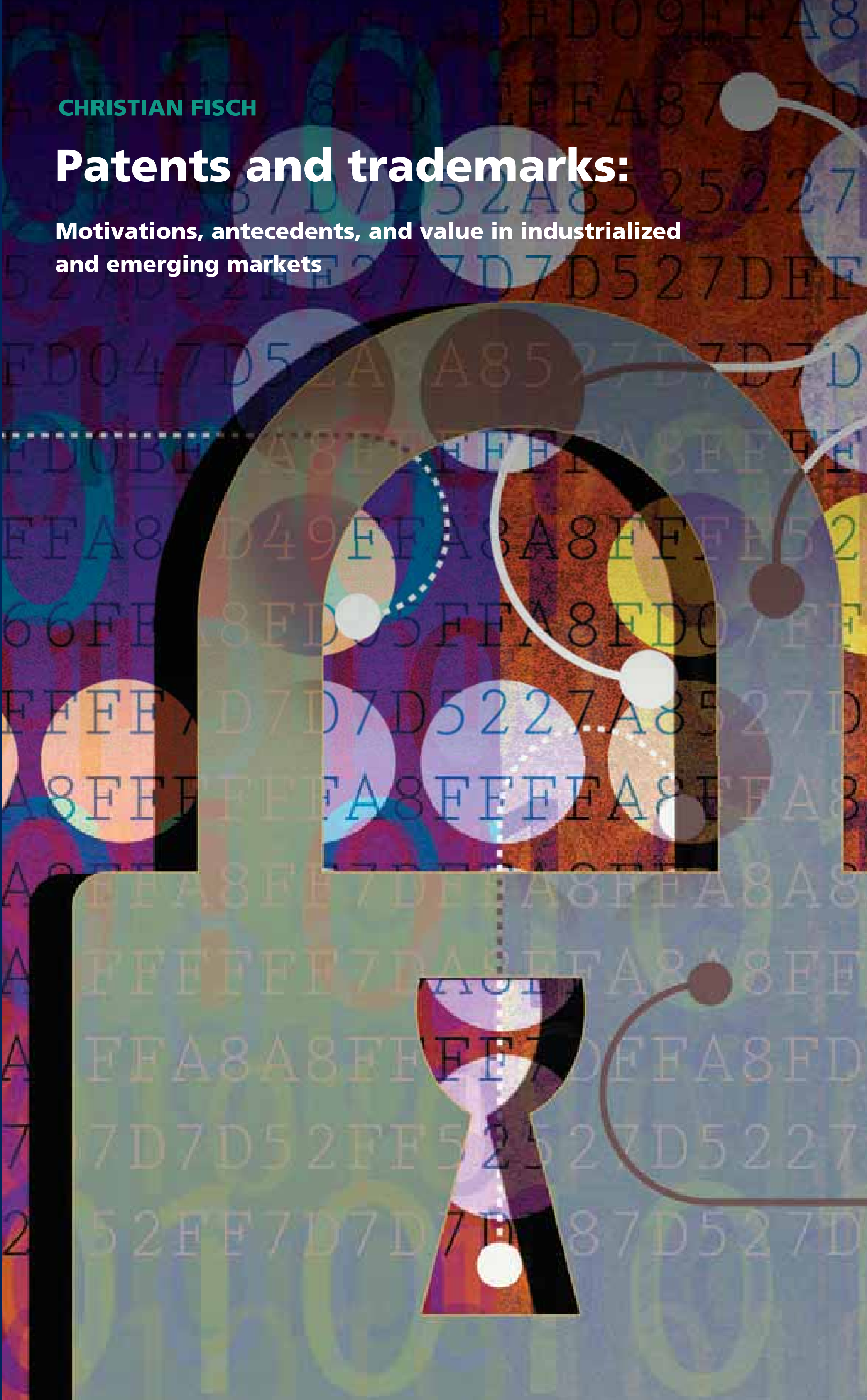
CHRISTIAN FISCH

Patents and trademarks:

Motivations, antecedents, and value in industrialized and emerging markets



Patents and trademarks:
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Patenten en handelsmerken:
Motivatie, achtergrond, en waarde in
geïndustrialiseerde en opkomende markten

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Preface

A lot of people accompanied me during my time as a PhD student and thus contributed to this thesis in various ways. Therefore, this thesis starts with a list of "thank you's" to those people:

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Christian Fisch
Trier, September 2016

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Summary

Intellectual property rights (IPRs) play a very important role for innovations. They serve as a mechanism for innovators (e.g., individuals, companies, universities) to protect their intellectual property and enable the holder of the IPR to profit from the innovation. Patents and trademarks constitute the two most important and most frequently utilized IPRs. This thesis contains five empirical studies that address recent research gaps in research on patents and trademarks.

With regard to patents, this thesis focuses on patenting in China, which underwent a remarkable and explosive growth recently: Only 15 years ago, Chinese applicants filed 1.9% of the patents they filed in 2014. This is because China is trying to transition itself from an imitation-based to innovation-based economy. However, even though China is actively and prominently fostering innovation in trying to become a leading innovator, China is still far away from reaching the world's innovation frontier. In light of this ongoing and still relatively unexplored phenomenon, this thesis addresses several important issues regarding the antecedents of patenting and the value of patents in China that are crucial, but have received little attention so far. In particular, this thesis addresses the more specific topics of university patenting, the impact of acquisitions on innovation performance, and patent value in China.

Findings show that an increase in patenting by Chinese universities, fostered by two subsidy programs, is an important antecedent of the overall increase in patenting in China (Chapters 2 and 3). Also, this thesis finds that Chinese companies profit from acquisitions that enable them to increase their post-acquisition innovation performance under certain conditions, hence contributing to the overall increase in patenting (Chapter 5). For example, Chinese firms successfully draw on the often more developed knowledge in foreign countries and use cross-border acquisitions to catch-up to developed countries in terms of patenting. While the increase in patent applications in China is remarkable, several findings in this thesis also indicate that patent quality has not yet risen to a similar degree (Chapter 3) and

that the value of Chinese patents is, overall, lower than that of patents from other countries (Chapter 4). The development of patent applications of high quality and value is, however, important to realize a meaningful and sustainable increase in a nation's innovative capacity and to reach China's goal of becoming a leading nation in terms of innovation.

In contrast to research on patenting, where most basic questions have been investigated thoroughly and demand a more nuanced perspective (e.g., a focus on patenting in China), research on trademarking is in comparatively early stages. Trademarks are a very important IPR for firms to distinguish themselves from competitors and have been linked positively to the market valuation, survival, and productivity of firms. However, little is known on why firms file trademarks, which is the focus of the final study in this thesis (Chapter 6).

A better understanding of trademarking motives is crucial to fully understand the meaningfulness and importance of trademarks. Therefore, this thesis analyzes firms' motives to file trademarks using data from small and medium-sized enterprises (SMEs) in innovative industries. It identifies and empirically validates three trademarking motives: protection, marketing, and exchange. The thesis also finds that firms can be grouped into four clusters based on their trademarking motives (i.e., trademark skeptics, marketing-focused trademarking SMEs, and marketing- plus protection-focused trademarking SMEs. These results enrich previous research and add a new layer of discussion to previous trademark research by showing the uniqueness and variability of SMEs with regard to their usage of IPRs. Because stimulating IPR usage by small firms is of particular interest for innovation policies, this finding has important implications and informs policy makers to develop better suited policies for the heterogeneous group of SMEs that better motivate them to increasingly engage in trademarking.

Chapter 1

Introduction

This thesis analyzes the motivations, antecedents, and value of patents and trademarks in industrialized and emerging markets. With regard to patents, this thesis focuses on exploring patenting in the emerging market context of China. Chapters 2 and 3 more specifically analyze university patenting in China, which is an important antecedent of the overall increase in patenting in China. Chapter 4 investigates the value of Chinese patents, while Chapter 5 assesses whether Chinese companies benefit from acquisitions in terms of their innovation performance. With regard to trademarks, this thesis explores SMEs' motivations for trademark applications. Hence, the final study (Chapter 6) addresses the question of why SMEs file trademarks.

The introductory chapter (Chapter 1) is structured as follows: Section 1.1 describes the motivation of this thesis and introduces the research contexts explored. Section 1.2 outlines the research questions investigated in this thesis, while Section 1.3 describes the five studies included in this thesis in more detail. Finally, Section 1.4 provides an overview of the publication status of the studies included in this thesis.

1.1 Motivation

Intellectual property rights (IPRs) play a very important role for innovations. They serve as a mechanism for innovators (e.g., individuals, companies, universities) to protect their intellectual property assets and enable the holder of the IPR to profit from the innovation. By providing protection, IPRs provide incentives and benefits to inventors, while simultaneously disclosing the intellectual property to the public. In this way, IPRs are stimulating innovation at the individual and societal level (e.g., Teece, 1986; Cohen et al., 2000; Yueh, 2009, WIPO, 2016b).

Patents and trademarks constitute the two most important and most frequently utilized IPRs (Cohen et al., 2002; Thomä and Bizer, 2013; WIPO, 2016a). They act as complementary assets in the allocation of returns from an innovation and can therefore be of huge economic significance to the innovator (e.g., Teece, 1986). Therefore, this thesis addresses important research gaps regarding the motivations, antecedents, and value of patents and trademarks in industrialized and emerging markets.

1.1.1 Research context: Patenting in China

Patents constitute an important protection mechanism for inventions and are one of, if not *the* most frequently utilized proxy to measure innovation in innovation research. A patent is an exclusive right, usually issued by a government, which grants the patent's owner the right to exclude others from using the patented invention. Patents are granted to provide inventors with a mechanism to protect new technology from free riding by third parties. In exchange, the patented invention is disclosed to the public (WIPO, 2016c).

By their very nature, patents are closely related to innovation because they are only granted for the development of a new technology that is commercially useful and thus of some economic significance (e.g., Ahuja and Katila, 2001; Alcaide-Marzal and Tortajada-Esparza, 2007; Godinho and Ferreira, 2012). Also, patents must pass the criteria of "novelty" and "non-obviousness". "Novelty" describes the requirement that the invention must not have been available to the public before the patent was filed. "Non-obviousness" requires that the invention must be sufficiently different from previous knowledge (USPTO, 2016a). Both criteria (theoretically) ensure a minimum level of innovativeness of the underlying technology (Ahuja and Katila, 2001). Underlining the usefulness of patents to measure innovation, previous research has described them as an externally validated measure of technological novelty. Also, patent statistics correlate with various other measures of innovation (e.g., Griliches, 1990; Ahuja and Katila, 2001). Empirical studies find that patents are closely related to new products (Comanor and Scherer, 1969), expert ratings (e.g., Narin et al., 1987), innovation and invention counts (e.g., Acs et al., 2002).

Because of their close link to innovation, statistics on patent applications have historically been dominated by countries generally known as innovative, such as the US, Japan, and Germany. Since the 1980s, the worldwide number of patent applications has skyrocketed. This explosive growth has drawn a lot of scholarly attention and has been attributed to factors like the emergence of research and development-intensive and patent-intensive industries, an overall increase in research and development (R&D) investments, and managerial improvements with regard to intellectual property (e.g., Kim and Marschke, 2004; Hall, 2005). Further studies partially attribute the increasing prevalence of patents to a more strategic use of patents, for example to block competitors or to signal innovativeness (e.g., Cohen et al., 2000; Blind et al., 2006).

Figure 1.1 provides an overview of the countries whose residents filed the most patent applications in 2014.[1] The surprising conclusion is that China, an emerging economy, takes the top spot. While the patent applications by applicants from the industrialized nations (South Korea, Japan, USA, and Germany) increased steadily, applications by Chinese applicants almost grew exponentially. In 2011, Chinese applicants filed the third most patent applications worldwide, slightly surpassed by the US and Japan. Since 2012, however, China takes the undisputed top spot and continuously increases the distance from other nations: In 2014, Chinese applicants filed 837,897 patent applications; 64.4% more than US applicants and 79.8% more than Japanese applicants. Only 15 years ago, Chinese applicants filed 1.9% of the patents they filed in 2014. While applications by Chinese applicants grew 52-fold since then, applications by US applicants grew 2-fold and applications by Japanese applicants even decreased by 3.3% (WIPO, 2016a). These numbers illustrate the remarkable and explosive growth in Chinese patenting.

As shown above, the development of China in terms of innovation is particularly intriguing and recent. In 1978, China introduced a large economic reform to open up its economy and to start the transition from a planned to a market-based economy. Since then, China has successfully transformed itself into a leading industrial nation. The Chinese economy has grown at a scale that has been unprecedented since the industrial revolutions of the 18th century (e.g., Tian and Yu, 2012; Scherngell et al., 2014). This extensive growth has largely been facilitated by a growth of the manufacturing industry, by utilizing the worldwide stock of knowledge in combination with low costs and a large scale, and by large inflows of foreign direct investment (FDI) (Wu, 2001; Brandt and Rawski, 2008; Hu and Mathews, 2008). Because of this development, China is often referred to as the "world's factory" (Ma et al., 2009).

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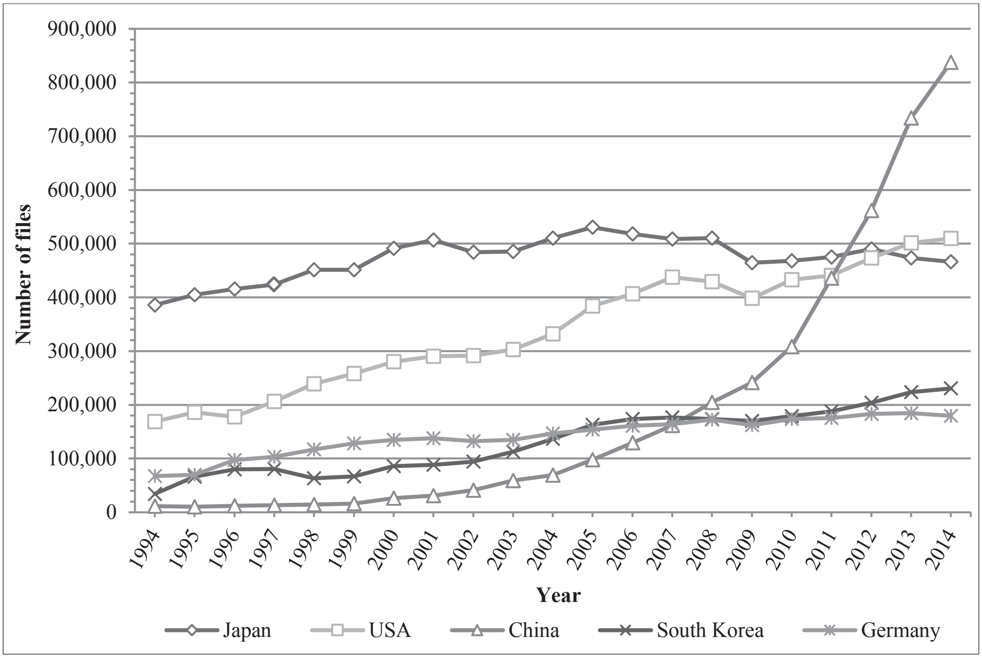
[1] This is the most recent data available as of April 2016.

Figure 1.1: Comparison of patent applications by the applicant's origin.



Source: WIPO (2016a).

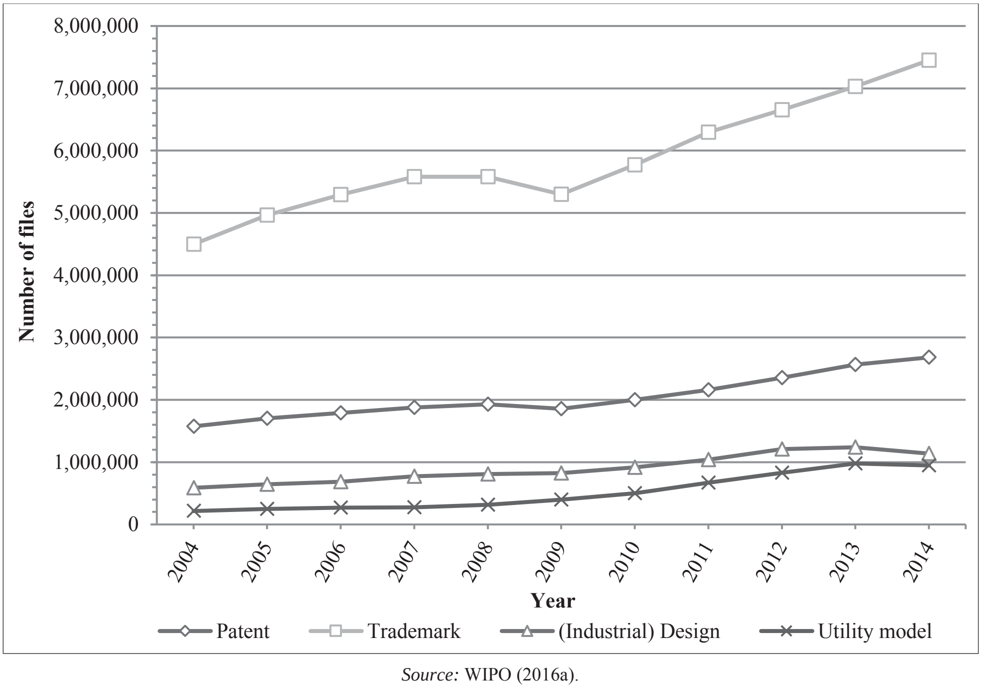
With its industrial transformation well underway, China now faces the follow-up challenge of transitioning from an imitation-based to innovation-based economy in order to complete its attempt to catch-up to further developed countries (Kim, 1997; Hu and Mathews, 2008). Past economic growth in China was largely driven by cheap labor and physical capital. These drivers, however, raise questions about the sustainability of this development and whether a similar development can be achieved in terms of innovation (Wu, 2001). To continue its economic growth, China needs sustainable growth and innovations to further improve its competitiveness moving away from low-cost manufacturing. China is aware of this problem and has undertaken several efforts to stimulate its transformation to an innovation-based economy by focusing their policies more on science and technology. The Chinese government reformed the funding system, developed high-tech industries, and encouraged private enterprises to engage in patenting (Scherngell et al., 2014; Guan and Yam, 2015). Also, China is actively trying to increase its patenting numbers even further: As part of the "National Patent Development Strategy" the Chinese government officially states that its goal is to quadruple invention patent applications by 2020 (SIPO, 2011) and the surge in patents can be seen as one indicator of a shift from imitation to innovation (Dang and Motohashi, 2015).

However, even though China is actively and prominently fostering innovation, research indicates that China is still far away from reaching the world's innovation frontier (Hu and Jefferson, 2009). This is mainly due to the rigidities of a planned, closed-market economy, in which innovation was neglected (Peng, 2003; Brandt and Rawski, 2008; Zhao et al., 2011). In light of this ongoing and still relatively unexplored phenomenon, this thesis addresses several important issues regarding the antecedents of patenting and value of patents in China.

1.1.2 Research context: Motives to file trademarks

While patents are the most frequently analyzed IPR, they are not the most frequently used IPR: As Figure 1.2 shows, trademarks are the most filed IPR overall. In 2014, 7.2 million new trademarks were registered worldwide, which is almost three times the number of new patent applications (2.7 million). Other important IPRs such as (industrial) designs and utility models are the third and fourth most filed IPRs, respectively.

Figure 1.2: Total number of applications of different IPRs.



Source: WIPO (2016a).

A trademark is an IPR that protects a distinctive sign in order to distinguish the goods and services of one individual or company from those of other individuals or companies (WIPO, 2016d). Trademarks protect words (e.g., product names), letters, and numerals.

They may also consist of drawings, symbols, logos, or three-dimensional signs. In some countries, non-traditional marks may be registered for distinguishing features such as holograms, motion, color, and non-visible signs (sound, smell, or taste) (WIPO, 2016d).

While patents are granted for technical inventions, the main function of a trademark is to distinguish the commercial source of a good or service in the eyes of customers, hence protecting the marketing assets and branding efforts of a company (Mendonça et al., 2004; Sandner and Block, 2011; De Vries et al., in press). Thus, trademarks constitute the legal basis of brands and enable a firm to protect its brands from free riding efforts by competitors (Block et al., 2014b). Through a trademarked brand name, consumers are able to identify the products that are offered by a specific firm. For example, by establishing an image of product quality, trademarks enable firms to demand premium prices for their products (Greenhalgh and Rogers, 2008; Jensen et al., 2008; Srinivasan et al., 2008). Also, brands can be among the most valuable assets that firms possess: For example, Apple's brand value, which is protected by trademarks, was estimated to be $170 billion in 2015, followed by Google ($120bn) and Coca-Cola ($78bn) (Interbrand, 2016).

In contrast to research on patenting, where most basic questions have been investigated thoroughly and demand a more nuanced perspective (e.g., a focus on patenting in China), research on trademarking is in comparatively early stages. While trademarks have been linked to the market valuation, survival, and productivity of firms (e.g., Srinivasan et al., 2008; Krasnikov et al., 2009; Sandner and Block, 2011; Greenhalgh and Rogers, 2012) little is known about firms' motivations to file trademarks, which is the second focus of this thesis.

