncertain property rights. In the market for technology, the imperfection of information may cause more practical problems compared to traditional markets as the buyers, i.e. licensees or assignees, are put in a disadvantageous position with limited access to the actual value of a patent. This imperfection of information is presented in several forms. Firstly, a patent is under high uncertainty during the application process where its scope of protection and grant possibility remain obscure until its grant. During the patent examination process, there will be several rounds of negotiations between patent applicants and the patent examiner with regards to the novelty and inventive step, as well as patent claims (Cohen and Merrill 2003). The scope of a patent might be narrowed down by a change in the wording of claims, and in many cases, a patent application may be rejected due to lack of novelty or inventive step. Patent licensing will be speeded up by the increase along with the clarification and confirmation of the scope of intellectual property (specifically, a description of the claims granted to a patent). The legal transformation from a patent application to an issued patent could increase the economic value to the patent holder, regardless of the underlying technology remaining the same. Secondly, even after it being granted, a patent may still face the risk of being invalidated. Gans (2008) posits that the uncertainty in the post-grant phase is fundamentally different from the previous one in the pre-grant period. The former risk is mostly caused asymmetry between owners and licensors/buyers regarding office action records, whereas the latter is an exogenous one initiated by a third party in a litigation case. Therefore, from the perspective of patent uncertainty, because the information asymmetry between patent owners and licensors are gradually eliminated, the propensity of a patent to be transferred will increase over time. On the other hand, as argued by Jeong (2015) the patent owners are exposed to the risk of being invented around during the negotiation process with the potential buyer. Therefore, for the licensors, it is beneficial to seal a deal earlier regardless of the uncertainty in the initial stage of a patent life.

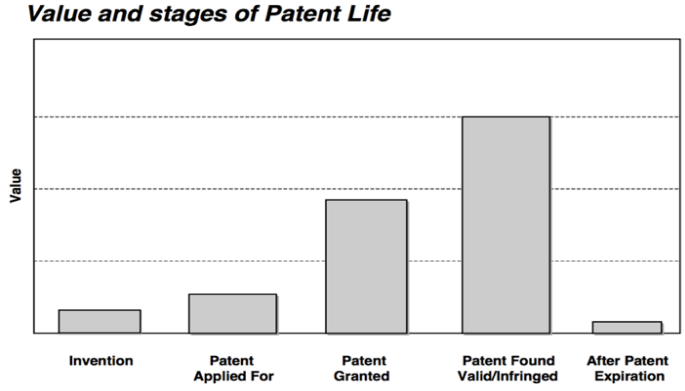


Figure 13 Value and Stages of Patent Life (Sherry, 2004)

Apart from the uncertainty underlying in patent right, the value of a patent will change in the market for technology. Sherry (2004) depicted the value of a patent within different stages of patent life as in Fig. 13. However, this is a valuation primarily based on the legal right of a patent. The time variant factor of market value is proven to be more crucial for patents that will be commercialized and implemented for product development. For one thing, it will require the knowledge of inventors to help the buyers to assimilate and implement the technology described in the patent, which poses uncertainty for the buyers to get prompt support from the inventors. The potential benefits of a patent to be commercialized by a firm will decline as the life span of a patent shortening (Grabowski and Vernon, 1984). Also, the market value of a patent depends on the commercialization opportunities. As Callon (1999) explained, there are emerging and stabilized phases of innovation. During the emerging stage, the knowledge is mostly tacit while in a stabilized phase knowledge become more codified and the market gets mature. With the transition from arising phase to stabilized phase, patents gain importance as they will be utilized for exclusivity. Callon's theory is focused on the development curve of innovation, which provides a perspective of how the relationship between the readiliness of a disruptive technology and the value of patents will evolve over time. For a particular patent, we argue that the market value of patent will decrease along with the increase of competition in the market for technology. Agarwal and Gort (2001) made a point that as an invention existing for a long time, there is an increasing chance that substitutes for this invention will emerge and thus the value of it will be depreciated. Allain (2015) centered on the licensing activities in pharmaceutical industry and discovered the relationship between the competition and the time of licensing. His results found that an increase in the number of potential buyers has a positive effect on promoting technology licensing. Therefore, the effect of competition on licensing delays is significant. Following this logic, we assume in this project that in the later years of a patent, the likelihood of one to be transferred outwards will descend over time.

As a combination of these two sides of arguments, it leads to the first hypothesis that the propensity of a patent to be transferred will first increase and later decrease. This is similar to a conclusion from Nerkar (2007) where the authors described the relationship of patent scope, pioneering nature of invention and age of invention against the likelihood of patent commercialization. Consistent with Nerkar's work, we will testify this hypothesis in a Chinese university setting comparatively. In the increasing period, it is mostly because of the uncertainty regarding the patent right is mitigated through patent allowance. Comparably, in the decreasing phase, the increased level of competition will result in a low propensity of one patent to be transferred. Due to these two opposing trend, it is logical to assume that the likelihood of a patent to be assigned is presented in a curvilinear relationship along the time axis.

Hypothesis 1: The likelihood of patent to be transferred against time will be in an inverted U-shape.