1.2 Research questions

1.2.1 Antecedents and value of patenting in China (Chapters 2–5)

First, this thesis addresses the very recent research topic of patenting in China. The previous section outlined China's remarkable development in terms of patenting and described China's intention to become a leading nation in terms of innovation. Several previous studies exist that assess the overall development of patenting in China (e.g., Hu and Mathews, 2008; Li, 2012). These studies identify increases in China's national innovative capacity, for example, through increasing technology transfer, large government subsidies, innovation clusters, and strategic alliances (e.g., Chen and Kenney, 2007; Hu and Mathews 2008; Fang, 2011; Li, 2012).

In order to contribute to this literature, this thesis investigates multiple research questions that refer to the antecedents of patenting and the value of patents in China. While several studies have empirically analyzed the explosive increase in patenting in China, there are some particularities that have received scant attention. Therefore, this thesis addresses three more specific topics that relate to this development: university patenting, acquisitions, and patent quality and value.

University patenting (Chapters 2 and 3): Universities play a prominent and increasing role for a country's national innovative capacity (e.g., Etzkowitz and Leydesdorff, 2000). While the historical contribution of universities to innovation lies in providing education and performing (basic) research, today, universities increasingly pursue a "third mission" (Etzkowitz and Leydesdorff, 2000), which takes the form of a more direct technology transfer from university to industry, for example via patenting (e.g., Henderson et al., 1998; Geuna and Nesta, 2006). This is particularly true for China, where the role of universities with regard to the creation of knowledge has traditionally been very important (e.g., Hu and Mathews, 2008; Li, 2009; Huang and Wu, 2012). However, so far, little is known about university patenting and its role in the recent development of patenting in China. Chapters 2 and 3 will address this research gap and address the following research questions. In particular, Chapter 2 approaches the subject of university patenting from a global perspective, while Chapter 3 exclusively focusses on China:

RQ 2.1: *How do universities worldwide compare with regard to their patenting output?*

RQ 2.2: *How do university characteristics (e.g., location, size, publication record) affect a university's patent output?*

RQ 3.1: *How did Chinese university patenting develop in terms of patent quantity and quality over the past 20 years?*

RQ 3.2: *What are the effects of two types of governmental subsidy programs on Chinese universities' patent quantity and quality?*

Patent quality and patent value (Chapters 3 and 4): While there are studies that assess the increase in Chinese patent applications and its antecedents, little is known about the corresponding development of patent quality or patent value as an outcome of this increase. However, the rapid increase in patent applications in China (see Section 1.1.1 above) raises questions regarding patent quality and patent value, which are equally important characteristics when evaluating the sustainability and meaningfulness of the Chinese innovation development (e.g., Li, 2012). Particularly, the impressive increase in patent quantity might hide the fact that China's catch-up in terms of innovation is rather superficial. Both constructs (i.e., patent quality and value) are very similar and can be used as a proxy for the (economic) significance of a patent, most commonly measured via a patent's citations (e.g., Harhoff et al., 2003; Luan et al., 2010; Acosta et al., 2012). RQ 3.1 and RQ 3.2 therefore not only address the development of Chinese university patenting in terms of patent quantity, but also in terms of patent quality. In addition, Chapter 4 addresses the following research question:

> ***RQ 4:*** *How does the value of Chinese patents compare to the value of international patents?*

Acquisitions (Chapter 5): In changing environments, such as during a transformation from imitation to innovation, organizations face two choices: They can either develop capabilities internally, or they can acquire knowledge externally and utilize other's experiences (Peng, 2003; Zhao et al., 2011). The external acquisition of knowledge is particularly attractive for companies with limited capabilities that wish to expand their knowledge base fast, which is the case for China (Hitt et al., 2000; Zhao et al., 2011). Vehicles to acquire knowledge externally include strategic alliances, joint ventures, and mergers and acquisitions (M&As) (Peng, 2003).

Chapter 5 focuses on knowledge transfer in acquisitions because of its paramount importance in the Chinese context. For example, acquisitions by Chinese companies have increased at remarkable rates. China's FDI outflows (which include acquisition activity) are the third largest worldwide and are increasing rapidly (Ramasamy et al., 2012; UNCTD, 2015). Particularly, the access to technology and knowledge is often named as one of, if not *the* most important motivation for those acquisitions (e.g., Deng, 2004; Morck et al., 2008; Buckley et al., 2014). Previous research on the post-acquisition innovation performance has largely focused on developed countries and has questioned the ability of Chinese firms to successfully integrate acquired knowledge because of a lack of absorptive capacity (Rugman and Li, 2007; Anderson et al., 2015). Therefore, this thesis addresses the following research questions:

> ***RQ 5.1:*** *To what extent can Chinese firms increase their patent output following an acquisition?*

> ***RQ 5.2:*** *Which acquisition-specific factors influence the post-acquisition patent output?*

1.2.2 Motives to file trademarks (Chapter 6)

As outlined in Section 1.1.2, trademarks are a very important type of IPR for firms to distinguish themselves from competitors. While previous research on trademarking has investigated various antecedents and outcomes of trademarking (e.g., Srinivasan et al., 2008; Krasnikov et al., 2009; Sandner and Block, 2011), little is known on why firms file trademarks.

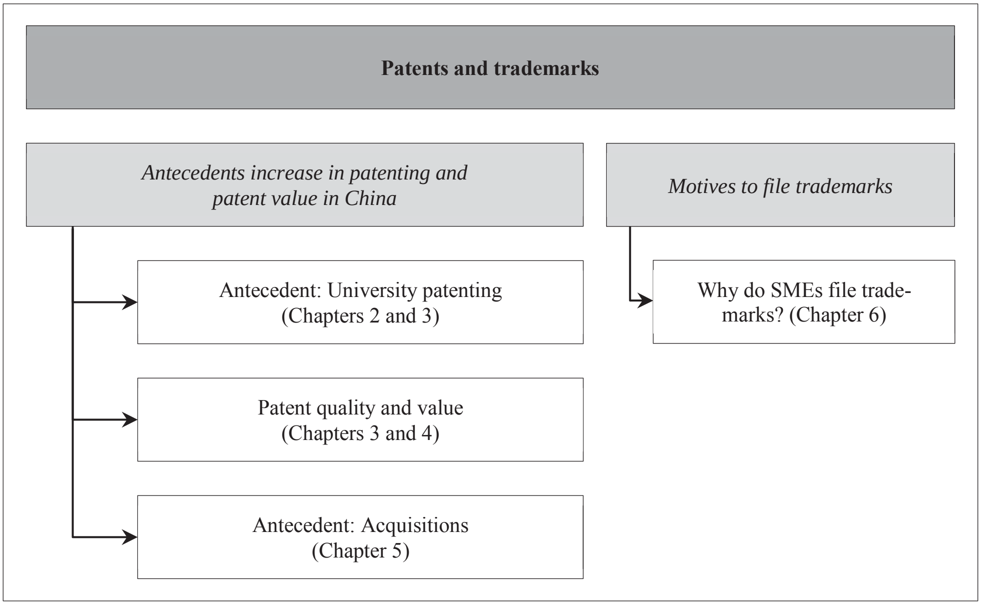
However, to interpret the increase in trademark filings and its economic effects, a better understanding of firms' trademarking motives is crucial. We chose to investigate SMEs because previous research has shown SMEs to be more active in trademarking than large firms

(Rogers et al., 2007; Greenhalgh and Rogers, 2008). Also, we expect SMEs to have a more clear motivation for filing trademarks, as they suffer from resource constraints. These constraints force them to more deliberately choose whether to file a trademark or not. Hence, this thesis investigates the trademarking motives of SMEs in an explorative way. More specifically, the following research question is addressed:

RQ 6: *Why do SMEs file trademarks?*

To provide an overview of the following chapters, Figure 1.3 illustrates the structure of this thesis. The chapters are described in detail in the following section.

Figure 1.3: Structure of the dissertation.



Source: Own illustration.

1.3 Chapter outlines

Chapter 2 addresses previously unexplored facets in the domain of university patenting. Universities play a very prominent role in a country's national innovation system (Mowery and Sampat, 2005b). Previous work on university patenting has mainly focused on the US and Europe, while there is very little research conducted at an international level. Moreover, prior research has focused on evaluating the impact of regulatory changes on patenting, such as the US Bayh-Dole Act, while research investigating university-specific determinants of patenting is scarce (e.g., Mowery et al., 2001; Geuna and Rossi, 2011). To address these shortcomings, Chapter 2 examines whether and how university characteristics affect a university's patent output and also provides a comparative overview of the universities' patent applications: While the ranking shows a huge predominance of US universities when investigating PCT (Patent Cooperation Treaty) applications (which provide a greater level of international comparability), Chinese universities take the top spots when only considering the total number of patent applications.

Chapter 3 more narrowly focuses on university patenting in China. Often, university patenting is stimulated by governmental subsidy programs or patent-friendly regulatory changes; for example, the Bayh-Dole Act in the US or similar regulations in Europe (e.g., Henderson et al., 1998; Sampat et al., 2003; Geuna and Rossi, 2011). Even though these regulatory changes intend to stimulate university patenting, their effects on patent quantity and especially on the equally important patent quality are not always straightforward (e.g., Mowery and Ziedonis, 2002; Sampat et al., 2003). In order to increase university patenting, the Chinese government has issued various initiatives in recent years. Chapter 3 focuses on two particular types of subsidy programs: First, China introduced cost-reimbursement subsidy programs at the regional level, which enabled patent applicants to receive a (partial) reimbursement of the costs of the patent application (Li, 2012). Second, the Chinese government introduced a large subsidy program to promote research excellence at selected leading Chinese universities and establish world-class universities ("Project 985"). In addition to analyzing the development of Chinese university patenting in terms of patent quantity and quality over the past 20 years in a descriptive way, Chapter 3 investigates and compares the effects of these two types of subsidy programs.

While Chapter 3 provides initial insights about the quality of Chinese university patents, **Chapter 4** deals with the economic value of Chinese patents in a more detailed way. Particularly, Chapter 4 assesses the value of Chinese patents compared to the value of international patents from further developed countries. Because there is no universally accepted definition of patent value, a patent's citation lag is used as a proxy for patent value. Citation lag refers to the time that elapses between the publication of a patent application and the first forward citation (i.e., citation received by a subsequent patent). A longer citation lag indicates a lower patent value, while a more valuable patent should be cited more quickly (Gay et al., 2005; Marco, 2007).

Chapter 5 focuses on acquisitions by Chinese companies. These acquisitions can be important vehicles for firms to increase their innovation performance (e.g., Hitt et al., 2000; Zhao et al., 2011). This is particularly true for Chinese firms, which partially rely on the external acquisition of knowledge to increase their innovation performance (e.g., Deng, 2004; Morck et al., 2008; Buckley et al., 2014). In addressing this unexplored phenomenon, Chapter 5 analyzes whether or not Chinese firms profit from acquisitions in terms of their innovation performance and also investigates which acquisition-specific factors influence the outcome.

While the previous chapters dealt with patenting in China, **Chapter 6** contributes to recent research on trademarking. To provide a systematic investigation of SMEs' trademarking motives, we conduct an empirical analysis comprising three steps using data from 600 SMEs in innovative industries. First, we draw on the extensive literature on patenting motives (e.g., Cohen et al., 2000; Blind et al., 2006) and develop a set of potential trademarking motives. We identify and empirically validate three trademarking motives using factor analysis: protection, marketing, and exchange. Second, we use these trademarking motives as active cluster variables in a cluster analysis to explore the empirical variation in the sample firms. We also compare the identified clusters with regard to passive cluster variables in order to provide a more detailed and nuanced description of the companies within these clusters (e.g., with regard to market, industry, and firm characteristics).

Finally, **Chapter 7** concludes with a summary and discussion of the main results of this thesis. In addition, the main implications of this thesis for both theory and practice are outlined. This thesis ends with a brief description of limitations and an outline for future research.

1.4 Publication status of the chapters and contribution of the author

Table 1.1 provides an overview on the publication status of the chapters included in this thesis. The chapters where co-authored by the following people (in alphabetical order): Joern H. Block, Tobias M. Hassel, Alexander Hahn, Philipp G. Sandner. Overall, three chapters have been published in international, peer reviewed journals. One of the remaining two chapters has been submitted for publication and is currently under review, while the other chapter is being prepared for submission. Table 1.1 also includes other completed manuscripts to which the author of this thesis contributed during the writing of this thesis and which have been published or are currently being submitted to journals. The manuscripts deal with the topics of entrepreneurship, innovation, patents, trademarks, and venture capital. Out of these seven manuscripts, six have been published or accepted for publication.

The following paragraphs describe the contribution of the author of this thesis to the different chapters:

Chapters 1 and 7: Both chapters were written independently by the author of this thesis.

Chapter 2: Large parts of the chapter were done by the author. The author of this thesis drafted and wrote large parts of the introduction, the literature review, the development and refinement of the hypotheses, as well as the discussion and conclusion. Also, the author was responsible for large parts of the data collection and for conducting and extending the empirical analyses. The paper is published in the *Journal of Technology Transfer*. The publishing process involved multiple rounds of major revisions, which were led and largely carried out by the author.

Chapter 3: The majority of work in this chapter has been done by the author of this thesis. The author wrote large parts of the introduction, performed the literature review, conducted the data collection analyses, interpreted and discussed the findings. The paper is published in the *Journal of Technology Transfer*. The publishing process involved multiple rounds of major revisions, which were led and largely carried out by the author of this thesis.

Chapter 4: In this chapter, the author wrote large parts of the introduction and conclusion, as well as the conceptual framework. Also, the author of this thesis was responsible for conducting the final empirical analyses.

Chapter 5: The majority of this manuscript was written by the author of this thesis. The author wrote the introduction, theory and hypotheses, collected all of the data, performed the empirical analyses, interpreted and discussed the findings. The manuscript is currently submitted to a journal.

Chapter 6: In this chapter, the author of this thesis contributed to the introductory section by drafting the motivation and contributions of the study. Also, the conceptual framework was largely written by the author. The author also conducted the final versions of the empirical analyses, and contributed to the interpretation and discussion. The paper is published in the *Research Policy*. The publishing process involved multiple rounds of major revisions, which were led and largely carried out by the author.

Table 1.1: Publication status of this thesis' chapters and other manuscripts the author of this thesis contributed to during the writing of this thesis.

Chap.	Full title	Publication status	Co-authors	Reference
Manuscripts used in this dissertation				
2	University patenting: a comparison of 300 leading universities worldwide	Published in *Journal of Technology Transfer*	Hassel, T.M., Sandner, P.G., Block, J.H.	Fisch et al. (2015)
3	Chinese university patents: Quantity, quality, and the role of subsidy programs	Published in *Journal of Technology Transfer*	Block, J.H., Sandner, P.G.	Fisch et al. (2016a)
4	The value of Chinese patents: an empirical investigation of citation lags	Submitted	Sandner, P. G., Regner, L.	Fisch et al. (2016c)
5	The impact of acquisitions on Chinese acquirers' patent output	-	Block, J.H., Sandner, P.G.	Fisch et al. (2016b)
6	Why do SMEs file trademarks? Insights from firms in innovative industries	Published in *Research Policy*	Block, J.H., Hahn, A., Sandner, P.G.	Block et al. (2015)
Other manuscripts				
	Socialist heritage and the opinion on entrepreneurs: Micro-level evidence from Europe.	Published in *Business Administration Review*	Adam-Müller, A.F., Andres, R., Block, J.H.	Adam-Müller et al. (2015)
	Trademark families: characteristics and market values	Published in *Journal of Brand Management*	Block, J.H., Sandner, P.G.	Block et al. (2014b)
	Who prefers working in a family firm? An exploratory study of individuals' org. preferences across 40 countries	Published in *Journal of Family Business Strategy*	Block, J.H., Lau, J., Obschonka, M., Presse, A.	Block et al. (2016a)
	Labor market institutions and the preference to work in family firms: A cross-country, multi-level investigation	-	Block, J.H., Lau, J., Obschonka, M., Presse, A.	Block et al. (2016b)
	Trademark or patent? The effects of market concentration, customer type, and venture capital financing on start-ups' initial IP applications	Accepted for publication in *Industry and Innovation*	De Vries, G., Pennings, H.P.G., Block, J.H.	De Vries et al. (in press)
	The significance of the CEO for the internationalization of small and medium-sized enterprises	Published in *Wirtschaftspolitische Blätter*	Block, J.H.	Fisch and Block (2013)
	The Schumpeterian entrepreneur: A review of the empirical evidence on the antecedents, behavior, and consequences of innovative entrepreneurship	Accepted for publication in *Industry and Innovation*	Block, J.H., Van Praag, M.,	Block et al. (in press)

Note: "Other manuscripts" are ordered alphabetically based on the names of authors.

Chapter 2

University patenting: A comparison of 300 leading universities worldwide

Despite a worldwide increase in university patenting, empirical studies have largely focused on analyzing university patenting in individual countries and regions. We provide analyses from an international perspective, examining patents at the top 300 universities worldwide. By providing a patent ranking system and an analysis of the determinants of university patenting, we enable an international comparison not only between different countries but also between universities within countries. A ranking of the top-patenting universities shows a huge predominance of US universities: 18 of the top 25 universities are located in the US, with the Massachusetts Institute of Technology (MIT) being ranked first. Our results show that the propensity to apply for patents is very high among US and Asian universities, while European universities lag behind. In addition to the home country, further determinants of university patenting are the quantity of the universities' publications and a technological focus in areas such as chemistry and mechanical engineering. However, the size of a university and the quality of its publications are not found to be significant determinants.

This chapter is based on Fisch et al. (2015).

2.1 Introduction

Universities are an important part of a country's national innovation system, which is the institutional landscape shaping the innovativeness of a country (Mowery and Sampat, 2005b) and contributes to its economic growth and international competitiveness (Furman et al., 2002; Van Looy et al., 2011). Historically, the contribution of universities to innovation lay in providing education and performing (basic) research (Rosenberg and Nelson, 1994; Henderson et al., 1998; Agrawal and Henderson, 2002).

Complementing the classical tasks of education and research, there has been a shift in universities' aims toward a more direct contribution to economic development (Etzkowitz and Leydesdorff, 2000). Today, most universities worldwide pursue this "third mission" (Etzkowitz and Leydesdorff, 2000) in the form of a wide range of technology transfer activities from universities to industry. Consequently, there has been a large increase in university-industry technology transfer to commercialize the research results of universities (Henderson et al., 1998; Siegel et al., 2003b). As one means of technology transfer, the universities' propensity to file patents has grown markedly (e.g., Henderson et al., 1998; Geuna and Nesta, 2006).

While previous work on university patenting has mainly focused on the US, evidence on European and Asian universities is growing (e.g., Henderson et al., 1998; Hu and Mathews, 2005; Geuna and Rossi, 2011). Despite the recognition of a worldwide upswing in university patenting, there is a surprising dearth of empirical studies on this topic at an international level. Because the increase in university patenting is observable worldwide, an analysis encompassing this international scope should lead to interesting and novel insights. Furthermore, prior literature on the determinants of university patenting has largely focused on evaluating regulatory changes such as the US Bayh-Dole Act (e.g., Mowery et al., 2001; Geuna and Rossi, 2011). While these policies are shown to be important determinants of the recent increases in university patenting, research on university-specific determinants is scarce, though there is a considerable heterogeneity among universities (e.g., size, R&D expenditures, and publication output) that is likely to influence technology transfer activities (Hewitt-Dundas, 2012).

To fill this gap, we examine the patent applications filed by the 300 leading universities worldwide as ranked by the renowned Academic Ranking of World Universities (ARWU) in 2013 (Shanghai Jiao Tong University, 2014). Drawing from this sample of the "best" universities worldwide, we analyze whether and how a range of university characteristics (e.g., location, size, and publication record) affect patent their output in terms of the number of patent applications. Further, we generate a university ranking comparing the top patenting universities worldwide. The main goal of our study is twofold. First, we want to analyze the determinants of university patenting on an international level, which will allow us to contribute to the literature on university patenting. Second, we aim to enable an international comparison of the patenting activity of universities and, as a result, generate a patent ranking of the top universities worldwide.

Our results show that the propensity to apply for patents is very high among US and Asian universities, while European universities lag behind. Furthermore, universities across all regions apply for significantly more patents in their country of residence. Additionally, the results show that a university's technological focus in the areas of chemistry, electrical engineering, and mechanical engineering lead to a higher patent output. The size of a university and the quality of its publications are not found to be significantly associated with the number of patent applications.

The remainder of the chapter is structured as follows: Prior literature on university technology transfer is reviewed in Section 2.2. Hypotheses are derived in Section 2.3, and data and variables are described in Section 2.4. Descriptive statistics, a patent ranking of the universities in our sample, and multivariate statistics are presented and discussed in Section 2.5. Section 2.6 concludes the chapter and provides avenues for future research.

2.2 Literature review on university patenting

Universities increasingly prioritize technology transfer (Henderson et al., 1998; Siegel et al., 2003b). Henderson et al. (1998) describe the search for new ways of funding and an increasing competition for funding as some of the main reasons for the increasing engagement. Common forms of university-industry technology transfer include research co-operations, start-ups, and licensing, with licensing being the primary mechanism for universities to benefit from inventions (Shane, 2004). This notion is also reflected in the organizational structure of universities, as most universities have established technology transfer offices (TTOs) to specifically manage and coordinate the activities associated with the commercialization of their research (Thursby et al., 2001; Siegel et al., 2003b). These increased commercialization efforts have also been supported by policymakers. Several regulations to facilitate technology transfer have been implemented worldwide. A prime example is the US Bayh-Dole Act, which enabled universities to retain intellectual property and appropriate licensing revenues from federally funded research (Mowery and Sampat, 2005a). It has since been emulated by most European countries (Geuna and Rossi, 2011).

The increasing interest in commercialization at universities has led to a large body of literature on university technology transfer. Patents, which are crucial for licensing, are frequently used to capture the innovative capacity of universities (Henderson et al., 1998; Mowery et al., 2001; Baldini, 2009). In accordance with the aforementioned increase in technology transfer, the previous literature has noted a huge surge in university patenting in the US (e.g., Henderson et al., 1998; Sampat et al., 2003), Europe (e.g., Geuna and Nesta, 2006; Geuna and Rossi, 2011), Asia (e.g., Hu and Mathews, 2005), and particularly China (e.g., Chapter 3). However, previous literature on university patenting has been regionally focused. Although universities worldwide have been analyzed, no study has examined universities' innovative capacities (i.e., patent output) from an international point of view (i.e., taking into account more than one country or region). A notable exception is the work of Wong and Singh (2010), who analyze the relationship between publishing and patenting in an international setting. However, the authors only use patents filed at the US Patent and Trademark Office (USPTO) and the European Patent Office (EPO).

Regarding the determinants of the increasing importance of technology transfer, prior literature has largely focused on assessing the effects of regulatory changes such the Bayh-Dole Act on university patenting (Henderson et al., 1998; Geuna and Rossi, 2011). These policies have been shown to have an important effect on the recent increases in university patenting on a general level; that is, the universities in a country are assumed to be affected in a uniform way. However, there is a considerable heterogeneity not only among universities in different regions but also among universities in the same country. This heterogeneity, as illustrated by the multitude of university rankings that have emerged in recent years, is likely to be reflected in technology transfer activities, thereby explaining differences in university patenting to some extent (Hewitt-Dundas, 2012). However, evidence on university-specific determinants is scarce and often limited to (individual) institutions or technological fields (Mowery et al., 2001; Crespi et al., 2011).

Due to these shortcomings, i.e., a regional focus and the negligence of university-specific factors, we believe that an international overview of university patenting that focuses on university-specific aspects can provide valuable insights.

2.3 Hypotheses

The number of university patents in the US has increased radically since the 1980s, in part due to the Bayh-Dole Act (Sampat et al., 2003). Inspired by this example, several European countries introduced Bayh-Dole-like legislations to facilitate patenting and licensing for universities in subsequent years (Baldini, 2009; Geuna and Rossi, 2011). These initiatives, which have enabled universities to more easily retain patents on academic inventions, were established to address the so-called "European Paradox": Although Europe produces a high academic research output, Europe is lagging behind the US in technology transfer (Baldini, 2009; Conti and Gaule, 2011).

Despite these initiatives, huge differences remain between the rate of research commercialization between US universities and European universities (Baldini, 2009; Conti and Gaule, 2011). Prior literature has shown that a large share of university-invented patents is still assigned to non-academic institutions or individuals, not the university engaged in developing the patent. For example, Lissoni et al. (2008) indicate that more than 60% of the patents by academic scientists in France, Italy, and Sweden are assigned to companies or other entities. Similarly, Crespi et al. (2006) show that approximately 80% of the patents with academic inventors in Europe are not university-owned. Additionally, Conti and Gaule (2011) largely attribute this gap to differences in TTO structure and staffing. The authors find that one of the main reasons that US TTOs are able to generate more licensing income is that they employ staff with more industry experience than European TTOs.

Differences in university patenting between Europe and the US are prioritized in this study. Besides, university patenting in Asia underwent a remarkable growth and is of great importance for the technological catch-up for countries such as China (Hu and Mathews, 2008; Chapter 3). As such, it will be interesting to further assess how Asian universities perform in comparison. Therefore, we propose the following hypothesis:

H2.1: *European universities file fewer patent applications than US universities do.*

Patent applicants tend to file patent applications domestically, first and foremost. This "home advantage effect" affects patenting rates at most patent offices worldwide (Criscuolo, 2006). Firms tend to file disproportionally large numbers of domestic patents to protect an already established market, which is usually their home market (Criscuolo, 2006). For universities, Leydesdorff and Meyer (2010) expect this home advantage effect to be even more prevalent. This prevalence could arise because university research has a tendency to be less market-oriented compared with industry research, leaving universities with fewer incentives to patent in foreign regions. This locality of knowledge transfer is further supported by literature describing the increasing knowledge spillovers from university to industry based on geographical proximity. As such, Acosta et al. (2009) note that companies located near universities benefit from early access to local inventions, while Owen-Smith and Powell (2003) describe that universities located in university-industry clusters tend to patent more as a result of extensive contacts to firms located in the cluster. Thus, these clusters support university knowledge transfer locally. Additionally, the home advantage effect is augmented by a familiarity with the domestic patent system. For example, Liegsalz and Wagner (2013) show that domestic applicants in China are able to achieve significantly faster patent grants than are foreign applicants because the former have more experience with the Chinese patent system, among other factors. Based on this familiarity, the home advantage effect should be present worldwide and should not differ greatly between regions. We suggest the following:

H2.2: *Universities file more patent applications domestically than they do in foreign countries.*

Although universities are heterogeneous not only between but also within regions and countries, research on university-specific determinants of university patenting is scarce (Hewitt-Dundas, 2012). Generally, there are various characteristics that are likely to affect a university's patent output (Mowery and Sampat, 2005a; Hewitt-Dundas, 2012). A university-specific characteristic that has been shown to affect patenting is the size of a university because universities of a greater size tend to have more resources to use in the development of patents. For example, Landry et al. (2006) found that the size of a university is a significant determinant of university-industry knowledge exchange based on a survey of 1,554 researchers in Canada. Based on US university patenting data, Bulut and Moschini (2009) and Coupé (2003) find a similar influence of university size. This importance is further underlined by Hewitt-Dundas (2012). Similarly, Carlsson and Fridh (2002) and Siegel et al. (2003a) find that the size of a university TTO is a relevant factor in explaining the number of university patents. Therefore, we similarly propose a positive relationship of university size on patent output of universities worldwide:

H2.3: *The size of a university is positively related to the number of patent applications filed.*

The productivity of a university in terms of scientific publications is connected to its patent output. Publishing and patenting might be expected to substitute each other, as the publication of a paper might, for example, limit the patentability of the same results and vice versa (Breschi et al., 2005; 2008). Despite this potential trade-off, empirical work has frequently found the relationship between patenting and publishing to be complementary and positive (e.g., Breschi et al., 2005; 2008; Meyer, 2006; Stephan et al., 2007; Crespi et al., 2011). In this vein, Agrawal and Henderson (2002) indicate that one explanation is non-exclusivity between publishing and patenting because most research can lead to both publications and patents. Another explanation is that publishing, or the prestige resulting from it, might serve as an advertisement (Fabrizio and Di Minin, 2008) that can lead to potential collaborations with industry partners and can stimulate both publishing and patenting. Other explanations include synergies between publishing and patenting that arise from the discovery of fertile research questions in collaboration with industry, access to new data and instruments, and increasing prestige (Breschi et al., 2005; 2008).

Although this topic has already received considerable attention, empirical work has primarily been conducted at the individual level of the scientist rather than at the university level. Moreover, previous studies have been limited in their scope because they generally refer to a set of universities within individual countries or specific disciplines such as nanotechnology. As a notable exception, Wong and Singh (2010) show that the publication quantity of international universities positively influences patenting numbers. Therefore, we propose the following:

H2.4: *The quantity of a university's publications is positively related to the number of patent applications filed.*

While prior literature on the relationship between publishing and patenting mostly refers to the quantitative effect of publishing, the quality of the published results might also affect patenting. The quality or the importance of publications is commonly measured by the citations they receive. Di Gregorio and Shane (2003) suggest that researchers who develop high-quality innovations may want to capitalize on them by engaging in not only publishing the results but also technology transfer. Furthermore, high-quality innovations might be better suited for commercialization (O'Shea et al., 2005; Perkmann et al., 2011). While Di Gregorio and Shane (2003) and O'Shea et al. (2005) empirically show that researchers with a high-quality publication output lead to a higher number of start-ups per university, this argument can be extended to explain increased patenting as another means for a scientist to capitalize on the information advantage from high-quality research results. As such, Lach and Schankerman (2008) find a positive effect of citations in publications on licensing in public US universities. Similarly, Meyer (2006) describes that in the field of nano-technology, university researchers engaged in patenting tend to outperform their non-patenting counterparts in publication citations, while Zucker and Darby (1996) discover similar results for bio-scientists. Finally, Wong and Singh (2010) find that publication citations positively influence the number of US patents for US universities. Taken together, the research results published in high-quality publications should be more likely to be patented. We thus suggest the following:

H2.5: *The quality of a university's publications is positively related to the number of patent applications filed.*

Many studies on university patenting focus on different technology-intensive areas such as biotechnology or biomedicine (e.g., Mowery and Ziedonis, 2002; Mowery and Sampat, 2005a; Sapsalis et al., 2006). This is not coincidental, as prior literature suggests that the surge in academic patenting has been largely driven by the emergence and increasing importance of these technology-intensive areas (Van Zeebroeck et al., 2008; Foltz et al., 2000). Zucker et al. (1998) highlight the importance of universities as central to the formation of the relatively young sector as a whole, which evolved around the scientific breakthroughs achieved largely in universities and by "star" scientists. Accordingly, Van Zeebroeck et al. (2008) describe biotechnology as the main area of growth for university patenting in the US and Belgium, while Geuna and Nesta (2006) identify biotechnology as showing the highest university activity in further European countries patenting in Europe. Note that biotechnology and pharmaceuticals are categories of the broader area of chemistry. Hence, we conjecture the following:

H2.6: *A university's share of patent applications in the area of chemistry is positively related to the number of patent applications filed.*

2.4 Data

2.4.1 Dataset

Our empirical analysis is based on a newly created dataset. The data were collected from two independent sources. Patent data were obtained from the database PATSTAT (version of October 2013). PATSTAT is currently the most comprehensive international database on patents. Data on university characteristics were obtained from the Academic Ranking of World Universities of the year 2013 (Shanghai Jiao Tong University, 2014). The ARWU is widely used and is one of the most comprehensive rankings of universities worldwide. The ranking is based on multiple objective indicators, such as the quantity and quality of its publications, primarily capturing the research performance of a university. We identified the patent applications by the top 300 universities as ranked in the ARWU of 2013. Because these universities are among the most research intensive universities worldwide, they can be expected to account for a large share of university patenting (Wong and Singh, 2010).

We identified all patents that list one of the 300 universities as applicant or assignee. Because PATSTAT is organized on the level of patent documents and not applicants, we developed a variety of search patterns to match patents to universities. To account for different variations of applicant names, we refined these search patterns in 13 iterations. For example, the search patterns accounted for name changes, different university names in different languages, spelling errors in the patent document, and entities that do not always share the name of the respective university but belong to it (e.g., hospitals, institutes, or TTOs). For instance, the University of Oxford files very few patent applications itself but instead files them through its technology transfer company ISIS Innovation Ltd. Thus, only identifying patents that list the University of Oxford as an applicant would severely underestimate its patent output.

Furthermore, the ARWU includes US universities on a campus level if they belong to a multi-campus university or university system. The prime example is the University of California (UC), which is represented by 8 different campuses (e.g., Berkeley, Los Angeles, and San Francisco) in the top 300 of the ARWU ranking. These universities file most of their patents as "The Regents of the University of California" so that the particular campus to which the patents belong is unclear. Wong and Singh (2010) describe the same problem and decide to exclude the UC. Another way would be to include UC as 1 instead of 8 universities. However, both approaches severely bias the analysis. As a solution, we divide the patents that are not clearly assignable to mirror their actual patenting output. In the case of the UC, information on patents filed per campus in 2011 is provided directly by the UC's technology transfer report (University of California, 2012). We use the shares of patent applications per campus reported and assign the patents in our sample accordingly. If information on patent applications per campus is not obtainable for the respective university, we use data on R&D

expenditures by campus to approximate the share of patents applied for by individual campuses and distribute them accordingly. These data are provided by the US National Science Foundation that was published in 2011 (National Science Foundation, 2013).

In total, our approach results in a sample of 300 universities from 32 different countries. These universities applied for 316,393 patents from 2001 to 2011. We limit our analysis to this more recent time frame because a longer history of university patenting in a country (e.g., in the US compared with China) would bias the estimates severely. Furthermore, 2011 was the most recent year that has been completely included in PATSTAT when the analyses were conducted.

2.4.2 Variables

Dependent Variable: To measure patent output, we use the number of *patent applications* filed by each university between 2001 and 2011. To account for potential differences between patents filed in different legislations and to assess the prevalence of a home advantage effect, we use different variants of this variable: patent applications under the Patent Cooperation Treaty (PCT applications), patent applications at the USPTO, patent applications at European patent offices including the EPO, patent applications at Asian offices, and the overall number of patent applications.

However, our main focus is on the number of *PCT applications*. A PCT application is an international patent application that can be filed instead of national applications and can lead to simultaneous patent protection in up to 140 contracting states. Hence, PCT patent applications are standardized worldwide with regard to different aspects, such as formal requirements and a high-quality international search. Consequently, PCT applications provide a high comparability among different countries and are frequently used in international analyses (e.g., Criscuolo and Verspagen, 2008; Godinho and Ferreira, 2012).

As a further check of robustness, we include the number of *patent families* per university. Patent families are frequently used to account for a potential overrepresentation of patents filed at multiple patent offices. At their core, patent families represent patented innovations, whereas patent applications or patents correspond to the geographic coverage where protection is sought for these innovations, i.e., multiple patent applications refer to and are filed to protect the same or a similar invention in multiple jurisdictions (Li, 2012). Members of a patent family are identified by the standard processes enshrined in patent law and build on the priority applications of a patent. Priority applications are highly important to determine the date on which an invention was recorded in the patent register. One such standard of grouping patent applications to patent families is the INPADOC classification, which is also included in PATSTAT. We rely on this standard to reconcile the patent families in our data. As a further measure used in the descriptive statistics, we calculate the average size of a family as the average number of different legislations in which the members of a family are filed.

Independent Variables: To address the differences between universities from the US, Europe, Asia, and other countries, we include a dummy variable for each region. Table 2.A1 (Appendix) provides further details on the specific countries in each region.

The size of a university is frequently measured in terms of its employed staff (Hewitt-Dundas, 2012) or its resource endowment (e.g., R&D expenditures or R&D budget) (Landry et al., 2006; Bulut and Moschini, 2009). The ARWU includes specific data on both a university's R&D staff (*R&D staff*) and its R&D budget in terms of external funds received (*R&D budget*). Both variables are provided as ordinal variables, ranking universities from 1 (best) to above 500. Harvard University was ranked first in terms of R&D staff, while the University of Pennsylvania was ranked first regarding the R&D budget. If the information was missing for a university, we assign the mean value in the respective scale to it.

To measure publication quantity, we use an indicator also obtained from the ARWU (*publication quantity*). A university's score is based on the number of papers that were indexed in the Science Citation Index-Expanded and Social Science Citation Index in 2012. The scores are normalized and given values from 0 to a maximum of 100 (only reached by Harvard University). Similarly, the quality of universities' research performance is measured using the HiCi score from the ARWU (*publication quality*). The values are calculated from the number of highly cited researchers in 21 subject categories. The measure is normalized taking values from 0 to 100 (the latter if which is only reached by Harvard University).

Finally, we account for the different areas in which patent applications are filed by including the share of applications filed in each *area* per university. We classify the patents according to Hinze et al. (1997), thus distinguishing the areas of chemistry, consumer goods, instruments, electrical engineering, mechanical engineering, and process engineering.

Control Variables: To account for further differences between countries in terms of IPR, we include the *patent protection index* developed by Park (2008), in its latest version from 2005. The index assigns each country a score based on different dimensions of the national patent system, such as the participation in international treaties or enforcement mechanisms. It is scaled from 0 to 5, with the US achieving the highest score of 4.88. Furthermore, we include a dummy that takes a value of 1 if the university is a technical university (i.e., carries a variation of the term technology in its name). We expect technical universities to file more patents due to their more patent-affine orientation.

2.5 Analysis

2.5.1 Descriptive statistics

Descriptive statistics are presented in Table 2.1. The majority of universities in our sample are European (42.0%), closely followed by universities from the US (35.7%). Approximately 9.7% of the universities are Asian, while the remaining 12.7% are not located in these regions. Table 2.A1 (Appendix) provides further details on the countries of origin, indicating that the country with the most universities ranked in the ARWU top 300 is the US (35.7%), followed by the United Kingdom (9.7%), and Germany (7.7%).

The universities in our sample obtained an average rank of 179.1 in terms of research staff and 152.7 in terms of research budget. While the maximum rank (i.e., the worst rank) is 1,000, the universities in our sample reach ranks from 1 to 556 (*R&D staff*) and 635 (*R&D budget*). Note that multiple universities can be ranked at the same rank. Regarding publication quality and quantity, the universities reach scores from 0 (*publication quantity*) and 13.1 (*publication quality*) to the maximum of 100. Again, there are multiple universities receiving equal scores, with Harvard University being exclusively ranked first in both dimensions.

The universities in our sample applied for approximately 1,055 patents on average between 2001 and 2011. However, the patenting rates vary considerably between universities. Zhejiang University (China) filed the overall most patent applications (16,339), and seven universities did not file any patents in the period considered. While the average number of patent families per university is 487.8, the average patent family consists of applications filed in 4.3 legislations. Note that there are many patent families with a size of 1. For example, while Zhejiang University filed the most patents in our sample (16,339), it also accounted for the maximum number of patent families (16,136), as most of the patents were filed only in China.

Similar to publication citations, forward citations (i.e., citations that patents receive) are used to measure the importance or quality of patents (Henderson et al., 1998; Mowery and Ziedonis, 2002; Harhoff et al., 2003). Forward citations are defined as the number of citations that a university's patent families receive within five years of the initial patent publication because forward citations typically peak within four to five years of the initial application (Mowery and Ziedonis, 2002). Because newer patents would be right-censored, we only include citations received by patent applications filed until 2006. Similarly, the citation intensity is the number of forward citations a university received divided by the overall number of patent applications until 2006. The universities received an average of 710.6 citations, or 0.6 citations per application filed. The Massachusetts Institute of Technology (MIT) received the most forward citations among all of the universities in our sample (10,936).

Table 2.1: Descriptive statistics.

Variable	Mean	SD	Median	Min.	Max.
University Characteristics					
US (dummy)	0.357	-	0	0	1
EU (dummy)	0.420	-	0	0	1
Asia (dummy)	0.097	-	0	0	1
Others (dummy)	0.127	-	0	0	1
R&D staff	179.13	117.96	179.00	1	556
R&D budget	152.73	102.90	153.00	1	635
Publication quality	21.86	15.12	17.70	0	100
Publication quantity	43.34	12.05	40.75	13.10	100
Technical university (dummy)	0.090	-	0.000	0	1
Patent protection index	4.605	0.306	4.670	2.980	4.880
Patenting activity (per university)					
Patent applications	1,054.64	1,635.34	588.50	0	16,339
Patent families	487.77	1,349.19	194.00	0	16,136
Average family size	4.295	1.577	4.324	0	9.331
Forward citations	710.58	1,135.70	315.50	0	10,936
Citation intensity	0.637	0.512	0.470	0	3.263
Patent applications by patent office					
PCT	186.27	214.06	116.00	0	1,733
USPTO	241.52	342.81	102.50	0	2,580
European offices (incl. EPO)	192.51	197.50	137.00	0	1,328
EPO	103.46	100.66	72.00	0	579
Asian offices (incl. SIPO)	298.13	1,371.08	34.00	0	16,165
SIPO	197.30	1,286.15	17.50	0	16,160
Area of the patent applications					
Chemistry	0.591	0.197	0.628	0.000	1.000
Consumer goods	0.019	0.028	0.011	0.000	0.250
Electrical engineering	0.188	0.139	0.164	0.000	1.000
Instruments	0.327	0.124	0.327	0.000	1.000
Mechanical engineering	0.036	0.042	0.024	0.000	0.255
Process engineering	0.105	0.070	0.093	0.000	0.444
Others	0.018	0.019	0.013	0.000	0.147

Notes: N = 300 universities.