The nature of technology has a substantial effect on the patent transaction. Verhoeven et al. (2016) separated the novelty essence of an invention into two components, novelty in recombination and novelty in technological and scientific origins. While the previous indicator reflects the extent to which an invention is novel in the way it recombines components and principles to serve its purpose, novelty in scientific origins represents the source of knowledge where an invention is originated. With regards to the last

indicator, university patents due to their scientific foundations, have long been presumed to be embryonic inventions which are far from commercialization in the market. This pioneering nature of technology will also request further participation from inventors to achieve successful development of products (Poyago-Theotoky et al., 2002). The novelty in recombination, on the other hand, has an impact on the potential application areas. According to Gambardella (2007), generic technologies are subject to higher possibilities to be licensed out. For one thing, the generality of invention comes with a broad scope of possible commercialization choices, and consequently more appealing to a larger number of potential recipients. Secondly, the patents associated with a high generality level are often related to later inventions that are derivate from several prior technology areas. From the industry perspective, a more general patent tends to appear more often in horizontally integrated business, while a patent with a narrow application area is more prone to happen in a vertical-specialized industry. The decision on whether to license or acquire a patent is closely related to the purpose of patent transfer and the firm's internal resources and external environment. Therefore, patents with high vertical specialization are more prone to be acquired, while patents with horizontal generality tend to be more easily targeted for licensing. In line with the above reasoning, we develop the following hypothesis.

Hypothesis 2: All other things equal, the stronger the generality nature of technology covered in a patent, the greater the chance a patent to be licensed out than to be sold.

The imperfection existing in the market for technology does not only characterize in the information asymmetry between licensors/assignors and licensees/assignees (Arora et al., 2001) but also show the high transaction costs (Kani et al., 2012). Through an empirical analysis of two-step model and by diving into the determinants of both potential licensors and licensees, Kani et al. (2012) found that a prominent factor in holding back the patent transaction lies in the difficulty patent owners are facing in finding suitable licensees. This notion is also reflected by Thursby (2001; 2002), where the authors believed that the primary source of growth in university licensing stems from an entrepreneurial bent of university administration rather than a change in faculty research.

Apart from the accessibility of potential buyer information, the transaction cost also exists after a buyer has been settled due to the unique features of patent transaction. Jensen and Thursby (2001) believed that technological inventions are nascent and require tacit knowledge transfer apart from a simple transfer of ownership. They examined the dual role of TTO as an agency for both school administration and faculty. One of the advantages is that with the help of TTO, a social network for the pairing with potential buyers is built to facilitate the efficiency of university patent transfer. The transaction cost is also exemplified in the negotiation process of contracts. Regarding contracts, a patent licensing tends to be more complicated than a patent selling. A licensing contract may be related to complex terms such as the definition of the royalty and right to use, which increase the transaction cost if a TTO agent is not in place in the negotiation process. Comparatively, a selling contract turns out to be much simpler with seldom following interaction needed. Patent sales generate instant income often in the form of lump-sum payment. Comparatively, a licensing contract may take various forms in payment scheme, for example, an up-front payment plus a royalty payment after a milestone in product development. The involvement of TTO in

negotiating a contract is thus more crucial for a licensing deal as most of the inventors are inexperienced in the business transaction, and the TTO's function may be utilized to the largest extent. Therefore, from the perspective of transaction cost in a patent transfer, the following hypothesis is developed.

Hypothesis 3: All other things equal, the involvement of TTO has a relatively larger positive effect on improving the likelihood of a patent to be licensed than to be sold.

Caviggioli et al. (2013) investigated the primary drivers of a proactive patent transaction from a corporate's view and distinguished the difference between patent licensing and sales. They argued that the reasons for a firm to prefer selling than licensing out include non-core technology, shorter residual life and minor awareness of suitable acquirers. University patent transfer differs from a corporate one in that University normally does not have a product market, its patent transfer thus seldom involving a strategic consideration. In contrast, the drivers of faculty's decisions over licensing or selling mostly come from a financial point and the willingness in later involvement in technology support. Caviggioli et al. (2013) also indicated that in a corporate's strategy, non-core patents are exposed to the higher chance of being sold than being licensed if there is little potential to successfully turn them into products or a blockbuster. This is different from university patent transfer. Chang et al. (2015) discovered that the commercialization mode selection of a faculty's invention is heavily dependent on monetary drivers including initial entrepreneurial capital and potential licensing income. The faculty is presumed to prefer selling than licensing in the case of little confidence in technologies to avoid risks in failing the commercialization process.

From the buyer/licensee's perspective, however, high quality will increase the patent value which gives more incentives to acquire the patent rather than licensing in. Ziedonis (2007) discussed the real option in technology licensing and found a close relationship between firms' ability to evaluate the technology and its motive for exercising options in university technology licensing. The quality of a patent should be divided into two parts, the quality of technology and the quality of patent claims. While the technology is often emphasized in the transfer process, it is worth noting that the quality of patent drafting should also be evaluated in parallel. It is justifiable to assume that firms' have more edge in assessing the patent quality and have initiatives in deciding the commercialization mode. Therefore, taking both sides' view on patent quality into consideration, the fourth hypothesis is developed as follow.

Hypothesis 4: All other things equal, the increase in patent quality will induce more increase in the likelihood of a patent to be sold than to be licensed.

4.3 Data, Methodology and Variables

4.3.1 Data collection

We examined the timing pattern in university patent transfer and the effect of patent quality, TTO involvement and nature of technology on the likelihood of patent licensing and patent selling. The quantitative analysis is based on a patent level to investigate the propensity of patent transfer. The sampled universities include the top 51 universities ranked on the webpage ("Overall Ranking, Best Chinese Universities Rankings - 2015"). According to the requirement of SIPO, every patent transaction contract needs to be registered within three months after the effective date. For each patent, the licensing/selling information is recorded in the SIPO database. Other information

attached for each patent also include basic items such as publication date, patent type, validity status, etc.