Data sources: PATSTAT (version: October 2013), Academic Ranking of World Universities 2013 (Shanghai Jiao Tong University, 2014), Hinze et al. (1997), Park (2008).

Table 2.1 further breaks down the patent applications per patent office. On average, each university filed 186.3 PCT patent applications, which is approximately 18% of all applications. While the universities in our sample filed an average of 241.5 US patents, an average of 192.5 patents were filed at European offices, and an average of 298.1 were filed at Asian offices. Next to the USPTO, the EPO and the State Intellectual Property Office (SIPO) were the two patent offices that received the second and third most applications and accounted for a majority of the patents filed in Europe and Asia. Again, the application numbers at Asian patent offices, particularly the SIPO, are comparatively high. This is largely driven by the very high application numbers of Asian (especially Chinese) universities that file large numbers of patents first and foremost in their country of residence. This bias is further illustrated by the very low median values, which show that half of the universities in the sample applied for 17.5 or fewer patents at the SIPO, in contrast to the misleadingly high mean value of 197.3.

Regarding the area of application, the majority of patents in the sample are applied for in the field of chemistry. In detail, most universities filed more than 59.1% of their patents in this area. With regard to the other areas of application, on average universities filed 1.4% of their total number of patents in consumer goods and construction, 18.8% in electrical engineering, 32.7% in instruments, 3.6% in mechanical engineering, 10.5% in process engineering, and 1.8% in other fields of research. Note that the sum is more than 100% because a patent can be filed in multiple areas. Consistent with previous research (Mowery and Ziedonis, 2002; Mowery and Sampat, 2005a), university patenting is concentrated in the broadly defined area of chemistry, including biotechnology and pharmaceuticals.

2.5.2 Patent ranking of international universities

Neither the ARWU nor any other ranking that we identified ranks universities based on their patenting activity. Consequently, Tables 2.2 (a) and 2.2 (b) present an excerpt of the top 25 universities in terms of PCT patent applications and overall patent applications based on our sample of the ARWU's top 300 universities worldwide.

Table 2.2: (a) Ranking of the top 25 universities according to the number of PCT applications filed between 2001 and 2011.

Rank	University	Country	Number of patent applications filed					Share of patent applications filed				Average family size	No. of forward citations	Citation_ intensity
			PCT	USPTO	EU	Asia	All	PCT	USPTO	EU	Asia			
1	MIT	US	1,733	2,580	791	497	6,531	26.5%	39.5%	12.1%	7.6%	4.51	10,936	1.67
2	Johns Hopkins University	US	1,154	1,563	694	251	4,634	24.9%	33.7%	15.0%	5.4%	4.88	4,417	0.95
3	University of Florida	US	1,059	1,148	387	190	3,361	31.5%	34.2%	11.5%	5.7%	3.97	3,066	0.91
4	Columbia University	US	956	961	342	205	2,972	32.2%	32.3%	11.5%	6.9%	4.45	3,787	1.27
5	University of Tokyo	JP	888	616	636	2,504	4,831	18.4%	12.8%	13.2%	51.8%	3.42	1,950	0.40
6	Stanford University	US	879	1,731	695	266	4,372	20.1%	39.6%	15.9%	6.1%	4.62	6,444	1.47
7	Harvard University	US	803	876	450	240	2,753	29.2%	31.8%	16.4%	8.7%	4.31	2,921	1.06
8	Univ. of Mich., Ann Arbor	US	764	1,261	469	254	3,146	24.3%	40.1%	14.9%	8.1%	4.24	4,446	1.41
9	Univ. of Wisconsin, Madison	US	746	1,327	713	200	3,960	18.8%	33.5%	18.0%	5.1%	5.78	3,974	1.00
10	UC, San Diego	US	744	1,582	414	288	3,641	20.4%	43.5%	11.4%	7.9%	4.75	4,003	1.10
11	California Inst. of Tech.	US	740	1,436	398	151	3,106	23.8%	46.2%	12.8%	4.9%	3.56	6,007	1.93
12	University of Pennsylvania	US	692	902	488	226	3,014	23.0%	29.9%	16.2%	7.5%	6.34	2,418	0.80
13	UC, San Francisco	US	646	1,371	373	218	3,164	20.4%	43.3%	11.8%	6.9%	4.84	3,523	1.11
14	Osaka University	JP	640	406	360	1,831	3,346	19.1%	12.1%	10.8%	54.7%	2.93	1,091	0.33
15	UC, Berkeley	US	633	1,429	345	237	3,174	19.9%	45.0%	10.9%	7.5%	4.48	3,638	1.15
16	Kyoto University	JP	627	405	331	449	1,951	32.1%	20.8%	17.0%	23.0%	4.30	892	0.46
17	Cornell University	US	625	930	386	214	2,570	24.3%	36.2%	15.0%	8.3%	4.26	2,281	0.89
18	UC, Los Angeles	US	619	1,324	355	199	3,032	20.4%	43.7%	11.7%	6.6%	4.65	3,325	1.10
19	Tohoku University	JP	572	526	335	1,074	2,543	22.5%	20.7%	13.2%	42.2%	4.07	992	0.39
20	University of Oxford	GB	557	359	1,292	150	2,700	20.6%	13.3%	47.9%	5.6%	4.87	1,221	0.45
21	Hebrew Univ. of Jerusalem	IL	535	518	544	113	2,439	21.9%	21.2%	22.3%	4.6%	5.59	1,548	0.63
22	University of Utah	US	534	772	326	109	2,132	25.1%	36.2%	15.3%	5.1%	3.82	1,569	0.74
23	Korea Advanced Inst. of S&T	KR	524	1,078	426	6,275	8,390	6.3%	12.9%	5.1%	74.8%	2.00	3,936	0.47
24	Duke University	US	512	693	359	131	2,179	23.5%	31.8%	16.5%	6.0%	4.93	1,996	0.92
25	Univ. of Southern California	US	472	999	292	188	2,294	20.6%	43.6%	12.7%	8.2%	4.97	2,307	1.01

Data source: PATSTAT (version: October 2013).

Table 2.2: (b) Ranking of the top 25 universities according to the number of overall patent applications filed between 2001 and 2011.

Rank	University	Country	Number of patent applications filed					Share of patent applications filed				Average family size	No. of forward citations	Citation_intensity
			All	PCT	USPTO	EU	Asia	PCT	USPTO	EU	Asia			
1	Zhejiang University	CN	16,339	96	39	35	16,165	0.6%	0.2%	0.2%	98.9%	1.04	372	0.02
2	Tsinghua University	CN	12,260	391	1,234	401	10,085	3.2%	10.1%	3.3%	82.3%	1.72	2,734	0.22
3	Shanghai Jiao Tong Univ.	CN	10,247	94	30	43	10,070	0.9%	0.3%	0.4%	98.3%	1.07	423	0.04
4	Korea Advanced Inst. of S&T	KR	8,390	524	1,078	426	6,275	6.3%	12.9%	5.1%	74.8%	2.00	3,936	0.47
5	MIT	US	6,531	1,733	2,580	791	497	26.5%	39.5%	12.1%	7.6%	4.51	10,936	1.67
6	Fudan University	CN	4,854	109	53	25	4,644	2.3%	1.1%	0.5%	95.7%	1.13	243	0.05
7	University of Tokyo	JP	4,831	888	616	636	2,504	18.4%	12.8%	13.2%	51.8%	3.42	1,950	0.40
8	Johns Hopkins University	US	4,634	1,154	1,563	694	251	24.9%	33.7%	15.0%	5.4%	4.88	4,417	0.95
9	Stanford University	US	4,372	879	1,731	695	266	20.1%	39.6%	15.9%	6.1%	4.62	6,444	1.47
10	Yonsei University	KR	4,191	370	405	144	3,244	8.8%	9.7%	3.4%	77.4%	1.83	1,120	0.27
11	Univ. of Wisconsin, Madison	US	3,960	746	1,327	713	200	18.8%	33.5%	18.0%	5.1%	5.78	3,974	1.00
12	Peking University	CN	3,831	220	121	73	3,400	5.7%	3.2%	1.9%	88.8%	1.38	207	0.05
13	Seoul National University	KR	3,706	354	446	245	2,591	9.6%	12.0%	6.6%	69.9%	2.24	2,353	0.63
14	UC, San Diego	US	3,641	744	1,582	414	288	20.4%	43.5%	11.4%	7.9%	4.75	4,003	1.10
15	University of Florida	US	3,361	1,059	1,148	387	190	31.5%	34.2%	11.5%	5.6%	3.97	3,066	0.91
16	Osaka University	JP	3,346	640	406	360	1,831	19.1%	12.1%	10.8%	54.7%	2.93	1,091	0.33
17	Nanjing University	CN	3,198	74	38	15	3,065	2.3%	1.2%	0.5%	95.8%	1.13	134	0.04
18	UC, Berkeley	US	3,174	633	1,429	345	237	19.9%	45.0%	10.9%	7.5%	4.48	3,638	1.15
19	UC, San Francisco	US	3,164	646	1,371	373	218	20.4%	43.3%	11.8%	6.9%	4.84	3,523	1.11
20	Univ. of Mich., Ann Arbor	US	3,146	764	1,261	469	254	24.3%	40.9%	14.9%	8.1%	4.24	4,446	1.41
21	California Inst. of Tech.	US	3,106	740	1,436	398	151	23.8%	46.2%	12.8%	4.9%	3.56	6,007	1.93
22	UC, Los Angeles	US	3,032	619	1,324	355	199	20.4%	43.7%	11.7%	6.6%	4.65	3,325	1.10
23	University of Pennsylvania	US	3,014	692	902	488	226	23.0%	29.9%	16.2%	7.5%	6.34	2,418	0.80
24	Columbia University	US	2,972	956	961	342	205	32.2%	32.3%	11.5%	6.9%	4.45	3,787	1.27
25	Harvard University	US	2,753	803	876	450	240	29.2%	31.8%	16.4%	8.7%	4.31	2,921	1.06

Data source: PATSTAT (version: October 2013).

MIT, Johns Hopkins University, and the University of Florida (all US) are the universities with the most PCT patent applications worldwide (Table 2.2 (a)). The first-place MIT has a long history of patenting activities: regulations on the usage of patents and the enhancement of technology date back to 1931 and make MIT one of the pioneers in university patenting (Etzkowitz, 1994). The earliest patent application included in our initial dataset was also filed by MIT in 1905. While MIT filed 1,733 PCT applications from 2001 to 2011 and is ranked first by a large margin, Johns Hopkins University filed 1,154 PCT applications, and the University of Florida filed 1,059 PCT applications. Eighteen out of the top 25 universities are US institutions. This overrepresentation is not entirely surprising given the comparatively long history of university patenting in the US. Furthermore, there are four Japanese universities and 1 university each from the Republic of Korea, Israel, and the United Kingdom. There is only 1 European university among the top 25 PCT applicants worldwide (University of Oxford), though most of the countries in the sample are European. The table provides further information on the number of applications and the share per patent office as well as details on patent families and forward citations. Overall, the applications per patent office underline the presence of a home bias: US universities generally filed most of their patents in the US, while Asian universities seem to file large proportions at Asian offices, particularly at the Japanese and the Chinese patent offices.

While PCT applications provide a greater comparability between different countries, descriptive statistics show that the university with the most overall patent applications worldwide is Chinese. Therefore, Table 2.2 (b) presents the top 25 universities ranked by the overall aggregated number of patent applications. The formerly first-placed MIT now ranks fifth, being surpassed by three Chinese universities and 1 Korean university; Zhejiang University, Tsinghua University, and Shanghai Jiao Tong University each filed more than 10,000 patents from 2001 to 2011. Overall, there are 11 Asian and 14 US universities in the top 25, while the highest-ranked European university is the University of Oxford at rank 26. However, Chinese universities file most of their patents at Asian offices, especially the SIPO. Zhejiang University and Shanghai Jiao Tong University filed more than 95% of their patents in China. Moreover, the average family size and the citation intensity of Chinese university patents are remarkably low. These findings of a very steep and non-international increase in patent applications by Chinese universities are consistent with other studies on university patenting in China, generally describing high patenting rates but a questionable patent quality (e.g., Luan et al., 2010; Chapter 3). One of the reasons for the high application numbers is that single-claim patents are generally favored in China (Sun, 2003). Moreover, Wu and Zhou (2012) indicate that Chinese universities often focus on the adaption and re-development of foreign technology. Both reasons might lead to more, but somewhat incremental, patent applications.

2.5.3 Multivariate statistics

Our dependent variable (*patent applications* per university) is a count variable with only non-negative integers. Therefore, we employ count data regressions to assess the relationship between university characteristics and their patent applications. Furthermore, the data on patent applications is overdispersed, as evidenced by a comparison of the (conditional) variance, the mean, and the highly significant overdispersion parameter Alpha (Table 2.4). To account for this overdispersion, we use negative binomial regressions as our main form of analysis. To further account for heteroscedasticity, we estimate the regressions with robust standard errors. We estimate multiple models to account for the differences between patents filed in different legislations. The results are presented in Table 2.4. Corresponding correlations and variance inflation factors (VIFs) for the main variables are presented in Table 2.3. Both measures indicate that our results are not greatly biased by multicollinearity.

We use different variants of the dependent variable to account for the differences between patent applications in different jurisdictions. In our main model (Model 1), we use international patent applications filed under the PCT because PCT applications provide the highest degree of international comparability. The main Model 1 shows that US and Asian universities file significantly more PCT patent applications ($p < 0.01$). Other significant determinants include publication quantity, whether the university has a technical focus and high shares of applications in the areas of chemistry, electric engineering, instruments, and mechanical engineering ($p < 0.01$). Size variables (*R&D staff* and *R&D budget*), publication quality, the patent protection index, and the remaining application areas do not exhibit a significant influence on the number of PCT applications. Our control variable for technical universities is highly significant, underlining the patenting activity enhancing effect of a clearly technological orientation.

In the following models, we use patent applications filed at the USPTO (Model 2), European patent offices including the EPO (Model 3), and Asian offices including the SIPO (Model 4) as dependent variables to shed further light on potential differences between these markets. Furthermore, we use the aggregated overall amount of universities' patent applications as the dependent variable (Model 5) because the descriptive statistics revealed large differences between PCT and overall applications for several universities. Finally, we use the number of patent families as a last check of robustness, accounting for a potential overrepresentation of patents filed at multiple offices (Model 6). The results are relatively robust across the different dependent variables with only minor changes, such as publication quality revealing a significant effect when assessing USPTO patent applications ($p < 0.05$).

Table 2.3: Correlations and variance inflation factors (VIF).

	Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	VIF
(1)	PCT applications																	2.46
(2)	US (dummy)	0.40*																2.66
(3)	Asia (dummy)	0.12*	-0.24*															2.05
(4)	Others (dummy)	-0.14*	-0.28*	-0.12*														1.44
(5)	R&D staff	-0.22*	0.16*	-0.02	-0.01													1.46
(6)	R&D budget	-0.45*	-0.38*	0.05	0.07	0.25*												1.95
(7)	Publication quality	0.66*	0.53*	-0.21*	-0.09	-0.26*	-0.49*											3.19
(8)	Publication quantity	0.57*	0.08	0.17*	0.05	-0.45*	-0.57*	0.58*										3.13
(9)	Technical university (dummy)	0.11	-0.09	0.09	-0.05	-0.02	-0.04	-0.04	-0.09									1.50
(10)	Patent protection index	0.30*	0.67*	-0.35*	-0.42*	0.14*	-0.31*	0.39*	0.00	-0.10								2.82
(11)	Area: Chemistry	0.05	0.24*	-0.29*	0.07	0.00	-0.21*	0.19*	0.14*	-0.41*	0.24*							1.86
(12)	Area: Consumer goods	-0.09	-0.11	0.03	0.11	0.01	0.11	-0.11	-0.03	0.25*	-0.30*	-0.24*						1.53
(13)	Area: Electric engineering	0.17*	-0.01	0.46*	-0.12*	-0.03	0.03	0.00	0.01	0.29*	-0.08	-0.52*	0.09					1.81
(14)	Area: Instruments	0.13*	0.09	-0.15*	-0.08	-0.07	-0.01	0.13*	0.07	-0.10	0.18*	0.05	-0.02	-0.13*				1.11
(15)	Area: Mechanical engineering	0.01	-0.11	0.14*	-0.05	-0.04	0.04	-0.12*	-0.07	0.40*	-0.09	-0.39*	0.34*	0.30*	-0.04			1.48
(16)	Area: Process engineering	-0.04	-0.08	0.04	0.04	-0.08	0.01	-0.09	-0.05	0.20*	-0.10	-0.08	0.41*	0.10	-0.04	0.31*		1.31
(17)	Area: Others	0.09	0.09	-0.15*	0.07	-0.05	-0.08	0.17*	0.14*	-0.16*	0.14*	0.23*	-0.04	-0.11	0.08	-0.02	-0.04	1.13

Notes: N = 300 universities. Pearson correlation coefficients with significance levels * $p \leq 0.05$.

Data sources: PATSTAT (version: October 2013), Academic Ranking of World Universities 2013 (Shanghai Jiao Tong University, 2014), Hinze et al. (1997), Park (2008).

Table 2.4: Multivariate statistics: Negative binomial regressions on university patent applications from 2001 until 2011.

Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Dependent Variable	**Applications: PCT**	**Applications: USPTO**	**Applications: EU**	**Applications: Asia**	**Applications: Total**	**Families: Total**
US (dummy)	0.368**	1.411***	-0.902***	0.844***	0.636***	0.998***
	(0.152)	(0.170)	(0.168)	(0.239)	(0.180)	(0.167)
Asia (dummy)	0.725***	1.153***	-0.676***	3.853***	1.498***	2.091***
	(0.191)	(0.274)	(0.209)	(0.439)	(0.336)	(0.340)
Others (dummy)	-0.093	0.311*	-1.119***	-0.158	-0.341*	-0.335*
	(0.198)	(0.180)	(0.211)	(0.217)	(0.193)	(0.185)
R&D staff	0.007	0.006	0.005	0.009*	0.006	0.004
	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)
R&D budget	0.000	-0.004	-0.000	0.002	-0.001	-0.001
	(0.006)	(0.007)	(0.007)	(0.008)	(0.006)	(0.006)
Publication quality	0.006	0.011**	0.009*	0.001	-0.003	-0.008
	(0.005)	(0.005)	(0.005)	(0.007)	(0.006)	(0.005)
Publication quantity	0.041***	0.031***	0.034***	0.055***	0.049***	0.052***
	(0.006)	(0.007)	(0.007)	(0.009)	(0.007)	(0.007)
Technical university (dummy)	0.949***	0.770***	0.845***	0.695***	0.690***	0.633***
	(0.193)	(0.218)	(0.225)	(0.240)	(0.221)	(0.212)
Patent protection index	0.557	-0.084	0.261	-0.330	-0.362	-0.698*
	(0.348)	(0.296)	(0.303)	(0.564)	(0.458)	(0.412)
Area: Chemistry	4.080***	3.662***	4.360***	3.111***	4.617***	3.482***
	(0.546)	(0.531)	(0.604)	(0.598)	(0.640)	(0.628)
Area: Consumer goods	-3.094	-3.250*	-4.905**	-2.970	-3.295	-4.792**
	(2.232)	(1.787)	(2.288)	(2.557)	(2.429)	(2.359)
Area: Electric engineering	3.725***	4.975***	4.008***	4.143***	4.477***	3.559***
	(0.635)	(0.721)	(0.706)	(0.765)	(0.757)	(0.738)
Area: Instruments	3.051***	2.934***	3.259***	1.471**	3.464***	2.948***
	(0.598)	(0.634)	(0.655)	(0.684)	(0.677)	(0.673)
Area: Mechanical engineering	5.953***	4.797***	8.703***	6.463***	8.648***	8.872***
	(1.387)	(1.559)	(1.784)	(2.124)	(1.790)	(1.736)
Area: Process engineering	1.382	1.505*	1.940**	1.761*	2.681***	2.752***
	(0.848)	(0.894)	(0.988)	(1.052)	(0.929)	(0.894)
Area: Others	2.963	4.761	4.137	6.572*	4.428	3.841
	(2.677)	(3.026)	(3.028)	(3.846)	(3.141)	(3.047)
N (Universities)	300	300	300	300	300	300
Years	2001–2011	2001–2011	2001–2011	2001–2011	2001–2011	2001–2011
Log likelihood	-1721.69	-1727.44	-1777.27	-1466.60	-2225.00	-1911.141
Chi-square	579.11***	1080.08***	293.28***	643.44***	465.26***	543.961***
Alpha	0.520***	0.554***	0.621***	0.824***	0.608***	0.595***

Notes: Robust standard errors in parentheses. R&D staff and R&D budget are divided by 10. * p < 0.10, ** p < 0.05, *** p < 0.01. Reference category for regional dummies: Europe. Constant not shown.

Data sources: See Table 2.3.