Another data source was consolidated from each university's official website, including whether there is a TTO organization and the initial starting time of TTO. All the patents from the year 2005 to 2015 that are initially owned by one of the 51 universities are gathered. Subsequently, by matching the owner's name with the TTO list, each patent is attached with school and TTO information. In total, 16 out of the 51 universities have no TTO in place by the time of data collection. A design patent is excluded in this study because the focus of the study is centered on inventions presented in utility model and invention patent. For the invention patent, pending patent applications and granted patents are differentiated to indicate how the uncertainty of patent right scope impacts the likelihood of a patent transfer. In total, the data set includes 511,667 patents, among which around 5% of patents were transacted with 9,161 patents being licensed out and 14,370 being sold.

4.3.2 Modelling Strategy

The dependent variable in this study is the event of a patent being transferred, which embodies whether the event happens or not, as well as a time duration between the initial date of a patent and the time when it was transacted. Based on the characteristics, the analysis model applied in this study is the survival mode. According to Kleinbaum and Klein (2012), this model requires the data under analysis to come with three main features. Firstly, the dependent variable or response is the waiting time until the occurrence of a well-defined event. Secondly, observations are censored, in the sense that for some units the event of interest has not occurred at the time the data are analyzed. And thirdly, there are explanatory variables whose effect on the waiting time we wish to assess or control. Survival model has been popularly utilized in medical research, but here in this study, we view the event of the patent transaction as a "death" event as described in the survival model and analyze the distribution of transaction hazard. The patent transaction data is a right censored one, as most of the patent records do not have a transaction at the end time of the study. Therefore, it is suitable to apply the survival model to study the effects of several factors on patent transfer. We tested the coefficients of independent variables to identify these effects.

4.3.3 Description of Variables

Dependent Variables:

To testify the first hypothesis, the patent transfer hazard ratio is used to indicate the likelihood of a patent to be assigned either through licensing or selling. This dependent variable is a continuous variable generated by the survival model. It primarily represents how the probability of a patent to be transferred varies over time after its publicity date. For the following three hypotheses, dummy variables Transfer, Selling and Licensing respectively representing the occurrence of a patent being transferred, licensed and assigned are adopted for the research. Taking the variable Transfer as an example, it is a dichotomous variable equal to 1 if the patent was transferred and 0 if not. The objective is to discover how different ingredients affect the choice of patent commercialization.

Independent Variables:

Generality Nature of Technology: A technology that has more application options does not only hold the opportunity to encounter more potential buyers or licensees but also

presents a low competitive environment for these buyers. Lerner (1994) and Gambardella et al. (2007) used the number of unique 4-digit IPC classification code as a proxy for the generality of technology along the spectrum of potential applications.

As adopted in Lerner (1994), an example patent assigned to classes C12M 1/12, C12N 1/14, and C12N 9/60 is accounted as falling into two categories, C12M, and C12N. Lerner used this proxy as an indicator for the patent scope, where a larger number of different IPCs represents a broader patent scope and thus higher economic importance. In the data set, the maximum of unique 4-digit IPC in a university patent is 9, and the average number is 1.4.

TTO Involvement: Siegel (2007) described the TTOs as an intermediary between university scientists and those potential stakeholders who can commercialize them, i.e. firms, entrepreneurs, and venture capitalists. As a result, IP arising from academic research are commercially transferred through licensing or assigning to existing companies. Shane (2002) posited that prior successful licensing experiences will feed back into the shift of concentration in university patenting. From the agent perspective, the buying process will be approached with a wider array of transfer strategies with the presence of a TTO with a solid base of skills and capabilities. The business empathy demonstrated by a transfer agent is therefore closely related to the success of technology transfer. Meanwhile, Thursby (2001) has argued that there is a moral hazard problem in university patent licensing. Since many of these patents need further cooperation with inventors during the commercialization phase, the patent transfer that takes in the form of licensing, compared to patent selling, will benefit more from the coordination advantages by TTOs. In this study, a dummy variable is constructed to indicate whether a patent transaction was completed before or after the establishing date of the corresponding school's TTO. In the data set, among all the patent transaction 16500 pieces were conducted after the establishment of a TTO while 6609 completed without a TTO in place. We used the dummy variable to investigate the effect of TTO involvement on the likelihood of patent transfer.

Patent Quality: Patent quality synthesizes the economic and technological value of patents. The higher patent quality often comes with a higher value attached to it. A natural logic is to presume that a patent with a better quality will be exposed to a greater possibility of being transferred to external parties. However, in the setting of the Chinese market for technology, one of the popular reasons for buying or licensing in a patent from a university is to fulfill the requirement from the government to get financial support for the firms. If this is the case, the patent quality should not be held as an important role to be considered in a patent acquisition decision. This assumption will be tested and explained in the data analysis later on. Apart from this exceptional reasoning, Svensson (2007) also proposed an argument concerning the adverse selection relevant to patent quality. He assumed that if an inventor is acutely aware of the patent quality being too low for commercialization, whereas the external firm has no access to such information, the inventor will have all incentives to sell the patent instead of licensing out. This is mostly because, in the licensing transaction, the revenue of patent transfer will depend on how successful the firm is. This assumption is built on the basis that the company has less access to a precise evaluation of the patent. The fourth hypothesis will be examined in parallel to this opinion by the survival model to estimate the actual effect of patent quality on the propensity of a patent transfer.