H2.1 states that European universities file fewer patents compared with universities in the US. This hypothesis is heavily supported by the descriptive patent ranking constructed; though most universities in the sample are European, no European university was ranked in the top 25 when examining the overall number of patent applications. Our regression results show the same results when analyzing the overall number of patent applications. Model 5 shows that US universities applied for significantly more patents than did European universities from 2001 to 2011. This is in line with previous results (Conti and Gaule, 2011). The reasons for this European gap are diverse and complex. Naturally, the shorter history of EU university patenting and technology transfer as a whole is one of these reasons, as European institutions have not yet been able to gain the same amount of experience as US institutions. Additionally, Crespi et al. (2006) and Baldini et al. (2006) indicate that European universities lag behind US universities in terms of university-owned patents, as the majority of patents developed with European universities involved are filed by third parties, particularly business companies.

Additionally, the results show that Asian universities filed significantly more patent applications than European universities did, which is also reflected by the patent ranking. Furthermore, this finding holds when analyzing PCT applications (Model 1), which should be robust against a potential home bias effect. While previous literature has suggested and shown large patenting activities in Asian universities (e.g., Hu and Mathews, 2008; Luan et al., 2010; Chapter 3), there has been little empirical evidence from a comparative perspective. We find empirical evidence for a comparatively weak performance of European universities compared with US universities, while we also find evidence for a comparatively strong performance of Asian universities.

H2.2 addresses the presence of a home advantage effect, i.e., universities filing more patent applications domestically. This hypothesis is addressed by the regional dummies in Models 2-4 and supported for all three main regions (US, Europe, and Asia). Model 2 shows that US universities apply for significantly more patents at the USPTO than do European universities ($p < 0.01$). The coefficients further indicate that the effect of US universities is higher than the effect of Asian universities, in contrast to Models 1 and 5. Analyzing applications at European patent offices, Model 3 shows that universities from all non-European regions file significantly fewer patents compared with European universities. This supports the notion of a home advantage effect for European universities. Finally, the strong effect of *Asia (dummy)* in Model 4 underlines the suggested a home advantage effect of Asian universities, which file their patents first and foremost domestically.

We do not find support for H2.3. The variables capturing the size of each university in terms of personnel and monetary resource endowment for research do not significantly influence patent applications. This non-finding is robust across all models. This finding is in line with Fritsch and Slavtchev (2007), who describe that neither the regular budget of a university nor its personnel seem to influence the patent output of German universities. However, this contradicts the results of Van Looy et al. (2011) for European universities and Bulut and Moschini (2009) for the US. We suspect that the effects of both variables are at least partly captured by publication quantity, which is highly correlated with both variables. Furthermore, the rather undetailed measurement (i.e., both variables use the rank of a university) might add to this insignificant finding.

H2.4 addresses the relationship between patenting and publication in terms of quantity. While a trade-off between both might be plausible, various studies report positive effects (Geuna and Nesta, 2006; Breschi et al., 2008; Van Looy et al., 2011). In line with these studies, our results indicate that research *publication quantity* is positively associated with the number of *patent applications*, thus supporting H2.4. *Publication quantity* is highly significant across all models ($p < 0.01$). As suggested, university patenting and research performance in terms of scientific publication has a complementary relationship with the potential for large synergies. For example, more publications or a researcher that has higher prestige due to high publication output may attract industry collaborations and thus lead to patents. Other synergies might include the discovery of new research questions, an increased accessibility to new data or instruments, or financial benefits that encourage both publishing and patenting (Breschi et al., 2008; Fabrizio and Di Minin, 2008; Crespi et al., 2011). While these findings were typically limited in terms of the scope of their analysis, our results are in line with those of Wong and Singh (2010). We provide empirical evidence on the positive relationship between publishing and patenting, which is also prevalent when analyzing this relationship in an international, cross-country setting.

We expected a positive relation between publication quality and patenting (H2.5) in addition to publication quantity. However, we must reject this hypothesis because our results do not consistently support it. While the effect is significant for patents filed at the USPTO ($p < 0.05$), it is insignificant in the main Model 1. Again, this insignificance might arise because we include more control variables than do other studies describing a positive effect (Wong and Singh 2010). Other studies describing a positive effect between publication quality and technology transfer might differ because they do not use patenting measures to capture university technology transfer, such as start-up rates (Di Gregorio and Shane, 2003) or licensing (Lach and Schankerman, 2008). Further, Fabrizio and Di Minin (2008) describe that researchers who frequently patent their work tend to receive fewer citations because they might refocus on more applied research that is not as likely to generate citations in publications. Another reason that might partially explain our non-finding is that academic citations (*publication quality*) are generated through processes that are often widely independent of the likelihood for research results to be patented (e.g., contribution to literature), which does not result in a causal relationship between these variables. For example, citation patterns differ greatly between different fields of publication, thus biasing the quality of a publication as measured through citations.

H2.6 suggests a particularly high influence of the *area of application* on the number of patents filed. It is widely acknowledged that the importance of university research is considerably strong in the area of chemistry, including biotechnology and pharmaceuticals (Mowery and Ziedonis, 2002; Geuna and Nesta, 2006). Our descriptive statistics (Table 2.1) also illustrate that universities generally file more than 50% of their patents in this area. We find support for H2.6, which states that a university with a greater focus in the area of chemistry has a higher patent output. Next to the area of chemistry, we find evidence for this relationship to also be true for the areas of electrical engineering, mechanical engineering, and instruments. This is not entirely surprising given the technical nature of these fields. These findings are highly significant across all models. Prior studies have often been limited to single areas or countries. Against this backdrop, our study provides empirical evidence across multiple technology fields in an international context.

2.6 Discussion and conclusion

This study investigates the patent activity of the top 300 universities worldwide according to the ARWU between 2001 and 2011. It is a first attempt to compare and study the patent output of universities across all fields of research on a worldwide basis. First, a descriptive overview by means of a university patent ranking is provided. Second, we perform an econometric analysis to analyze how different university characteristics influence the number of patent applications. In particular, we analyze the extent to which patenting by universities is linked to their location, the quantity and quality of scientific publications, the university size, and the area of its patent applications. Our empirical results show that European universities file fewer patent applications than do their US and Asian counterparts. Furthermore, the patent output is considerably influenced by a university's technological focus on chemistry and mechanical engineering.

The increasing interest in commercialization at universities has led to a large body of literature on university technology transfer and especially on university patenting. Prior literature has assessed university patenting in various regions and countries, mainly focusing on the US and Europe and more recently Asia (e.g., Henderson et al., 1998; Hu and Mathews, 2005; Geuna and Rossi, 2011). We contribute to the literature on university patenting by adopting an integrative international perspective that provides new and interesting insights on the phenomenon as a whole. In addition to this international perspective, we add to the previous literature by including a variety of university-specific characteristics that are shown to be important determinants of university patenting. Previous literature has largely focused on analyzing the effects of regulatory changes on university patenting (Henderson et al., 1998; Geuna and Rossi, 2011) while neglecting the potentially huge differences between universities not only between countries but also within one country.

Our study is not without limitations. Because university researchers are frequently involved in patented research without the university being listed as patent applicant, our figures should be considered lower-bound measures. This is particularly important with regard to European universities (Crespi et al., 2006; Lissoni et al., 2008). Furthermore, universities from different countries vary with regard to their institutional and organizational structure and their IPR regulation (Geuna and Rossi, 2011). Although we try to control for this by including regional dummies, a patent protection index, and the number of applications at different offices, these differences might still affect university patenting. Finally, patents are not the only channel through which universities contribute to innovation and economic growth. While patenting by universities seems to be increasingly attractive, other forms of knowledge transfer are more commonly used (Cohen et al., 2002).

Future research should award more attention to how other forms of university-industry relationships are influenced by university characteristics. While our study underlines their importance for university patenting, a careful assessment of the impact of university-specific factors might yield interesting results concerning other forms of technology transfer. Additionally, it might be fruitful to analyze these other forms of technology transfer from an international perspective. As evidenced by our study, an international analysis and comparison reveals interesting differences between countries, which might similarly affect licensing, the generation of start-ups, and other forms of technology transfer.

2.7 Appendix

Table 2.A1: Distribution of universities in the sample by region and country.

Region	No. of universities per region (share of total)	Countries	No. of universities	Share
United States (US)	107 (35.7%)	United States	107	35.7%
Europe (EU)	126 (42.0%)	Austria	3	1.0%
		Belgium	6	2.0%
		Switzerland	7	2.3%
		Czech Republic	1	0.3%
		Germany	23	7.7%
		Denmark	4	1.3%
		Spain	4	1.3%
		Finland	1	0.3%
		France	17	5.7%
		Ireland	1	0.3%
		Italy	9	3.0%
		Netherlands	10	3.3%
		Norway	3	1.0%
		Sweden	8	2.7%
		United Kingdom	29	9.7%
Asia	29 (9.7%)	China	8	2.7%
		Hong Kong	3	1.0%
		Japan	10	3.3%
		Republic of Korea	4	1.3%
		Singapore	2	0.7%
		Taiwan	2	0.7%
Others	38 (12.7%)	Argentina	1	0.3%
		Australia	10	3.3%
		Brazil	1	0.3%
		Canada	16	5.3%
		Israel	4	1.3%
		Mexico	1	0.3%
		New Zealand	1	0.3%
		Russia	1	0.3%
		Saudi Arabia	2	0.7%
		South Africa	1	0.3%
Total	300 (100%)	32	300	100.0%

Data sources: Academic Ranking of World Universities 2013 (Shanghai Jiao Tong University, 2014).

Chapter 3

Chinese university patents: Quantity, quality, and the role of subsidy programs

Chinese university patenting has gained importance in recent years. Using a comprehensive dataset of university patents by 155 leading Chinese universities from 1991 to 2009, our study pursues two objectives: First, we analyze the quantity and quality of patents filed by leading Chinese universities. Second, we analyze the role of subsidy programs with regard to university patenting in China. With regard to the first objective, our results show that university patents witnessed rapid growth in terms of quantity while patent quality did not increase to a similar degree. Regarding the second objective, we find that a subsidy program to promote research excellence at selected universities is a significant driver of patent quantity and quality. In contrast, a subsidy program that decreases the costs of patent applications seems to enhance patent quantity but not patent quality. We conclude that innovation policies which aim to stimulate patents of higher quality should focus primarily on increasing university R&D, and to a lesser extent on decreasing the costs of university patenting.

This chapter is based on Fisch et al. (2016).

3.1 Introduction

Universities influence a country's innovative potential and can thereby act as driving forces for economic development, technological performance, and competitiveness. There are multiple ways in which universities contribute to innovation, for example by providing education, by generating spin-offs, or through university patenting (Acosta et al., 2012). We focus on the latter aspect and analyze university patenting in China.

To stimulate university patenting, governments frequently introduce initiatives such as subsidy programs or patent-friendly regulatory changes. A prominent and well-researched example of such a change is the Bayh-Dole Act, which was introduced in the US in 1980 to facilitate university patenting and licensing (e.g., Henderson et al., 1998; Sampat et al., 2003; Mowery and Sampat, 2005a). Subsequently, various European countries introduced similar regulations to promote university patenting. While these initiatives varied slightly between countries, they intend to imitate the conditions as established through the Bayh-Dole Act (Geuna and Nesta, 2006; Geuna and Rossi, 2011). Examples include France (Malva et al., 2013), Germany (Czarnitzki et al., 2011), and Italy (Baldini et al., 2006). Even though these regulations are often described as stimulating university patenting, their effects are heterogeneous between countries and not entirely clear in their direction. For example, Henderson et al. (1998) find an increasing patent quantity but decreasing patent quality as a result of the Bayh-Dole Act. However, this finding is revised by Mowery and Ziedonis (2002) and Sampat et al. (2003), who demonstrate that the effect of the Bayh-Dole Act on patent quantity and quality was modest. For Europe, Geuna and Nesta (2006) similarly suggest that the rise in university patenting is largely driven by factors unrelated to policy changes.

Focusing on university patenting in China, our study pursues two objectives: First, we assess the development of Chinese university patenting in terms of patent quantity and quality over the past 20 years. This first objective is primarily of exploratory and descriptive nature. Second, we investigate and compare the effects of two types of governmental subsidy programs with regard to university patenting. While one subsidy program aims to decrease the costs of university patenting, the other program focusses on promoting research excellence in selected leading Chinese universities (Li, 2012; Zhang et al., 2013).

This study aims to contribute to the literature on the role of governmental initiatives regarding university patenting (e.g., Henderson et al., 1998; Mowery et al., 2002; Geuna and Nesta, 2006; Wong and Singh, 2010; Geuna and Rossi, 2011; Hülsbeck et al., 2013) in two ways. First, our study focuses on China, an emerging country that aims to transform itself from an imitation-based to an innovation-based economy. Thus, we extend the research on the role of governmental initiatives regarding university patenting, which has been focused on the US and Europe, to the context of emerging countries. Second, our study analyzes and compares the effects of two different types of governmental subsidies. So far, little research exists that compares the effects of different governmental initiatives promoting university patenting with each other.

Our study also contributes to the more general literature on patenting in China (e.g., Hu and Mathews, 2008; Li, 2012). While several prior studies exist that emphasize the importance of universities for innovation in China, we know little about Chinese university patenting and its determinants. University patenting is a form of (potential) technology transfer and analyzing its quantity, quality, and determinants helps us to understand the role of universities in China's national innovation system. By comparing patenting rates over time and across universities, our research helps to grasp the innovative efforts of universities in China in a quantitative way. To deepen our analysis, we also account for patent quality by investigating patent citations, which are a proxy for the economic and technological importance and quality of innovations (e.g., Henderson et al., 1998; Mowery and Ziedonis, 2002; Acosta et al., 2012).

The remainder of the study is organized as follows: Section 3.2 describes the research context of this study and explains patenting and university patenting in China. It introduces two important subsidy programs promoting research and patenting in Chinese universities. Section 3.3 explains the data employed and provides descriptive statistics and trends in patent quantity and quality (e.g., patent growth rates, grant lags, family sizes, and citations). Section 3.4 presents regressions on the effects of the subsidy programs with regard to university patenting. The final section discusses the study's contributions to the literature, its limitations, and avenues for further research.

3.2 Research context: Patenting and university patenting in China

3.2.1 Patenting in China

As outlined in Section 1.1.1, China witnessed an explosive growth in terms of patent applications in recent years. This growth is unlikely to halt in the near future. As part of its "National Patent Development Strategy" (SIPO, 2011), China states that it plans to further quadruple patent applications from 2010 to 2020. Six universities were among the top 10 Chinese applicants at the SIPO in 2011, and the share of patents applied for by universities increased from approximately 6% in 2000 to approximately 16% in 2010 (National Bureau of Statistics of China, 2001–2011a). The "National Patent Development Strategy" (SIPO, 2011) refers specifically to the advancement of university patenting.

Since its introduction in 1985, China's patent law has been amended several times with the goal of improving the Chinese patent system. Today, the Chinese patent system meets international standards, as for example established by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) or the PCT, and is largely comparable with the patent systems of developed countries (Sun, 2003; Liegsalz and Wagner, 2013). As such, the system is based on the “first-to-file” principle and the standards of patentability include the criteria of novelty, utility, and non-obviousness. Patent applications are published after 18 months, and the maximum patent duration is 20 years (Yang, 2008; Sun, 2003; Tang, 2008). The average costs of a SIPO application match those of an EPO application (Liegsalz and Wagner, 2013). Because patent applications must undergo an examination before being granted, the SIPO has expanded its capacities significantly to keep pace with the rapid increase in applications. Concurrently, China established a tiered-court system to improve the enforceability of the patent law (Liegsalz and Wagner, 2013). Still, in spite of these efforts, the enforceability of patent rights in China is regarded as questionable (Bird, 2006).

Patenting in China and by Chinese applicants has received attention in recent research. Hu and Mathews (2008) analyze the innovative capacity of China via patenting at the USPTO. The authors identify a number of factors that influence the quantity of Chinese patents, such as R&D expenditures, R&D personnel, and gross domestic product (GDP), and note that the quality of Chinese patents has increased over time. Supporting these findings, Hu and Jefferson (2009) demonstrate that the surge in patenting by large and medium-sized Chinese enterprises can partly be explained through higher R&D expenditures. The authors further identify an increase in foreign direct investment and various pro-patent changes in the legal environment, in particular an amendment to the patent law in 2000, as determinants of the surge in patenting. A number of studies have examined particular aspects of patenting in China such as the strong increase in foreign patent applications (Hu, 2010; Keupp et al., 2012).

3.2.2 University patenting in China

Prior to 1994, patents resulting from publicly funded research in universities formally belonged to the Chinese state. However, Guo (2007) notes that these patents were de facto owned by the respective university. The ownership rights of universities have since been clarified and extended in 1994 and 2002, with the latter often being referred to as the “Chinese Bayh-Dole Act” (e.g., Guo, 2007; Graff, 2007, Tang, 2008).

A number of studies address university patenting in China. Hu and Mathews (2008) describe universities as a critical part of the Chinese innovation system and emphasize an indirect contribution of Chinese universities to the patent surge by educating a skilled labor force and by creating a substantial number of spin-offs. They emphasize that universities play a more prominent role in the Chinese technological catch-up process compared to other East Asian latecomers, such as Taiwan or Korea. Similarly, Huang and Wu (2012) identify R&D expenditures and the R&D personnel of universities and research institutions as important drivers of patenting in the nanotechnology sector. Other industry and market forces, such as FDI, are described as less important. Hong (2008) also underlines the importance of universities in the Chinese innovation system and describes a heavy dependence of the industry on university research by analyzing regional differences in the knowledge transfer from university to industry. Li (2009) explains patenting disparities between Chinese regions. Among other findings, the study reports that universities and research institutes play an important role with respect to invention patents, whereas firms tend to apply for utility model patents connected with marginal innovations. Li (2012) demonstrates that the increase in the number of patent applications by universities at an aggregated regional level is stimulated by regional patent subsidy programs, increasing R&D expenditures, and an increasingly patent-friendly legal environment. Finally, Luan et al. (2010) as well as Chapter 2 of this thesis examine the quantity of university patenting worldwide and highlight the strong role of Chinese universities. The authors raise concerns about the quality of patents from Chinese universities but do not examine this particular aspect in great detail.

3.2.3 Two subsidy programs to promote research and patenting at Chinese universities

The Chinese government has issued various initiatives to stimulate university patenting. Previous literature on the effects of governmental initiatives on university patenting has mostly analyzed changes in the legal framework (e.g., the Bayh-Dole Act). However, subsidy programs are a comparable and similar, yet more direct way for governments to try to stimulate university patenting. In this study, we focus on two particular types of Chinese subsidy programs which play an important role for university patenting in China: (1) cost reimbursement subsidy programs (cost reimbursement subsidy) and (2) a subsidy program aimed at promoting research excellence in selected leading universities (research excellence subsidy).

Li (2012) describes and demonstrates that cost reimbursement patent subsidy programs introduced at the regional level contribute to explaining the overall patent surge in China as well as the increase in university patenting. In 1999, the municipal government of Shanghai was the first to introduce a policy initiative to stimulate patenting that established a special fund for applicants who reside in Shanghai (i.e., individuals, firms, universities, and research institutes). In the following years, most regional governments in China introduced similar patent subsidy programs. Although the subsidy programs differ slightly between regions, the overall similar primary benefit is the reimbursement of the costs of patent applications and their maintenance through the established special fund (Li, 2012). The amount that is reimbursed is not fixed and varies between provinces and patent applications. This subsidy supports patent applications irrespective of the technological or economic value of the underlying invention. As such, the subsidies are presumed to be attractive for firms patenting strategically or universities and research institutes that are less interested in commercializing their inventions (Li, 2012). As the cost of patent applications decreases, the number of applications can be expected to increase. However, because the program does not account for the quality of the patent application (with regard to the economic and technological value of the underlying invention), the share of low-quality patent applications is also expected to increase. This would result in a primarily quantitative effect of the cost reimbursement subsidy with regard to university patenting.

The Chinese government has also introduced a subsidy program to promote research productivity and research excellence at selected leading Chinese universities ("Project 985"). The program aims to establish world-class universities in China, for example by increasing their research performance (Zhang et al., 2013). In 1999, Peking University and Tsinghua University were among the first to receive funds from Project 985. Both universities received an initial funding of approximately 225 million USD over five years. All of the participating universities were assigned substantial funding. In total, 39 universities have been included in this research excellence subsidy and received approximately 32 billion RMB (approximately 5 billion USD) in total funding (Zhang et al., 2013). Project 985 has been described as "a critical component of one of the largest sustained increases of investment in university research in human history" (Zhang et al., 2013). In contrast to the cost reimbursement subsidy, this subsidy program was not primarily intended to stimulate patenting by offering cost savings but to increase research productivity and excellence at selected universities through large investments. The program aimed to not only increase the research capacity and size of universities, but also to increase research quality (Zhang et al., 2013). While Zhang et al. (2013) demonstrate the impact of Project 985 on scientific publications, the subsidy program has not yet been assessed with regard to its impact on university patenting. Given the program's aims and structure, we expect a positive effect of the program on both patent quantity and patent quality.