Several dimensions could be applied to measure the patent quality. In this study, four factors are analyzed including PCT, forward citation, claims, and the number of owners. PCT is a dummy variable which indicates the patent is an international filing if it equals to 1 and a domestic patent if 0. A patent has both backward citations and forward citations. Backward citations are often used by examiners to assess the patentability as they include the nearest prior arts. However, though backward citations give hints on the knowledge origin of the invention, the number of forward citations is the most frequently used patent quality indicator (Kani & Motohashi, 2012), which reflects the size of subsequent inventions based on the original patent. Boeing (2016) used the forward citation to measure the patent quality and found that China's rise in international patenting was achieved to the detriment of quality. This will be revisited in the following model analysis. The number of claims is regarded to be closely associated with the technological and economic value of inventions, as claims determine the technology and subject matter protected by law (Tong & Davidson, 1994; Lanjouw & Schankerman, 2004). However, though the number of claims has been broadly applied as an indicator of patent quality, we assume that the number of claims is too vague to represent quality. The number of inventors is used as a proxy for intellectual resources invested into an invention. Fleming (2008) demonstrated that collaboration within inventors can have opposite effects, where it reduces the probability of poor outcomes while simultaneously increasing the likelihood of extremely successful outcomes. Besides, the existence of multiple inventors also suggests a faster and easier diffusion of knowledge, as well as a greater extent and breadth of technological search, benefited from the teamwork.

Control Variables:

Patent Effectiveness: This term is adopted by Arora (2006) to represent the strength of patent protection. According to Horstmann et al. (1985), a variety of factors may drive the effectiveness of patents, including increases in length or breadth of protection, greater codifiability of knowledge, decreases in costs of application, and costs of disclosure. In this study, the legal right of patents is considered. Following Reitzig (2009), dummy variables "granted patent" and "pending patent application" are constructed to capture whether a patent was granted or remains in pending in the study window.

Technology field: Kani (2012) argued that the information asymmetry associated with technology market imperfection varies accordingly with the technology filed. For example, in the science-based industry such as biopharmaceuticals, scientific content is necessary for innovation, and the technological contents can be expressed more explicitly. This facilitates licensing deal-making because potential licensees can understand the technical contents more clearly (Arora and Gambardella, 1994; Arora and Ceccagnoli, 2006). In this study, the eight categories from IPC system are adopted to represent the technology fields, which include human necessities; transporting; chemistry; textiles; fixed constructions; mechanical engineering; physicals; and electricity.

4.3.4 Result Discussion

The descriptive statistics and the correlations between variables are reported in the table. All correlations above 0.02 are significant at the 0.05 level. In model 1, we describe the baseline which contains only the independent variables: generality of technology, TTO involvement, and patent quality. In model 2, control variable of patent effectiveness is

added. In Model 3, we added the technological field as a control variable.

Table 3 Descriptive Statistics & Regression Result

		Mean	Std. Dev.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Generality	1.403495	0.7346046	1	9	1													
2	TTO involvement	0.8924046	0.309869	0	1	0.0454	1												
3	PCT	0.0114997	0.1066182	0	1	0.0141	0.0193	1											
4	Forward citations	2.281093	2.120715	1	23	-0.0252	0.0235	0.0249	1										
5	Claims	39.36398	24.06461	1	81	0.0407	0.0088	0.0106	-0.0177	1									
6	Invention application	0.5469768	0.4977888	0	1	0.0401	0.03	0.0122	-0.2521	0.1045	1								
7	Granted Invention	0.2971151	0.4569881	0	1	0.0198	0.0241	0.0154	0.4355	-0.0664	-0.7666	1							
8	IPC_B	0.1355768	0.342339	0	1	-0.0116	0.0021	-0.0136	0.0422	0.0012	-0.0423	-0.0013	1						
9	IPC_C	0.236797	0.4251171	0	1	0.2247	0.0591	0.0092	-0.0312	0.0466	0.0584	0.0552	-0.2206	1					
10	IPC_D	0.0129751	0.1131671	0	1	0.0304	0.0305	-0.0078	0.012	0.0213	0.0022	-0.0004	-0.0454	-0.0639	1				
11	IPC_E	0.0383446	0.1920271	0	1	-0.0428	-0.0299	-0.0068	0.0211	-0.0114	-0.0422	-0.0238	-0.0791	-0.1112	-0.0229	1			
12	IPC_F	0.059186	0.2359728	0	1	-0.0179	-0.001	-0.0087	0.0299	-0.0075	-0.0442	-0.0234	-0.0993	-0.1397	-0.0288	-0.0501	1		
13	IPC_G	0.2600263	0.4386491	0	1	-0.1342	-0.0177	-0.0136	-0.0049	-0.0291	0.0258	-0.0162	-0.2348	-0.3302	-0.068	-0.1184	-0.1487	1	
14	IPC_H	0.1722889	0.3776317	0	1	-0.0787	-0.0516	0.0318	-0.006	-0.0008	0.0242	0.0065	-0.1807	-0.2541	-0.0523	-0.0911	-0.1144	-0.2705	1

	Model 1			Model 2			Model 3		
Dependent Vaiarbles	Transfer	Selling	Licensing	Transfer	Selling	Licensing	Transfer	Selling	Licensing
Independent Vairables									
Technology Nature									
Generality	1.069577***	1.009435	1.169622***	1.054836***	0.9935821	1.157152***	1.03234***	1.006812	1.081092***
Coordination									
TTO Involvement	3.916043***	3.102067***	5.398217***	4.023393***	3.201759***	5.509429***	4.096176***	3.2821***	5.527993***
Patent Quality									
PCT	2.211624 ***	2.999567***	0.9475074	2.058428***	2.782401***	0.8863372	2.051864***	2.694841***	0.9251389
Forward Citations	1.017547***	1.017488***	1.018077***	1.020429***	1.020115***	1.021204***	1.020215***	1.019464***	1.021791***
Claims	.9994789**	.9988762***	1.000307	0.999654**	.999008***	1.000557	.9994206**	.9990854***	0.9998834
Control Variables									
Invention Application				1.912507***	2.066469***	1.702585***	1.897801***	2.095013***	1.633155***
Granted Invention				2.856273***	3.004075***	2.664093***	2.827049***	3.04217***	2.552546***
IPC_B							1.178286***	.9245049**	1.71789***
IPC_C							1.074538***	.8429858***	1.561198***
IPC_D							2.163757***	0.9152944	4.782294***
IPC_E							.9096765**	0.9993161	.7909885**
IPC_F							1.061504	.9083973**	1.383634***
IPC_G							.7908677***	.8426865***	.6984745***
IPC_H							1.095167***	1.184417***	0.9109748*
Chi-square (LR chi2)	3614.81	1652.18	2476.38	5341.16	2731.26	3177.94	5947.36	2949.37	4581.56
Log-likelihood	-270377.14	-168358.91	-107065.69	-269513.97	-167819.37	-106714.91	-269106.06	-167616.42	-105975.44
Observations	489,313	489,313	489,313	489,313	489,313	489,313	488,879	488,879	488,879