3.3 Data

3.3.1 Dataset

Patent data: Our patent data is obtained from the worldwide patent database PATSTAT (version of October 2012), which is provided by the EPO. PATSTAT is one of the most comprehensive databases and contains data on more than 90 million patent applications and grants in more than 100 countries. Liegsalz and Wagner (2013) refer to PATSTAT as the most comprehensive database on Chinese patents because it contains approximately 7 million Chinese documents.

Universities: In 2010, there were 2,358 regular institutions of higher education in China (National Bureau of Statistics of China, 2011b). These institutions include universities and colleges offering specialized courses. Of these 2,358 institutions, we identify 155 "leading" universities from various sources. These sources include multiple rankings that assess and compare universities with regard to different dimensions, such as teaching, research performance, and global influence. We analyze the Chinese entries in university rankings such as the Times Higher Education World (THE) University Rankings (2004–2012) (THE, 2013), the Academic Ranking of World Universities (2003–2012) (Shanghai Jiao Tong University, 2013) and various other rankings. Note that patenting output is not a specific criterion for inclusion in any of the rankings included.

Matching: To obtain data on university patenting, we identified patent documents in which one of the 155 universities served as applicant or assignee. Because PATSTAT is organized on a patent document level, the identification and matching of patents and applicants results in various problems. A particular problem refers to the often flawed and inconsistent depiction of the names of the applicants and their translation from Chinese into English, which can produce varying and inconsistent university names in the patent documents. As described in Chapter 2, we thus generated search patterns that included variant spellings, abbreviations, and applicant names. Additionally, the search patterns accounted for the mergers of different institutions and changes in university names. Moreover, we include the universities names in pinyin. The search patterns were refined in several iterations to improve the identification and matching of relevant patents. A comparison of the obtained data with official data and further details on the search patterns can be found in Tables 3.A1 and 3.A2 (Appendix).

We obtained an initial dataset of 278,477 university-owned (not necessarily university-invented) patents applied for by the universities in our sample. Next, we excluded 34,895 patent documents that do not refer to invention patents but to utility model patents (approximately 13% of all documents) and entries that contain missing values. The high share of invention patents in our sample is noteworthy because usually the number of utility model patent applications exceeds the number of invention patent applications in China (WIPO, 2016a). To avoid an overrepresentation of patents filed at multiple offices, we examine patent families. The final dataset covers the period from 1991 to December 2009. Although we only include 155 universities (i.e., 7% of all institutions of higher education), our final dataset contains 121,184 patent families. Compared with official data on total patent applications by institutions of higher education in China (available at the national level), the universities in our sample account for approximately 75% of the patent applications of the more than 2,350 institutions of higher education from 2000 to 2009 (National Bureau of Statistics of China, 2001–2010a).

3.3.2 Variables

Dependent variables: To measure patent quantity, we use the number of patent applications per university per year (*applications*). To measure patent quality, we use the number of forward citations that the patents of a university received per year (*citations*).

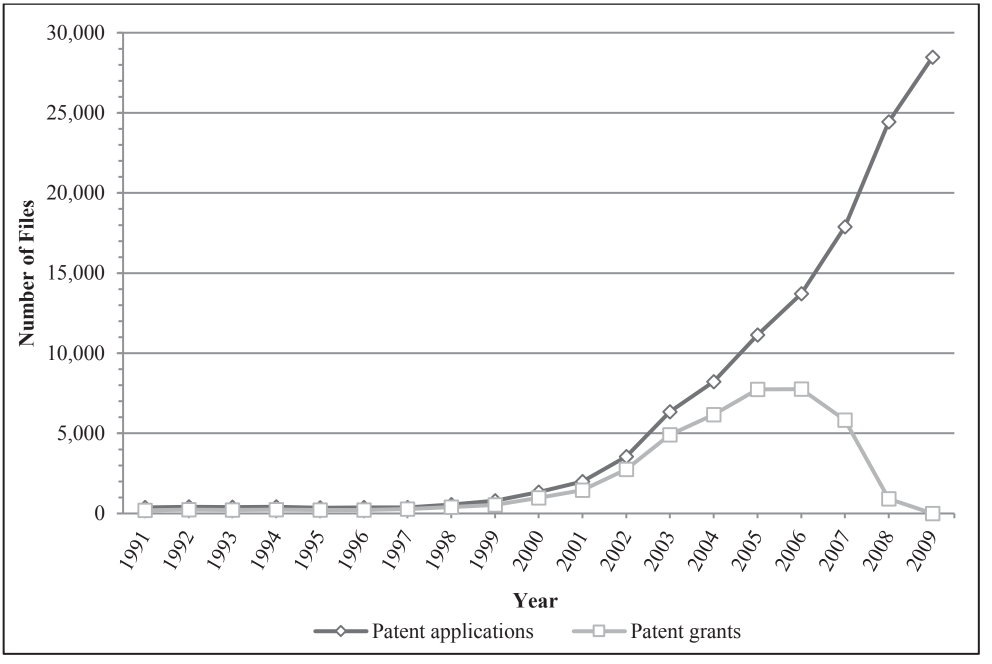
Independent variables: We add two variables to capture the impact of the subsidy programs described in Section 3.2. First, we include a dummy variable that indicates the existence of the cost reimbursement subsidy (*cost reimbursement subsidy*). The variable takes a value of 1 for years in which this subsidy program was available in the region of the university and a value of 0 otherwise. Data on this program was obtained from Li (2012). Second, we include a variable for the participation of the respective university in Project 985 (*research excellence subsidy*). The program is included as a dummy variable that assumes a value of 1 in years in which the university benefitted from this subsidy program and a value of 0 otherwise (Ministry of Education of the P.R. of China, 2006).

Control variables: As controls, we include a variety of explanatory variables based on prior research on patenting in China (e.g., Hu and Mathews, 2008; Hu and Jefferson, 2009; Li, 2012). We control for the gross regional product per capita and capture the overall economic development at the regional level (*GRPPC*). Additionally, we account for the number of R&D personnel employed in institutions of higher education (*IHE*) in China, measured in man-hours (*IHE R&D personnel*). We account for the intensity of investments in R&D by including the ratio R&D expenditures by institutions of higher education in China in the gross regional product (GRP) (*IHE R&D exp./GRP*) The control variables are recorded at the regional level and are drawn from the official China Statistical Yearbook China (National Bureau of Statistics of China, 1992–2010b) as well as the China Statistical Yearbook on Science and Technology (National Bureau of Statistics of China, 1992–2010a), available from 1991 onwards. In addition to these variables, we capture the overall developments of the patenting landscape (e.g., amendments of the patent law) by including year-fixed effects (*year dummies*) and a dummy that takes a value of 1 if a university did not file any patent at all (*no-patent dummy*). Finally, we control for the differences that result from patenting in different technological fields by including a set of variables that capture the share of patent applications filed in each International Patent Classification (IPC) class per university per year (*IPC classes*). Universities that did not file patents in a specific year were assigned values of 0. Table 3.A3 (Appendix) provides further information on selected variables (e.g., number of universities per province and the different types of subsidy program).

3.3.3 Descriptive statistics on patent quantity

Figure 3.1 shows the development of university patenting in China over time. The figure illustrates the total number of patent applications (121,184) and the number of grants that these applications received by the year of the application (41,064) from 1991 until 2009. The graphs demonstrate rapid and nearly exponential growth in patent applications and grants beginning in 1998. Before 1998, the numbers are stable at a comparatively low level of under 1,000 applications or grants per year. Because applications are not immediately registered in PATSTAT, we were forced to exclude years later than 2009. The late decrease in grants results from a right truncation of our data because there is a lag between the application and granting of patents (Li, 2012; Liegsalz and Wagner, 2013).

Figure 3.1: Patent applications and grants by Chinese universities from 1991 to 2009.



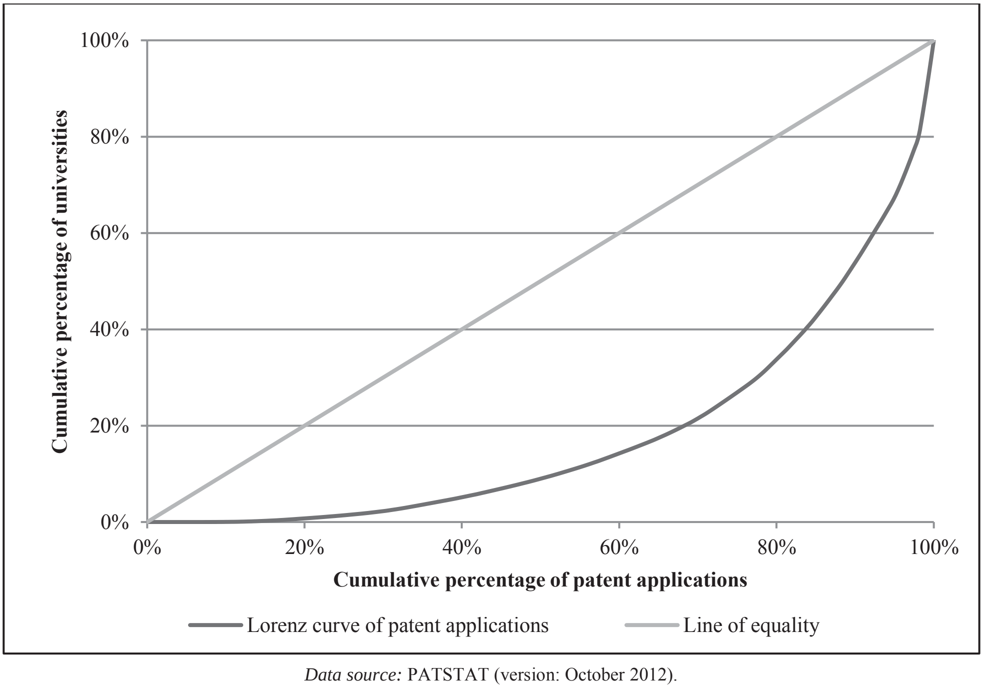
Data source: PATSTAT (version: October 2012).

Table 3.1 describes the development of university patenting in greater detail. This development exhibits a high level of volatility (from -16% to +12%) in growth rates until 1997. However, with approximately 400 new applications per year, the volume is small until 1997. After 1997, applications increased by more than 40% for six consecutive years (1998–2003), with a peak at 79.1% from 2002 to 2003. These years mark a period of explosive growth. One explanation for the spike in applications is China's entry into the World Trade Organization (WTO) in 2001 (Liegsalz and Wagner, 2013). These peaks noticeably surpass the growth rates in the overall number of patents applied for in China, which were between 22% and 40% during the same period (WIPO, 2016a).

Table 3.1 provides further statistics, such as the mean, median, and the coefficient of variation of the number of annual university applications. In sum, we obtain a mean of 41 patent applications per university per year, whereas the median is only 3. Our data is thus highly skewed. A large number of universities have zero applications in early years, whereas a few universities exhibit high numbers of patent applications, most notably the top universities listed in the appendix in Table 3.A1 (Appendix). The coefficient of variation indicates an interesting trend: Although the measure is at a stable level above 2.00 in early years, it decreases to a value of 1.36 in 2009. The decrease in recent years indicates that universities have become more homogenous with respect to patenting and that the distance between the top universities and other universities has become smaller. While patenting by universities increases sharply overall, universities with fewer patent applications appear to catch up with top universities. To further assess the dispersion of the patent application of the universities in our sample, Figure 2 illustrates the cumulative distribution function of universities and their respective patent applications. The figure reveals large differences in the patenting behavior of the universities (e.g., 20% of the universities file approximately 66% of all patent applications). This is similar to observations in Europe and the U.S.

Regarding patent family size, Table 3.1 shows that each patent family has been applied for in 1.07 different jurisdictions on average. Of all patent families, more than 99% have been applied for only in China. International patents are an exception.

Figure 3.2: Cumulative distributions of universities and patent applications.



Data source: PATSTAT (version: October 2012).

3.3.4 Descriptive statistics on patent quality

The rapid increase in patenting numbers raises questions with regard to patent quality. A measure that is commonly used to assess patent quality is the number of forward citations (Henderson et al., 1998; Mowery and Ziedonis, 2002; Acosta et al., 2012). Forward citations are the citations that a patent receives by subsequent patents (Harhoff et al., 2003). Because forward citations typically peak within four to five years after the publication of a patent (Mowery and Ziedonis, 2002), we only include citations received within the first five years after the publication of the patent document. Therefore, our analyses of patent quality cover a shorter period (1991 to 2004). Newer patents would be right truncated.

The distribution of forward citations is highly skewed. Table 3.1 shows the number of citations the patents in our sample received within the first five years after the publication of the patent document. For example, the 8,230 patents applied for in 2004 received a total of 1,052 citations. More than 80% of the cited patent families received only one citation, and only one patent received more than 50 citations (72). The ratio of patent citations to patent applications is highly volatile. It increases to a maximum of 0.25 citations per application for patents filed in 1998 and then, interestingly, decreases slightly. A truncation of the citation data cannot explain this development. As such, the number of forward citations, which we use to measure patent quality, does not appear to indicate an increase in patent quality. However, because we do not control for the effects of other variables in this initial univariate assessment, this finding should to be interpreted carefully.

Table 3.1: Patent applications filed by Chinese universities.

Year	Patent applications	Growth rate of patent app.	Mean of patent applications	Median of patent applications	CV of patent applications	Mean patent family size	Average grant lag	Total citations	Citations per application
1991	369	-	2.38	0	2.74	1.02	4.01	22	0.06
1992	413	11.92%	2.66	0	2.35	1.05	4.10	28	0.07
1993	395	-4.36%	2.55	0	2.68	1.07	4.62	27	0.07
1994	424	7.34%	2.74	0	2.30	1.06	4.83	31	0.07
1995	355	-16.27%	2.29	0	2.19	1.07	4.78	25	0.07
1996	377	6.20%	2.43	0	2.23	1.12	4.43	33	0.09
1997	382	1.33%	2.46	0	2.83	1.11	3.95	83	0.22
1998	565	47.91%	3.65	0	2.79	1.08	3.81	140	0.25
1999	788	39.47%	5.08	1	3.12	1.22	3.68	149	0.19
2000	1,336	69.54%	8.62	1	3.09	1.15	3.41	293	0.22
2001	2,004	50.00%	12.93	2	2.74	1.09	3.02	355	0.18
2002	3,545	76.90%	22.87	6	2.52	1.07	2.78	672	0.19
2003	6,348	79.07%	40.95	12	2.27	1.04	2.74	852	0.13
2004	8,230	29.65%	53.10	16	2.11	1.04	2.72	1,052	0.13
2005	11,144	35.41%	71.90	28	1.93	1.05	2.58	-	-
2006	13,715	23.07%	88.48	38	1.71	1.04	2.40	-	-
2007	17,883	30.39%	115.37	53	1.54	1.03	2.04	-	-
2008	24,434	36.63%	157.64	75	1.46	1.03	1.55	-	-
2009	28,477	16.55%	183.72	97	1.36	1.02	0.82	-	-
Total	*121,184*	*27.3%[a]*	*41.15*	*3*	*2.76*	*1.07*	*3.28*	*3,762*	*0.14*

Notes: [a] = Geometric mean. CV = Coefficient of variation.

Data source: PATSTAT (version: October 2012).

3.4 Analysis

3.4.1 Determinants of patent quantity over time

We use the annual number of patent *applications* per university as the dependent variable to analyze the determinants of patent quantity. Because this variable is a count variable with only non-negative integers, we employ count data regressions. While Poisson models require the dependent variable to be equidispersed, negative binomial models are more efficient when the data is overdispersed. Our data on patent applications exhibits severe signs of overdispersion, as the (conditional) variance is significantly greater than the mean. The presence of overdispersion is further supported by the overdispersion parameter alpha, which is highly significant for every model estimated (Table 3.3). Finally, we performed a regression-based test for overdispersion following Cameron and Trivedi (1990), which also indicated high overdispersion.

Table 3.2 presents summary statistics, correlations, and variance inflation factors. Because several variables (i.e., *research excellence subsidy*, *GRPPC*, *IHE R&D personnel*, *IHE*

R&D exp./GRP) are not likely to affect patent applications and citations immediately, we include them with a lag of three years. Therefore, we are forced to exclude years prior to 1994 in our multivariate analyses. Regarding patent quantity (panel (a)), we analyze a total of 2,480 observations and 120,007 patent applications (1994 until 2009).

The results of the negative binomial regressions with standard errors clustered at university level are presented in Table 3.3. To assess patent quantity, we estimate three models. The number of patent applications per university per year is estimated as a function of the control variables $GRPPC_{t-3}$, *IHE R&D personnel*$_{t-3}$, *IHE R&D expenditures/GRP*$_{t-3}$ and the independent variables *cost reimbursement subsidy* and *research excellence subsidy*$_{t-3}$. Furthermore, the models include year dummies, IPC classes, and a dummy for non-patenting universities. The independent variables are included alternatively in Models 1 and 2 and simultaneously in Model 3. The results indicate that both programs appear to influence the number of patent applications independently and positively, as expected. Thus, the introduction of a cost reimbursement subsidy resulted in a significant increase in the number of patent applications filed by a university. A similar finding results for the inclusion of a university in the research excellence subsidy. However, while the effect of the research excellence subsidy is highly significant ($p < 0.01$), the effect of the cost reimbursement subsidy is not as clear ($p < 0.05$). With regard to the control variables, the results show that a higher GRPPC as well as more R&D personnel lead to a significant increase in patent applications. Further, a higher share of applications in each IPC class except for class E ("fixed constructions") is associated with a higher number of patent applications.

3.4.2 Determinants of patent quality over time

To analyze the development of patent quality, we use the annual number of patent *citations* received per university as the dependent variable. To account for a possible truncation effect, our patent citations measure is based on the citations received within five years after the publication of the patent application (Mowery and Ziedonis, 2002). Similar to the number of patent applications, the number of patent citations is a severely overdispersed count variable, which suggests the use of negative binomial regression models. Additionally, the dependent variable also shows a comparatively large number of zeros (75% of the data). A university can either receive zero citations in a given year because its patents did not receive any citations or because it did not file any applications at all (excess zeros). In the presence of these excess zeros it is more appropriate to estimate zero-inflated than standard negative binomial regressions, which account for the differences in zeros and thus yield more appropriate estimates. In support of this approach, the highly significant Vuong statistic in Table 3.3 indicates an excess of zeros and suggests the use of zero-inflated models.

Thus, we estimate three zero-inflated negative binomial regressions with standard errors clustered at university level. The patent quality regressions are constructed in the same manner as the patent quantity regressions and reported in Table 3.4 (Models 4–6). The analyses contain 1,705 observations with a total of 3,685 citations and cover the period from 1994 until 2004. Summary statistics and correlations are presented in Table 3.2 (panel (b)). Again, *research excellence subsidy*, *GRPPC*, *IHE R&D personnel*, *IHE R&D exp./GRP* are included with a lag of three years.

The final model (Model 6) includes all of the independent variables simultaneously and shows a highly significant effect of the variable *research excellence subsidy* ($p < 0.01$), whereas the variable *cost reimbursement subsidy* is insignificant. Consequently, we find a quality-enhancing effect of the research excellence subsidy, while the cost reimbursement subsidy has not influenced patent quality. This outcome agrees with the expectation of a mere quantity-enhancing effect of the cost reimbursement subsidy because this type of subsidy did not target or address patent quality. Additionally, a higher GRPPC, higher number of R&D personnel, a smaller share of applications in IPC class E, and a larger share of applications in IPC class H ("electricity") lead to a higher number of patent citations.

Table 3.2: (a) Summary statistics and correlations: Patent quantity (1994–2009).

	Variable	Mean	SD	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(19)	(11)	(12)	(13)	(14)	(15)	VIF
(1)	Applications	48.39	129.4	0.00	1,762																-
(2)	$GRPPC_{t-3}$	12.50	11.42	0.89	58.25	0.41															3.07
(3)	IHE R&D $personnel_{t-3}$	9.86	5.82	0.07	25.95	0.18	0.66														3,65
(4)	IHE R&D exp./GRP_{t-3}	1.73	1.74	0.02	7.04	0.10	0.49	0.78													2.90
(5)	Cost reimbursement sub.	0.53	-	0	1	0.31	0.57	0.33	0.24												3.83
(6)	Research exc. $sub._{t-3}$	0.09	-	0	1	0.61	0.25	0.11	0.09	0.27											1.22
(7)	IPC class A[a]	0.17	0.27	0.00	1.00	-0.01	0.05	-0.01	-0.05	0.15	-0.01										-[b]
(8)	IPC class B	0.11	0.18	0.00	1.00	0.11	0.06	-0.04	-0.08	0.12	0.10	-0.14									1.06
(9)	IPC class C	0.23	0.26	0.00	1.00	0.09	0.02	-0.14	-0.17	0.14	0.06	-0.03	0.09								1.17
(10)	IPC class D	0.01	0.06	0.00	1.00	0.01	0.03	-0.01	-0.05	0.01	-0.03	-0.02	0.00	0.01							1.02
(11)	IPC class E	0.01	0.07	0.00	1.00	0.03	0.02	0.02	-0.01	0.07	0.01	-0.08	0.03	0.01	-0.02						1.02
(12)	IPC class F	0.02	0.09	0.00	1.00	0.09	0.00	-0.03	-0.04	0.03	0.07	-0.09	0.04	-0.03	0.00	0.01					1.03
(13)	IPC class G	0.10	0.17	0.00	1.00	0.22	0.17	0.13	0.10	0.19	0.22	-0.11	0.06	-0.01	-0.03	0.05	0.05				1.14
(14)	IPC class H	0.05	0.13	0.00	1.00	0.18	0.10	0.10	0.09	0.16	0.17	-0.12	0.03	-0.05	-0.04	0.00	0.03	0.16			1.09
(15)	2009 (dummy)	0.06	-	0	1	0.27	0.36	0.17	0.04	0.23	0.14	0.01	0.04	0.05	-0.01	0.03	0.02	0.13	-0.07		3.27
(16)	No-patent dummy	0.06	-	0	1	-0.09	0.14	0.26	0.29	0.03	-0.08	-0.16	-0.15	-0.22	-0.04	-0.05	-0.06	-0.14	0.00	0.00	1.22

Notes: N = 2,480. VIF = Variance inflation factor, estimated for Model 3 (Table 3). Values above .04 and below -.04 are significant at $p < .05$. [a] = The IPC classes do not add up to 1 because universities that did not apply for any patents were assigned values of zero. [b] = Variables had to be omitted for the estimation of the VIFs.

Data sources: PATSTAT (version: October 2012), National Bureau of Statistics of China (1992–2010a), National Bureau of Statistics of China (1992–2010b), Ministry of Education of the P.R. of China (2006), Li (2012).

Table 3.2: (b) Summary statistics and correlations: Patent quality (1994–2004).

	Variable	Mean	SD	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(19)	(11)	(12)	(13)	(14)	VIF
(1)	Citations	2.16	16.31	0.00	396															-
(2)	$GRPPC_{t-3}$	8.20	6.21	0.89	32.28	0.18														2.56
(3)	IHE R&D $personnel_{t-3}$	8.92	5.12	0.07	19.45	0.11	0.55													3.27
(4)	IHE R&D $exp./GRP_{t-3}$	1.59	1.77	0.02	7.04	0.13	0.50	0.80												3.23
(5)	Cost reimbursement sub.	0.33	-	0	1	0.13	0.61	0.28	0.24											2.98
(6)	Research excellence $sub._{t-3}$	0.03	-	0	1	0.37	0.16	0.02	0.04	0.21										1.15
(7)	IPC class A[a]	0.15	0.28	0.00	1.00	0.01	0.05	0.00	-0.05	0.13	0.01									-[b]
(8)	IPC class B	0.09	0.19	0.00	1.00	0.04	0.03	-0.05	-0.08	0.06	0.06	-0.12								1.03
(9)	IPC class C	0.21	0.29	0.00	1.00	0.04	0.03	-0.12	-0.15	0.10	0.06	-0.04	0.06							1.08
(10)	IPC class D	0.01	0.07	0.00	1.00	-0.01	0.06	0.00	-0.04	0.01	-0.02	-0.02	0.00	0.00						1.02
(11)	IPC class E	0.01	0.07	0.00	1.00	0.00	0.01	0.02	-0.01	0.05	0.00	-0.06	0.00	0.00	-0.02					1.01
(12)	IPC class F	0.02	0.10	0.00	1.00	0.03	-0.03	-0.05	-0.05	0.01	0.04	-0.07	0.02	-0.03	0.00	-0.01				1.03
(13)	IPC class G	0.08	0.18	0.00	1.00	0.08	0.09	0.07	0.07	0.10	0.10	-0.08	0.03	-0.01	-0.02	0.03	0.02			1.03
(14)	IPC class H	0.04	0.13	0.00	1.00	0.10	0.06	0.07	0.06	0.13	0.12	-0.09	0.03	-0.01	-0.03	0.00	0.02	0.08		1.04
(15)	2004 (dummy)	0.09	-	0	1	0.09	0.32	0.06	0.06	0.37	0.30	0.05	0.05	0.13	0.00	0.04	0.01	0.07	0.08	2.89

Notes: N = 1,705. VIF = Variance inflation factor, estimated for Model 6 (Table 3). Values above .04 and below -.04 are significant at $p < .05$. [a] = The IPC classes do not add up to 1 because universities that did not apply for any patents were assigned values of zero. [b] = Variables had to be omitted for the estimation of the VIFs.

Data sources: PATSTAT (version: October 2012), National Bureau of Statistics of China (1992–2010a), National Bureau of Statistics of China (1992–2010b), Ministry of Education of the P.R. of China (2006), Li (2012).

Table 3.3: Determinants of patent quantity (Model 1–3) and quality (Models 4–6).

	Standard negative binomial regression			**Zero-inflated neg. binomial regression**		
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Dependent Variable	**Applications**	**Applications**	**Applications**	**Citations**	**Citations**	**Citations**
$GRPPC_{t-3}$	0.029**	0.026***	0.023**	0.079***	0.058***	0.061***
	(0.012)	(0.010)	(0.010)	(0.018)	(0.013)	(0.014)
IHE R&D $personnel_{t-3}$	0.028	0.042**	0.042**	0.040	0.061**	0.060**
	(0.023)	(0.020)	(0.020)	(0.032)	(0.029)	(0.029)
IHE R&D $exp./GRP_{t-3}$	-0.055	-0.064	-0.076	0.169	0.101	0.103
	(0.077)	(0.065)	(0.064)	(0.133)	(0.101)	(0.101)
Cost reimbursement sub.	0.509***		0.450**	-0.073		-0.138
	(0.193)		(0.185)	(0.233)		(0.219)
Research excellence $sub._{t-3}$		1.450***	1.442***		2.022***	2.025***
		(0.140)	(0.136)		(0.196)	(0.195)
IPC class B	2.216***	2.098***	2.153***	0.673	0.517	0.486
	(0.315)	(0.283)	(0.283)	(0.602)	(0.553)	(0.563)
IPC class C	3.386***	3.334***	3.336***	0.724	0.547	0.532
	(0.370)	(0.353)	(0.345)	(0.539)	(0.511)	(0.517)
IPC class D	1.754***	2.260***	2.230***	-1.906**	-1.180	-1.173
	(0.526)	(0.628)	(0.613)	(0.852)	(0.731)	(0.746)
IPC class E	0.195	0.379	0.366	-4.662***	-3.389**	-3.400**
	(0.504)	(0.381)	(0.394)	(1.534)	(1.396)	(1.385)
IPC class F	3.953***	2.964***	2.964***	3.607*	2.048	2.058
	(1.396)	(0.874)	(0.851)	(2.070)	(1.350)	(1.360)
IPC class G	3.533***	2.677***	2.701***	1.655**	0.700	0.683
	(0.686)	(0.488)	(0.489)	(0.817)	(0.703)	(0.707)
IPC class H	3.262***	2.469***	2.438***	2.013**	1.147*	1.170*
	(0.833)	(0.421)	(0.422)	(0.833)	(0.625)	(0.626)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
No-patent dummy	Yes	Yes	Yes	No	No	No
Constant	-1.217***	-1.117***	-1.102***	-1.753***	-1.379**	-1.377**
	(0.236)	(0.214)	(0.210)	(0.616)	(0.597)	(0.599)
Universities	155	155	155	155	155	155
Years	1994–2009	1994–2009	1994–2009	1994–2004	1994–2004	1994–2004
Observations	2,480	2,480	2,480	1,705	1,705	1,705
Log likelihood	-8290.86	-8153.76	-8142.652	-1588.611	-1542.583	-1542.245
Chi-square	7508.72***	8414.45***	7925.34***	197.93***	321.23***	319.22***
Alpha	1.47***	1.26***	1.24***	1.97***	1.51***	1.50***
Vuong statistic	-	-	-	9.86***	10.14***	10.12***

Notes: Standard errors clustered at university level in parentheses. IPC class A was omitted because of high multicollinearity. The Vuong statistic is estimated for models without clustered standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Data sources: PATSTAT (version: October 2012), National Bureau of Statistics of China (1992–2010a), National Bureau of Statistics of China (1992–2010b), Ministry of Education of the P.R. of China (2006), Li (2012).

3.4.3 Robustness checks and further analyses

Several robustness checks and further analyses are reported in Table 3.4. To further assess the interaction between the two subsidy programs, we run sub-sample regressions. We divide our sample into two sub-samples according to whether a university received a research excellence subsidy (Project 985) (Models 1 and 2) or not (Models 3 and 4). The sub-sample regressions allow us to analyze whether the cost reimbursement subsidy has a different effect on university patenting depending on whether the university is included in Project 985. One could argue that the two types of subsidy complement or reinforce each other's effects. Yet our results do not support this notion. We do not find substantial differences regarding the determinants of patent quantity and quality between both subgroups. Similar to Table 3 (our main model), the cost reimbursement subsidy is associated with an increase in patent quantity in both subgroups, while patent quality remains unaffected.

To gain further insights, we also divided our sample according to whether the university was located in a region with a high or low value of *IHE R&D personnel* (i.e., greater or lower than the median). While the results (Models 5–8) confirm the quantity and quality enhancing effect of the research excellence subsidy, the quantity-enhancing effect of the cost reimbursement subsidy is significant only for universities with lower values of *IHE R&D personnel*. Thus, universities with an already high endowment of R&D personnel seem to not benefit from the cost reimbursement subsidy introduced at regional level. This finding indicates an increasing utility of cost reimbursement subsidy with decreasing R&D inputs.

Finally, we include an interaction term between both subsidy programs in Models 9 and 10. The interaction term is insignificant, underlining the robustness of our main models.

Table 3.4: Robustness checks and further analyses.

	Univ. which received research excellence sub.		Univ. did not receive research excellence sub.		High IHE R&D personnel		Low IHE R&D personnel		With interaction terms	
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Regression	**Nbreg**	**Zinb**	**Nbreg**	**Zinb**	**Nbreg**	**Zinb**	**Nbreg**	**Zinb**	**Nbreg**	**Zinb**
Dependent Variable	**App.**	**Citations**	**App.**	**Citations**	**App.**	**Citations**	**App.**	**Citations**	**App.**	**Citations**
$GRPPC_{t-3}$	0.026**	0.067***	0.016	0.046**	0.017	0.040**	0.038*	0.101***	0.023**	0.061***
	(0.013)	(0.019)	(0.013)	(0.019)	(0.014)	(0.019)	(0.021)	(0.030)	(0.010)	(0.014)
IHE R&D $personnel_{t-3}$	0.024	0.062**	0.054**	0.054*	-0.027	-0.033	0.044	0.115**	0.042**	0.060**
	(0.026)	(0.028)	(0.024)	(0.032)	(0.041)	(0.058)	(0.035)	(0.049)	(0.020)	(0.030)
IHE R&D exp./GRP_{t-3}	-0.063	0.160	-0.181**	0.108	-0.037	0.209*	0.042	0.166	-0.076	0.103
	(0.087)	(0.148)	(0.070)	(0.102)	(0.090)	(0.109)	(0.101)	(0.174)	(0.064)	(0.101)
Cost reimbursement subsidy	0.675***	0.282	0.435**	-0.216	0.126	-0.512	0.496**	0.240	0.435**	-0.143
	(0.238)	(0.222)	(0.209)	(0.286)	(0.327)	(0.356)	(0.193)	(0.288)	(0.190)	(0.224)
Research excellence $subsidy_{t-3}$					1.263***	2.249***	1.541***	1.807***	1.213***	1.955***
					(0.182)	(0.333)	(0.184)	(0.285)	(0.263)	(0.309)
Cost reimb. subsidy x Research excel. $subsidy_{t-3}$									0.241	0.078
									(0.288)	(0.339)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IPC classes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No-patent dummy	No	No	No	No	No	No	No	No	Yes	No
Constant	-0.471	-0.152	-1.585***	-2.171***	-0.724	-1.410	-1.260***	-1.277**	-1.102***	-1.376**
	(0.498)	(1.150)	(0.221)	(0.617)	(0.451)	(0.936)	(0.214)	(0.506)	(0.210)	(0.599)
Universities	39	39	116	116	74	74	81	81	155	155
Years	1994–2009	1994–2004	1994–2009	1994–2004	1994–2009	1994–2004	1994–2009	1994–2004	1994–2009	1994–2004
Observations	624	429	1,856	1,276	1,184	814	1,296	891	2,480	1,705
Log likelihood	-2921.36	-813.83	-5160.29	-653.12	-4058.73	-856.75	-4141.91	-645.26	-8142.43	-1542.24
Chi-squared	3163.24***	781.07***	2217.40***	164.18***	2744.48***	283.71***	1548.52***	379.78***	8153.72***	325.65***

Notes: Nbreg = Negative binomial regression, Zinb = Zero-inflated negative binomial regression. Clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

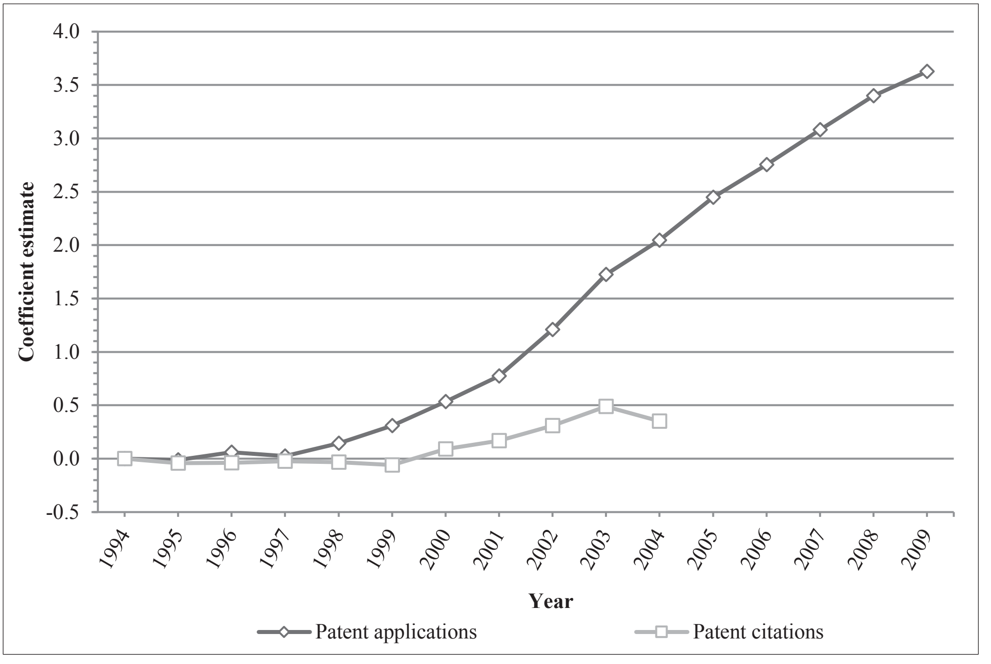
Data sources: PATSTAT (version: Oct. 2012), National Bureau of Statistics of China (1992–2010a), National Bureau of Statistics of China (1992–2010b), Ministry of Education of the P.R. of China (2006), Li (2012).

3.4.4 Trends in patent quantity and patent quality

To further assess the developments in patent quality and quantity over time, Figure 3 shows coefficients of year dummies as estimated in an OLS regression. We use a fixed effects regression based on Model 3 of Table 3.3 for patent quantity and a regression based on Model 6 of Table 3.3 for patent quality. To account for the skewed nature of the dependent variable, we include patent applications and citations in logged form. These coefficients represent growth estimates for the entire period considered and estimate the growth in a flexible way because they do not assume the growth to be constant over time. Moreover, in contrast to the descriptive statistics describing an increase in patent quantity and quality, these coefficients describe the growth after controlling for important determinants such as GRPPC, R&D personnel, and subsidy programs. Following Hall and Ziedonis (2001), we display the normalized coefficients of the year dummies. That is, the difference between the respective year coefficient and the coefficient of 1994 is reported.

The results for patent quantity are similar to the descriptive statistics. The time dummies indicate increasing growth from 1999 onward. Compared with 1994, the number of annual patent applications per university increased by 30.8% in 1999 and by 172.6% in 2003. Prior to 1998, the coefficients are insignificant and volatile at a low level. However, Figure 3 does not display a similar and significant increase in patent quality, which indicates that patent quality did not increase over time when accounting for control variables. Rather, the increase in citations over time can be explained to a substantial degree by the university subsidy program and the other variables. The gap between patent applications and citations widens, which indicates an increasing divergence between patent quantity and quality.

Figure 3.3: Estimated year effects of patent applications (patent quantity, 1994–2009) and patent citations (patent quality, 1994–2004).



Data source: PATSTAT (version: October 2012).

3.5 Discussion and conclusion

This study assesses Chinese university patenting by analyzing the quantity, quality, and determinants of patents filed by 155 leading Chinese universities in the years 1991 to 2009. Our results reveal a strong increase in patent applications by Chinese universities. Using regression analysis, we identify two types of subsidy program (cost reimbursement subsidy and research excellence subsidy) as significant determinants of the growth in patent applications. Regarding the evolution of patent quality we do not observe a similarly strong increase. Analyzing patent citation data, we find that the subsidy aimed at promoting research excellence is an important determinant of patent quality, whereas the cost-reimbursing subsidy program does not influence patent quality.

The increasing divergence between patent quantity and quality may reflect a problematic incentive structure for patentees. Given the strong quantitative increase, submitting patent applications appears to be of greater importance than producing high-quality patents. As such, while it is explicitly stated that the Chinese government wants to quadruple patent applications by 2020, it is mentioned only parenthetically that this growth should be accompanied by increasing quality. This quantitative orientation is not only evident in the formulated goals of the government (SIPO, 2011), but also seems to be present at individual level:

Shapira and Wang (2009) indicate that scholars in universities are incentivized to apply for patents because they can be important for career development and promotion. Similarly, Huang and Wu (2012) describe a general interest in obtaining a patent, not its usage or value. Thus, scholars in universities that are under the pressure to produce measureable outcome in the form of patents might prioritize the application of patents and disregard the quality of the underlying inventions. This notion is also supported by our findings regarding the cost reimbursement subsidy, which primarily aims to reduce application costs and does not consider the quality of the patent application (Li, 2012). In line with this argument, our empirical results show that this type of subsidy program succeeded in stimulating patent applications but did not have a sizeable effect on patent quality.

Although the primary interest in China seems to be a quantitative increase of patent applications, our results indicate that the research excellence subsidy (Project 985) also results in higher patent quality. The program aims to strengthen the overall research performance of selected universities and seems to produce an increase in both patent quantity and quality. From a policy perspective, we conclude that subsidy programs promoting research excellence through general investments in universities can achieve an increase in both the quantity and quality of innovative efforts and thus can play an important role in developing a functioning national system of innovation. Therefore, innovation policies which aim to stimulate patents of higher quality should focus on subsidy programs increasing university R&D and less on decreasing the cost of university patenting.

Our study is not without limitations. We would have liked to include more university-specific variables in our regressions in addition to the subsidy program at university level, particularly variables concerning R&D expenditures, R&D personnel, or other variables, such as scientific publications. However, data on these university-level variables is not (publicly) available. Second, we include only patents that explicitly name a university as an applicant. This approach excludes patents that list the inventor as the applicant or those that have been created in collaboration with companies in joint research projects or in spin-offs. University spin-offs are another increasingly important way in which universities contribute to innovation (e.g., Fryges and Wright, 2014; Heblich and Slavtchev, 2014; Stephan, 2014). However, although spin-offs or joint ventures are affiliated with a university, their patents typically do not list the respective university as an applicant. Further, this shortcoming limits us to analyzing university-owned patents. While university-owned patents have been utilized frequently to analyze university patenting (e.g., Baldini, 2009; Acosta et al., 2012) several authors indicate that they only capture a fraction of all academic patents (e.g., Geuna and Nesta, 2006; Lissoni et al., 2008). While university-invented patents are better suited to analyze innovative activities (e.g., Lissoni et al., 2008; Azagra-Caro, 2014), they are difficult to obtain because they usually require knowledge on the affiliation of the inventors listed in the patents. This information was not available to us, partly because of the simplified translation of inventor names from Chinese in PATSTAT. Third, we rely on patent citations as a measure of patent quality. This proxy has caveats, particularly with respect to distinguishing inventor and examiner citations (e.g., Criscuolo and Verspagen, 2008; Azagra-Caro et al., 2011) or distinguishing self-citations from other citations.