Fig.14 gave the distribution of transfer hazard. The vertical axis is the survival odds of an invention, meaning the likelihood that an invention survives in the observation period without a transaction event. Hypothesis 1 predicts a curvilinear curve of the transfer hazard ratio. This is proved by the distribution of transfer hazard. The likelihood of a patent being transferred went through an increasing period after its publicity. At around 48 months after its publicity, the transfer possibility reaches its highest point and decreases afterward.

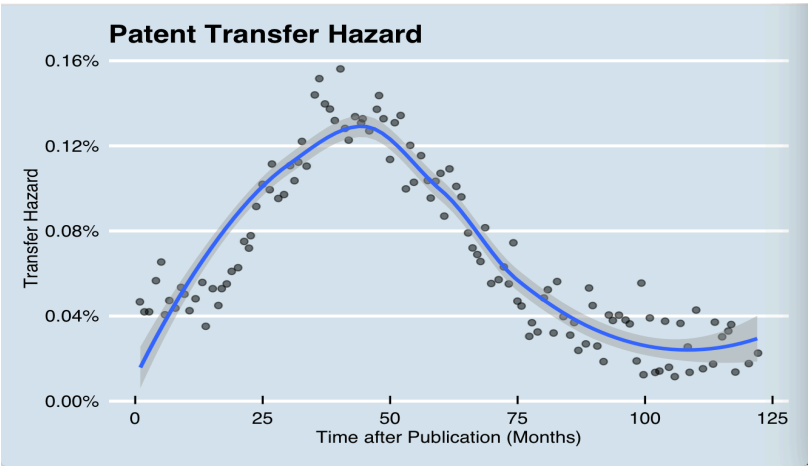


Figure 14 Patent Transfer Hazard

Hypothesis 2 is tested in Model 3, the main effect of generality is positive and significant for licensing, while it does not have a noticeable effect on patent selling. The coefficient of the generality of a patent in Model 3 for licensing hazard is greater than 1 and statistically significant, which proves that the generality of an invention is positively related to the probability of a patent being licensed. On the contrary, the coefficient of the generality of a patent is not significant for the propensity of patent selling, indicating that more potential applications of an invention do not have an apparent positive nor negative function on selling a patent. This result is coherent with our hypothesis in that the potential buyers do not pose high requirement on more

potential applications. It is also partly caused by the vast potential licensees across different industries that are attracted by the generality of an invention.

Hypothesis 3 predicted the positive effect of TTO involvement on the propensity of patent transfer. The coefficients of TTO involvement are all greater than one significantly throughout all the models, which proves the facilitating function of TTOs in promoting the patent transfer. Moreover, the degree of positive effect on patent licensing and patent selling is relatively different. The presence of TTO will increase the likelihood of patent licensing twice as for patent selling. This could be explained by the complexity in negotiating a licensing deal which benefits more from prior experiences.

Whereas patent licensing is given more edges with the generality of invention and TTO involvement, patent quality in the regression results has been shown to be more closely related to patent selling. Hypothesis 4 is supported by the fact that the coefficients for proxies of patent quality are greater than 1. The exception here is some claims, where the coefficient is very close to 1 which indicates a very limited effect on the patent transaction hazard. The reason for this might be that though some claims have been adopted in literature, it is the number of independent claims and their lengths that represent the scope of patent protection. For the PCT indicator, it has a significantly positive effect on patent selling, meaning that a patent that has international protection stands a much higher chance of being sold. On the contrary, this PCT indicator has no relevance to the propensity of a patent being licensed out. The reason for this could be that the patent licensees tend to utilize the license into production for which purpose a domestic patent will suffice. Additionally, some forward citations have also been shown to be positively related to the propensity of patent transaction.

Besides, in the regression result, the effects of control variables also are also showed as expected. Compared to utility model patents which are often the time viewed as “tiny” patents, invention patent proves to be more likely to be transferred. Further, pending applications compared to those that have been granted already, have less attractiveness for a patent transaction. With regards to the technology field, textiles are among one of the most transacted categories, while physics has been shown negatively related to patent transfer partly due to its scientific origin.

4.4 Discussion and Conclusion

In this study, a data set of patent records from top Chinese universities is constructed to analyze the effectiveness and determinants of patent transfer. The patent transfer hazard is analyzed to show its time various characteristic. We further investigated the differences in determinants concerning patent selling and patent licensing. Through using a survival model to test the effects of three aspects from a patent level, we investigated how the propensity of patent transaction mode was affected by these determinants.

The results have several levels of implications. First, with regards to the timing strategy of patent transfer, there is an optimal period when the propensity of patent transfer is increasing. This is due to the tradeoff between uncertainty in patent effectiveness and market value. For the TTOs, this gives an implication on putting more emphasis on patents that have not become too old in age to target potential buyers. For the firms who are seeking out for university patents, it is suggested to conduct full due diligence and

evaluate the uncertainties in patent effectiveness to capture the market value before it shrinks over time. The differences between patent selling and patent licensing also provide background information for TTOs on patent transfer strategies. Depending on the goal, emphasis shall be placed on different determinants. For instance, if selling a patent is preferred, then patent quality shall be prioritized compared to the potential general applications of the invention. On the other hand, for patents with more horizontally intensive applications, TTOs need to make more efforts in decreasing the transaction cost and facilitating the negotiation process. The technological field is also an important factor that needs to be considered, and a focus on those areas which TTOs already have handful experience may increase the probability of patent transfer.

This chapter focused on a patent level investigation to analyze the probability of a patent to be transacted. The results have shown unique features of university patents compared to firms' behavior in the technology market. This is mostly caused by the lack of product development from university side, which led to the difference from firms' outward patent transaction strategy, However, because a patent transaction is not only managed on a micro-level, it is more often the case pulled off from the demanders, i.e., a firm's strategic level. Therefore, the next chapter will try to complement it by giving an analysis of firm level considerations in university patent transfer.

5 Analysis from an Enterprise Perspective

This chapter will focus on a firm-level discussion around the incentives and strategic considerations of university patent acquisition. Based on the motivations of enterprises, a patent acquisition may be driven by various factors. Through analyzing the licensees/assignees, this study summarizes the primary factors in a firm's considerations on decision making.

5.1 Motives to in-licensing or buying university patents

The inward patent acquisition activity is usually incentivized by a firm's patent strategies. As described by Cohendet (2009), there are several major positive normative implications of patent transfer. Firstly, it facilitates the division of labour and allows each firm to specialize where it is most efficient. Secondly, it also enhances the distribution of technologies, which ensures that innovations are used to create the most of value by feasible. Finally, it prevents costly duplication of research. Cohendet further distinguished between two categories of motives, i.e., to exclude and to include. The function of excluding imitators has been emphasized to a large extent, while the function of including all the heterogeneous stakeholders of the innovation process has often been understated. Caviggioli (2013) further divided the drivers for patent transaction into several types: strategic, monetary, mitigation, and exogenous, etc. Each of these drivers will be discussed and the status quo of firms involved in Chinese university patent transfer is analyzed.

Strategic Drivers: The strategic motives to trade patents were mostly discussed in relation to industrial economics and strategic management. One predominant motive is to block competitors from entering into the market. In this case, both exclusive patent licensing or patent selling is preferred. The interviews revealed that firms which fall into this category usually feature in a weak or null patent portfolio but has been implementing the technology for quite a long time. Because of their research capability and knowledge accumulation, these firms have an edge in assessing and negotiating the patent transfer contract. Another motive is to expand into new geographic or product markets. In this respect, firms tend to explore patents that are in distant field from their initial patent portfolio. Due to the knowledge gap, this type of patent transfer relies heavily on know-how and training from the inventors. The terms of royalties are also more complicated than the previous one. Typical forms of royalties include milestone payment, patent as equity or share from profits. As the complexity of transfer increasing, the success of this type of patent transaction relies heavily on the agent role of TTOs.

Monetary Drivers: In this categories, the transferred patents are utilized for generating direct or indirect inflow of cash. NPEs are typical entities who license in patents and transmit it to a third-party later on. In this situation, the transition of patent ownership is highly valued and licensing is less attractive. In the setting of Chinese university patents, patent brokers associated with university consist a big part of these patent acquisition. The benefits from this activity is a more efficient scrutiny procedure as many of the bureaucratic steps are skipped. For firms who needs complementary technology to accomplish the development of products, the patent transfer usually comes out of indirect monetary incentives. This situation is found in certain cases where firms lack of freedom to operate with regards to certain accessory technologies. Concerning this specific incentive, the low prices are more attractive whereas there is

no discrimination over patent licensing or patent acquisition.

Exogenous Drivers: This category of motives is related to market forces and conditions, technological trends and industry specificities. Both technology push and market pull effects are potential underlying reasons for firms to reach out to universities. The incentives behind include to gain a competitive advantage in the defensive position, to shorten internal technology development life cycle, and a shift from an obsolete technology to an emerging one. Patents are thus treated as a defensive tool aimed at protecting its holder against legal attacks. In this situation, patent acquisition is preferred compared to licensing. However, because of the early-stage characteristic of market, the nature of technology is paid more attention in this category. The more generality a patent, the more likely it will be transferred.

Mitigation Drivers: Patents are not always exchanged for money, but instead they can also be used to barter for other patents within cross-licensing agreements. This is popular in industries where technological change and innovation are cumulative. Product research and development often the time has to read on other firm's IP. Cross-licensing is intended to lift the burden from both parties regarding the patent infringement. As Hall and Ziedonis (2001) put it, anticipating such situations, firms are induced to gather large patent portfolios that serve as "legal bargaining chips". Companies protect themselves against mutual infringement by cross-licensing their patent portfolios. Acquisition of university patent ownership is preferred in such a case. The validity of patents is one of the most important factors taken into consideration. Patent application, due to its uncertainty in patent right grant and patent scope, is less appealing than granted patents.

Apart from these drivers, there is another special factor for companies to acquire patents from university. Small and medium firms with a good maintenance of patents will be granted extra financial support from government. From the interviews with TTOs, normally firms with such an incentive do not care too much about the patent quality as long as it is granted. Though the university patent transfer has been criticized for consisting of many such cases, the empirical study in Chapter 3 has proved that patent quality is a significantly positive factor for promoting patent transfer. This result could be viewed as a response to such criticism and we could assume that many of the patent transactions were initiated from the previous four categories of drivers on the firm level instead of a simple measure to get governmental funds.

5.2 Main considerations in patent transfer

As much as the corporate strategies are taken into account in the decision of patent acquisition, there are also some other considerations that should be addressed, for example, market position, different capabilities, internal resources and so on. Based on interviews and second data source, several key factors are discussed as follow.

Firm size: Within the patent transaction, there are two phenomena regarding firm size. Small companies, such as start-ups and incubators, consist a big part of the licensee or assignee entity. However, the patents under transaction for these firms are distributed loosely, often with one or two patents transferred to a firm. University-associated companies, on the contrary, tend to transfer patents in a large batch. Among these recipients, large companies are seldom identified. The reason for which may be the inflexibility induced by the bureau procedure disincentives established companies to

make too much effort into promoting a transaction deal. Another reason for this pointed out by the interviewees is that academic patents tend to be distant from being immediately commercialized. This pioneer characteristic of technology hinders the exchange of knowledge with firms.

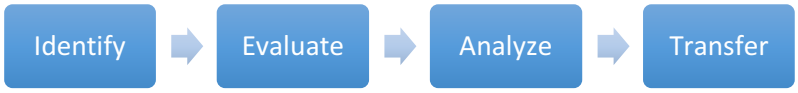
Partner relationship: Partnership could be traced back as a ground for university patent transfer, but could also be a result of it. A portion of university patent transactions happened with patents that were simultaneously owned by a university and its industrial partner(s) in the first place. However, as highlighted by some interviewees, some firms utilize the patent transaction as a pathway to build contact with researchers. Under this condition, partnership is a result of the patent transaction and the role of patent transaction goes beyond merely allocating existing resources.

Financial consideration: With regards to the choice of patent licensing or patent acquisition, one important part is the financial investment. Patent acquisition tends to cost slightly less than licensing, but it requires a lump sum payment, which sometimes could be a big burden for enterprises. Licensing, on the other hand, requires an upfront payment and following-up royalties.

Internal capabilities: On one hand, Srivastava (2015) argued that firms that participate in technology market through both licensing-in as well as licensing-out develop superior licensing and knowledge assimilation capabilities, which help them improve their patenting performance. On the other hand, strong internal capabilities could also escalate the patent transfer from university to firms. In the context of Chinese university patent transfer, the forward impact of transfer on firms' capability improvement is superior than the other way around.

5.3 An efficient patent scouting procedure

In this section, we designed a workflow for a firm to conduct university patent scouting. It consists of four steps, i.e., identify, evaluate, analyze and transfer. The prerequisite of this workflow is to search among established inventions that has been either filed or granted as a patent. Other collective modes of knowledge such as potential technology development is not covered here.



Identify: This step starts with a business strategy, as described in section 5.1. Based on the strategic consideration, a technology space will then be defined as a collection of IPC codes. If it is out of an exclusivity purpose, the technology space should be defined the competitors' technology coverage. If it is an approach to enter a new market, then the technology space shall be described as the new sector. Within a definitive technology space, patents with high quality and high citations will be filtered according to the keyword search. Because of the intensity and highly expertized characteristic of scholars, the most prolific individual researchers and research groups within this technology space should also be highlighted. Indexing by the researchers and research group help accelerate the screening of relevant patents.

Evaluate: For the selected patents, the next step is to conduct an evaluation regarding their value. This stage is centered primarily around the patent level assessment regarding its quality and legal validity. Three primary aspects need to be taken into

consideration. Firstly, the nature of invention is to be assessed in terms of generality and pioneering feature, and further to be matched with the strategic consideration to decide whether the patent should be targeted as a potential object to be purchased. Secondly, the drafting quality of patents is another important factor to be included. Because the interpretation of claims is dependent on the description part, the drafting of a patent plays an important role in deciding the validity and other legal rights of a patent. In addition, both the independent claims and dependent claims are the decisive part of a patent. If an independent claim is written with too many descriptive terms, the scope of patent might be narrowed down to a large extent; on the other hand, if it is written in too general terms, the claims may face a high risk of being rejected or invalidated. For firms who have found interesting patents, a transfer of patent application instead of a granted patent is one feasible approach to avoid a deterioration of the patent right merely caused by poor drafting. This is because firms then intervene fairly early in the patenting process and utilize their expertise in patent portfolio management to compensate the common shortcoming of university patents in drafting.

Analyze: Distinguished from the previous step, the third step emphasizes the commercialization part of patents. First, we need to place the patent under the market context to assess the market value. One approach is to conduct a technology landscape to get a macro impression of technology. Market value is also measured against internal resources, deciding whether the patent is an incremental, a complementary or a novel invention to the existing technology portfolio. Second, the expected output of the patent is also an indicator for its market value. This is in aligning with the four categories of motives, i.e., strategic, monetary, exogenous, and mitigation. Depending on the type of motive, the expected result from the patent licensing or patent purchasing shall be calculated to be accounted as part of the market value of a patent.

Transfer: Before entering the negotiation of a patent purchasing deal, it is necessary to get a full understand of the corresponding university's TTO policy as the requirement differs from each university. The decision of whether purchasing or licensing in the patent needs to be made beforehand. This decision is expected to conform with the primary motive as well as all the other factors such as financial consideration. The royalties and payment mechanism is also drafted in this stage.

5.4 Summary

So far, we have discussed the motives from a firm's perspective to acquire university patents. The motive underlying the firm's attempt shall serve as a guiding principle for the subsequent scouting process. Further, a framework for organizing the technology transfer process is described, which includes identifying, evaluating, analyzing, and transferring. In each step, there are some highlights that need to be paid attention to in order to achieve a successful and effective university patent transfer.

6 Conclusion & Future Research

This chapter gives a conclusion of the thesis and highlights the findings. The research questions were designed to investigate the Chinese university patent transfer, specifically how effective it is and the primary determinants in the process.

6.1 Conclusion

University technology transfer may be conducted through various forms, such as university-industry cooperation, high-tech spin-offs, university science park, and so on. In this study we focused on the approach of patent transfer of developed academic research results. Though the totality of Chinese university patents has surged over recent years, there are still many obstacles hindering the patent transfer to private sectors. This study made an attempt to clarify some of the ambiguity from three arenas, i.e., legal, administrative, and business perspective. Based on a combination of qualitative and quantitative research, we were able to identify the main issues in each arena that discouraging the patent transfer process. Each research question is answered through this study:

- Research Question 1: *How is the overall environment for university intellectual asset transfer in China?*

This study found a lack of comprehensive legislations on the management of university patents. Though the latest revision of laws on academic research results has loosened the restrictions over the ownership, the transfer method, etc., there still exist grand differences across provinces and universities. This ambiguity hinders the administrators from making too many efforts into promoting the patent transfer out of the fear of going against the law.

In the institutional part, this study discovered the low involvement of TTOs in the patent transfer process. Researchers, on the other hand, have been the primary connection with enterprises. The drawbacks of the absence of TTOs through the whole process of patent transfer include several aspects. First, the patent filing is missing a business consideration, which leads to the devaluation caused by inappropriate drafting. Second, the gap between researchers and enterprises in terms of incentives and needs of patents needs to be bridged by TTOs.

With regard to the patenting activity, both patent filing and patent transaction are increasing in the past 10 years. The ratio of invalid patents against totality valid patents, however, is slightly decreasing which indicates an increase in patent quality. This is further exemplified by the gross number of PCT patents.

- RQ2: *What is the propensity of a given patent to be successfully transferred from university to firm and the determinants in an effective university patent transfer?*

This study examined the optimal timing for a university patent transaction and three factors that have an impact on the transfer propensity and the patent transfer form (licensing/selling), which are the generality of technology, involvement of TTOs, and patent quality. With regards to the optimal timing of patent transfer, our study found that there is an inverted U-shaped relationship between the propensity of patent transfer and time axis. Compared to corporate patents which reaches its peak of likelihood at

around 7 years after publicity, Chinese university patents have a faster circulation speed, about 2 years after publicity. From the quantitative analysis, it is also shown differences between patent selling and patent licensing. Though patent quality, TTO involvement, and nature of invention all having effects on the likelihood of patent transfer, it needs to distinguish between the two types of transfer. The patents in study were chosen from top 51 Chinese universities based on ranking. On the school level, the preference between licensing and selling varies depending on the guiding policy instructed by each TTOs. On the patent level, patent quality is more closely related to the increase of patent selling probability, while the other two factors having bigger impact on patent licensing.

- RQ3: *What considerations should a firm take into account before acquiring a university patent?*

Based on a qualitative analysis of the patent transaction records, the incentives of a firm before acquiring a university patent include strategic, monetary, exogenous, and mitigation drivers. Other considerations include firm size, partner relationship, financial consideration, and internal capability. A majority of the firms involved in Chinese university patent transfer are small & medium enterprises. These firms tend to be more financial sensitive. However, a further detailed analysis still needs to be conducted in order to understand the situation better. From the analysis of enterprise's incentives to engage in university patent transfer, a corporate first needs to identify their individual needs and strategic considerations. By tailoring to their specific assets and objectives, it will be more efficient to identify, evaluate and eventually accomplish a patent transfer with the university.

6.2 Implications

The research results gave us several implications.

Firstly, currently the role of faculty is critical in the commercialization of academic research as they undertaking most of the job from patent drafting to contract negotiation. This slack management is induced partly by the absence of help from TTOs. Therefore, sufficient resources need to be devoted to TTOs with an aim to increase its human resources and capabilities, to build a multidisciplinary team with technical, business, administrative expertise.

Secondly, an effective patent transfer could not stand alone without a corporate's strategies. From the university's perspective, an organized portfolio customized for each type of potential buyers will work beneficially for improving the effectiveness of patent transfer. Though academic patents tend to be viewed as too pioneering in technology and thus far from being successfully commercialized, our study found this is not necessarily the case. Therefore, a proactive patent management by the university could be catered to attract more buyers/licensees. For TTOs, the design of patent transfer strategy shall take into consideration of preferences in different types of corporates. On the other hand, firms who actively reach out to find a potential patent needs to start from its business strategy and depends on its internal capability and absorptive capacity to identify and implement an appropriate patent acquisition strategy.

Thirdly, the patent transfer does not necessarily need to be viewed as the end goal of university technology transfer. Instead, it should be pivoted by academic technology transfer. Therefore, diverse ways to to commercialize patents are needed to utilize patents or proprietary technology as knowledge capital. In certain cases, patent could

be utilized as a media to connect enterprises and researchers for future research collaboration.

6.3Future Research

This study has been focused on three aspects, i.e., a general description of the legal and institutional environment for university patent transfer, a patent-level analysis of determinants, and a firm-level strategy discussion. Though the differences between patent selling and patent licensing were analyzed to a certain extent, it will be interesting to further compare the pattern with firms' outsourcing patent activities. The reason behind is that firms as licensors/assignors have more business concerns involved, while for inventors who focus on academic research, they seldom need to make tradeoff between gains from outsourcing and internal commercialization.

Besides, currently the firm-level is only based on a qualitative analysis stressing the importance of strategies in the process of scouting university patents. An empirical study on the Chinese firms' patent transaction records might reveal more factual results as to their incentives and licensing-in patterns.

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