This study offers a number of avenues for further research. Because the Chinese patenting surge has not ceased, it will be interesting to continue the analysis of this development. In this vein, Leydesdorff and Meyer (2010) note a decrease in university patenting in the U.S., which experienced a similar overall patent surge until 2005 (Hall, 2005). The authors primarily attribute this decrease in university patenting to an increasing orientation toward university rankings that often do not consider patents. Furthermore, China will continue its policy of expanding the role of universities as a key component of its official patenting strategy through 2020 (SIPO, 2011). Thus, there will most likely be further regulatory changes or subsidy programs that warrant investigation, particularly in comparison with the programs analyzed in this study. Similarly, future research could focus on the territorial level of governance of these programs and, for example, analyze whether subsidies at regional or national level differ in their effects. Finally, it would be interesting to similarly assess the quality of non-university patents because such an approach would enable an intra-Chinese comparison to examine whether universities or companies provide patents of higher quality. Thus, our study could be easily extended to public research institutes and university spin-offs, which previous studies have demonstrated to play a prominent role in China (e.g., Hu and Mathews, 2008; Li, 2012).

3.6 Appendix

Table 3.A1: Comparison of our data with SIPO data.

	2002			**2004**			**2008**		
Rank	**University**	**SIPO**	**Our data**	**University**	**SIPO**	**Our data**	**University**	**SIPO**	**Our data**
1	Tsinghua U	497	495	Shang. Jiaotong U	791	826	Zhejiang U	1,641	1,687
2	Shanghai Trans U	311	345	Tsinghua U	676	711	Tsinghua U	1,229	1,210
3	Zhejiang U	283	283	Zhejiang U	642	660	Shang. Jiao Tong U	1,061	1,126
4	Tianjin U	180	169	Fudan U	335	330	Harbin Inst. of T	821	824
5	Fudan U	133	128	Tianjin U	257	281	Beihang U	799	741
6	Wuhan U	106	117	Haerbin Industial U	255	271	Donghua U	647	591
7	Sichuan U	97	110	Nanjing U	211	220	Southeast U	528	539
8	Xi'an Jiaotong U	97	90	Sichuan U	186	171	Tianjin U	522	494
9	Zhongshan U	89	97	South Chin. S&E U	165	159	Shanghai U	484	438
10	South Chin. S&E U	81	61	Tongji U	161	144	South China U of T	473	420
		r = 0.994 ***			r = 0.999 ***			r = 0.997 ***	

Notes: U = University, T = Technology, S = Science, E = Engineering, Trans = Transportation. r = Pearson's correlation coefficient, *** = significant at 1%-level.

Data sources: SIPO (2003–2009), PATSTAT (version: October 2012).

Table 3.A2: Sample of applicant names in PATSTAT matched to universities.

University:	**Beihang University**	**Harbin Institute of Technology**	**Tsinghua University**	**Shanghai Jiao Tong University**
Applicant names:	Beihang University	Harbin Institute of Technology	Tsinghua University	Shanghai Jiao Tong University
	Bei Hang University	Harbin Polytechnic Univ.	Tsinghua Univ.	Shanghai Jiaotong University
	Beijing University of Aeronautics & Astronautics	Harbin Polytechnical Univ.	Qinghua Univ	Shanghai Communication University
	Beijing University of Aeronautics and Astronautics	Harbin Univ. of Technology	Qinghua Univ.	Shanghai Second Medical University
	Beijing Aerospace University	Harbin Univ. of Tech.	Tsing Hua University	Shanghai Jiatong Univ.

Data source: PATSTAT (version: October 2012) .

Table 3.A3: Detailed information on the subsidy programs.

Region	Start: Cost reimbursement subsidy	No. of universities	No. of universities receiving research excellence subsidy	Start: research excellence subsidy
Anhui	2003	3	1	1999
Beijing	2000	31	8	1999
Chongqing	2000	3	1	2001
Fujian	2002	5	1	2001
Gansu	-	2	1	2001
Guangdong	2000	9	2	2001
Guangxi	2001	1	-	-
Guizhou	2002	1	-	-
Hainan	2001	1	-	-
Hebei	2005	3	-	-
Heilongjiang	2001	5	1	1999
Henan	2002	2	-	-
Hubei	2005	7	2	2001
Hunan	2004	6	3	2001
Inner Mongolia	-	1	-	-
Jiangsu	2000	17	2	1999
Jiangxi	2002	1	-	-
Jilin	2004	3	1	2001
Liaoning	2006	4	2	2001
Ningxia	2007	1	-	-
Qinghai	2005	1	-	-
Shaanxi	2001	9	3	1999
Shandong	2003	8	2	2001
Shanghai	1999	11	4	1999
Shanxi	2003	3	2	2001
Sichuan	2001	6	-	-
Tianjin	2000	4	2	2000
Xinjiang	2002	2	-	-
Yunnan	2003	2	-	-
Zhejiang	2001	6	1	1999

Data sources: Li (2012), Ministry of Education of the P.R. of China (2006).

Chapter 4

The value of Chinese patents: An empirical investigation of citation lags

China has been experiencing a substantial growth in patent applications. But is this increase accompanied by a similar increase in patent value? To assess this question, we examine the citation lag of Chinese patents as a proxy of patent value in comparison with patents from the US, Europe, Japan, and Korea. Our empirical analysis comprises a unique data set of 60,000 patents with priority years between 2000 and 2010. Utilizing Cox regressions, our results show that Chinese patents suffer from a large citation lag in comparison to international patents, indicating a lower value. This is especially true for patents filed domestically. However, we find empirical support for a positive moderation of this effect by the number of patent references, the number of patent claims, and for more recent patents. China shows a strong dynamic in the field of patenting and our results suggest that the gap between Chinese patents and international patents might narrow down in the near future.

This chapter is currently submitted to a journal.

4.1 Introduction

Formerly labeled as the "world's factory" (Ma et al., 2009), China has shifted its economic model from a production-oriented to a knowledge-based economy (Hu and Mathews, 2008). China's objective of becoming a leading nation in terms of innovation is reflected in the number of Chinese patent applications, which have exploded in recent years: In 2014, Chinese applicants filed 837,897 patent applications; 64.4% more than US applicants and 79.8% more than Japanese applicants. Only 15 years ago, Chinese applicants filed 1.9% of the patents they filed in 2014. While applications by Chinese applicants have grown 52-fold since then, applications by US applicants doubled while applications by Japanese applicants actually decreased by 3.3% (WIPO, 2016a). These numbers illustrate the remarkable and explosive growth in Chinese patenting.

Naturally, an increase in patent quantity raises questions regarding patent quality and patent value. Both constructs are important when evaluating the development of innovation in China, in particular its meaningfulness (e.g., Li, 2012; Chapter 3). For example, a mere quantitative increase in patent applications may raise concerns about whether China is actually catching up with other developed economies in terms of innovation, or whether impressive application numbers hide the fact that China's catch-up is rather superficial.

Patent citations are the most frequently used proxy to measure patent value (e.g., Harhoff et al., 2003; Gambardella et al., 2008). Forward citations are typically measured within 5 years of the initial publication of the application. The first publication of a patent occurs 18 months after patent filing. Thus, a patent's quality can only be assessed 6.5 years after the patent was initially filed: If data is sampled in the year 2015, patents can only be included if they have been filed in 2008 or earlier – otherwise they lack comparability. This leads to a potential loss of data, as the observations in recent years have to be excluded to establish comparability. This is a particularly important limitation when examining highly dynamic economies such as China, in which patenting numbers have exploded in recent years. Against this background, we use the closely related measure of the citation lag, which is the time elapsed between the publication of the application and the first forward citation it receives (Gay et al., 2005; Marco, 2007). Thus, we use the citation lag as a proxy of patent value and use survival time analysis to explicitly deal with truncated data. Applying this approach, we assess the following research question: How does the value of Chinese patents compare to the value of international patents?

Our empirical analysis is based on an international dataset of 60,000 patent applications. We use survival time analysis (Cox regressions) to analyze the hazard ratio of a patent receiving forward citations. A longer period of time until the first forward citation establishes a longer citation lag. Our results show that Chinese patents have the longest citation lag by far, indicating that the overall value of Chinese patents is low in comparison with other countries. This is particularly true for patents filed domestically (i.e., patents filed in China by Chinese applicants). However, the longer citation lag is shortened by a higher number of patent references and patent claims. Also, our results indicate that patent value has been increasing in recent years.

Our results contribute to the increasing and current literature on innovation in China. Previous studies have empirically analyzed the explosive increase in patenting by Chinese entities and its antecedents (e.g., Hu and Mathews, 2008; Li, 2012; Chapter 3). Overall, these studies identify stark increases in China's national innovative capacity, for example through increases in technology transfer, subsidies, and strategic alliances (e.g., Chen and Kenney, 2007; Hu and Mathews, 2008; Fang, 2011; Li, 2012). In spite of this, little attention has been drawn to the value of Chinese patents, which is often assumed to be comparatively low. By extending the research on innovation in China by an analysis of citation lags in recent years, we hope to add a further layer of discussion to China's endeavor of becoming a leading innovative nation.

This study is structured as follows: In Section 4.2 we describe our conceptual framework. This includes a review of related literature and the development of hypotheses. Section 4.3 details our data and empirical model. Section 4.4 presents the empirical results, which are discussed in Section 4.5.

4.2 Conceptual framework: China's patent system and patent value

4.2.1 China's patent system

China's innovation system was restructured in the last three decades as a part of China's intent to become a leading innovative nation. China joined the WIPO in 1980, providing a basis for a patent system complying with international standards (Bosworth and Yang, 2000). The first formal patent law in China was adopted in 1985. In 1993, the first major amendments of China's patent law took place. Among other modifications, these amendments extended patent protection to new categories of inventions and replaced a pre-grant opposition process for patent disputes with a post-grant revocation procedure. As a consequence, the examination process became faster by an average of six to ten months (Hu and Jefferson, 2009). In 2001, China became a member of the WTO and agreed to follow the TRIPS agreement (Yang and Clarke, 2005).

As part of these restructuring measures, the Chinese patent system has become similar to those of Europe and the US. According to Liegsalz and Wagner (2013), the basic application fee is 950 RMB, which is similar to filing fees at the EPO. After the fulfillment of the formal requirements, the patent is classified according to the IPC. Further, the SIPO issues a patent certificate and carries out a registration, which follows the publication of the patent 18 months after filing. Renewal fees have to be paid annually and increase over time. The time required to examine patent filings decreased from around 56 months during the 1990s (Liegsalz and Wagner, 2013) to an average of 25 months in 2010. By contrast, the pendency time at the USPTO was 33 to 35 months.

China also introduced several subsidy programs as part of its plan to become a leading innovative nation. For example, the Chinese government announced its "Guideline for the National Medium- and Long-term Science and Technology Development Programs" in 2006. This 15-year plan comprised policies and standards to increase domestic IP. Further, the government identified 16 megaprojects to develop key technological fields. In 2008, the Chinese government introduced the "National Intellectual Property Strategy". According to this policy, companies were to incorporate IP into their technical standards, and universities were allowed and encouraged to commercialize their IP. It also set objectives for the near future, for example, quadrupling the number of inventions and patents filed abroad by 2020, two million patent filings at the SIPO by 2015, reducing the pendency time to 22 months for invention patent filings, and increasing the number of examiners at the SIPO to 9,000 (Liang, 2012). Other important subsidy programs to promote patenting comprise cost reimbursement subsidies as well as large-scale investments in universities (e.g., Li, 2012; Chapter 3).

4.2.2 Patent value and citation lag

There is no universally accepted definition of patent value (e.g., Trajtenberg, 1990; Graf, 2007; Valentini, 2012; Squicciarini et al., 2013). In addition to the multitude of definitions of patent value, there is a large body of research on how to measure it. For example, Tong and Frame (1994) find patent claims, which define the extent of rights claimed by the patent, to be a possible indicator of patent value. Alternatively, Harhoff et al. (2003) measure the value of a patent by using the size of the patent family, among other proxies (i.e., the number of national or regional patent offices in which a patent is filed). Another possible measurement of patent value is patent renewal data (Lanjouw et al., 1998; Bessen, 2008) or grant lags (i.e., the time elapsed between the filing date of the application and the date of the grant of the patent). Also, Harhoff and Wagner (2009) argue that if applicants document their patent applications well, formulate the patent claims clearly, and work closely with the patent office, it is an indication that they themselves consider their patents valuable. Similar conclusions were reached by Règibeau and Rockett (2010). Trajtenberg et al. (1997) created a generality index, which is based on forward citations and has been used frequently since (e.g., Henderson et al., 1998; Galasso et al., 2011). Trajtenberg et al. (1997) also proposed an originality index that relates to the breadth of technological fields of a patent. A third index of patent value is the index of patent radicalness proposed by Shane (2001). This index counts the number of IPC classes in which the patents cited by the respective patent are classified.

However, forward citations are the most frequently used indicator of patent value. Forward citations refer to the number of times a patent has been cited by subsequent patents, indicating that these newer patents are technologically built upon the cited (previously filed) patent. Hence, a larger number of citations indicate a more valuable patent. Trajtenberg (1990) found that forward citations outperform simple patent counts as a proxy for the value of a patent; citations have since been used and validated frequently (e.g., Albert et al., 1991; Hagedoorn and Cloodt, 2003; Harhoff et al., 2003; Gambardella et al., 2008). However, using forward citations has drawbacks. For example, the patent examiner ultimately decides which and how many citations are included in a patent. More importantly, forward citations suffer from right truncation (i.e., newer patents have a lower propensity to receive numerous citations) (Mowery and Ziedonis, 2002). To avoid this problem, most studies use the forward citations a patent received within 5 years after the publication of the application. Recall that the patent application is published 18 months after filing. Thus, researchers typically award 6.5 years to a patent application to collect citations. This leads to a potential loss of data, as the observations in the last 6.5 years have to be excluded to establish comparability. This is a particularly important limitation when examining highly dynamic economies such as China, in which patent filing activity has exploded in recent years. Leaving out the last 6.5 years of development might lead to biased conclusions or a lack of identifying interesting results.

Against this background, we use the closely related measure of the citation lag, which is the time elapsed between the publication of the application and the first forward citation it receives (Gay et al., 2005; Marco, 2007). Thus, the citation lag is very similar to forward citations but circumvents the loss of the most recent data points. One reason for this is that Cox regressions can be employed that are explicitly able to deal with right truncation. For example, Gay et al. (2005) identified a link between number of forward citations and the citation lag. The authors noted that a technologically important patent is cited more quickly. Furthermore, a patent that received its first citation during the first year after being granted receives a higher number of forward citations overall. Put differently, the advent of the first citation is a good predictor for all citations accumulated in a 5-year window. In contrast, a patent that received its first forward citation a long time after being granted receives a lower total number of forward citations. Thus, a short citation lag can be associated with a higher patent value, while a longer citation lag can be associated with a lower patent value. Of course, using citation lag as a proxy of patent value also has several drawbacks, which we outline at the end of the study.

4.2.3 Hypotheses

The Chinese government has committed to transform China into a leading innovative nation. However, it is doubtful whether its policies have led to meaningful innovations that will help the Chinese economy to develop or whether the increase in patenting is merely of a quantitative nature. These doubts have been supplemented in previous studies: Liang (2012) points out that a low share of invention patents in China raises questions on the meaningfulness of Chinese patents. Liang (2012) identified that in 2010 only one quarter of all patent filings were invention patents, which undergo a more thorough examination process (as opposed to utility models and design patents). Further concerns are described in Chapter 3 of this thesis, which shows that the increase in Chinese university patenting is driven by subsidy programs designed to stimulate patenting, but is not accompanied by a similar increase in patent quality. Chinese subsidy programs to promote patenting often do not take into account patent quality, but are rather only interested in patent quantity increases.

Finally, in spite of the enormous increase of the number of patents filed at the SIPO, the number of patent examiners has not increased in a similar magnitude: Between 2002 and 2010, the filing of invention patents in China rose by 500%. However, the number of patent examiners only increased by 300% (Liang, 2012). This indicates that the average workload per patent examiner increased by 60%, while the total number of patent examiners at the SIPO was only a third of that at the USPTO. The resulting increase in the examiners' workloads suggests that the examination process might not be as thorough as in other countries, which might lead to patents of lower quality being granted or at least not being declined.

Taken together, we expect Chinese patents (i.e., patents by Chinese applicants) to have a lower patent value than patents from other regions. A lower patent value is represented by a longer duration between the application and first citation of the patent. Thus, we propose the following hypothesis:

H4.1: *Patents filed by Chinese applicants have a larger citation lag than patents from the US, Europe, Japan, and Korea.*

Petruzzelli et al. (2015) examine six factors that influence forward citations: (a) the use of scientific knowledge, (b) the breadth of the technological base, (c) the novelty, (d) the scope of the patent, (e) the number of claims, and (f) the existence of collaboration in patent development. We include most of these factors in our empirical analysis. However, we are interested in the specific impact of these factors on the value of Chinese patents (in comparison with other regions). Therefore, we propose that the relationship between the applicant's origin and the patent's value is moderated by most of these factors.

The technological scope of a patent is frequently used to determine a patent's value. Following Lerner (1994), we measure the technological scope of a patent as the total number of IPC4 classes in which a patent is categorized. Lerner (1994), as well as Merges and Nelson (1990), identified a positive relation between the number of IPC4 classes a patent is categorized in and patent value. In addition, Petruzzelli et al. (2015) demonstrate a positive relation between the patent scope and forward citations. Therefore, we expect the number of IPC4 classes to increase the patent's value and have a positive impact on the citation lag (i.e., lowering the citation lag). We expect this positive moderation to be similar across regions and also apply to China. Therefore, we suggest:

H4.2: *The more IPC4 classes a patent from China has, the shorter the citation lag.*

The breadth of the technological base reflects the ability of an innovator to discover new and valuable knowledge (Fleming, 2001). The broader this search for new knowledge, the higher is the likelihood of discovering new and valuable knowledge (Fleming, 2001). Thus, patents that involve a larger technological scope should be of higher value (Singh, 2008). The breadth of the technological base is indicated by the number of backward citations a patent contains. In contrast to a forward citation, a backward citation is a reference of a patent to another patent, which it builds upon (Jaffe and Trajtenberg, 2002; Petruzzelli et al., 2015). Closely related, it is crucial to examine the novelty of a patent when researching an innovation. Squicciarini et al. (2013) employed backward citations to evaluate the novelty of innovations, and we follow their approach. Therefore, backward citations can be seen as an indicator of both the breadth of the technological base and the novelty of a patent. Both constructs should impact patent value positively. Assuming a lower value of Chinese patents, we expect that the number of backward citations positively moderates patent value, resulting in a shorter citation lag. Thus, we expect:

H4.3: *The more backward citations a Chinese patent has, the shorter the citation lag.*

Patent claims determine the volume of the rights assigned by a patent and have been shown to correlate with patent value. Patent claims measure the volume of the rights assigned to a patent (Lanjouw and Schankerman, 2004). In order to assess the volume of rights assigned by a patent, we follow Petruzzelli et al. (2015) and count the number of exclusive rights a patent has as indicated by the number of claims. Tong and Frame (1994) introduced patent claims within an application as a possible indicator of patent value. However, we do not employ the variable patent claims as a proxy for patent quality, but rather as a determinant of patent value. Therefore, we expect that the number of patent claims a patent from China possesses will have a positive influence on the citation lag. We thus hypothesize:

H4.4: *The more patent claims a Chinese patent has, the shorter the citation lag.*

Patent applicants tend to file patent applications domestically, first and foremost (see Chapter 2). This "home advantage effect" affects patenting rates at most patent offices worldwide (Criscuolo, 2006). The home advantage effect can be explained by a greater familiarity with the domestic patent system, for example with regard to language requirements or other administrative requirements (Criscuolo, 2006; Liegsalz and Wagner, 2013). Also, previous research has frequently investigated whether domestic applicants are treated with preference at the respective patent office. With particular regard to China, studies have shown that there seems to be a slight preference for Chinese applications at the SIPO, in that Chinese applicants achieve comparably faster patent grants (Yang, 2008; Liegsalz and Wagner, 2013). Hence, patent applicants might prefer to apply for a domestic patent, as it is more likely to be granted. While the home advantage effect has been shown with regard to the quantitative share of domestic patent applications, it also has implications for the value of the patents. Van Zeebroek (2011) describes how companies might be inclined to file a lot of domestic patents in their home country to achieve faster patents grants or establish a priority. Also, this might lead to a higher share of low quality patents as these patents are often not intended to be extended worldwide, hence resulting in a lower average patent value. In the same vein, Harhoff et al. (2003) show that patents of a higher value are more likely to be extended worldwide, as indicated by a larger patent family size. Therefore, we suggest:

H4.5: *Chinese patents filed at the domestic patent office have a larger citation lag than patents filed at foreign patent offices.*

The Chinese patent office (SIPO) was established in 1980, the same year in which China also joined the WIPO (Bosworth and Yang, 2000; Liegsalz and Wagner, 2013). The first patent law was introduced in 1985, in which China also signed the Paris convention for the protection of intellectual property and established priority rights (Yang, 2008, EPO, 2016). Hence, the Chinese intellectual property system is still relatively young compared to the patent systems of the US and some European countries that were established at the end of the 19th century (USPTO, 2016b). Even though there is still some dispute over whether the Chinese patent system fully adheres to all required standards, the Chinese patent system in its current form can be described as meeting international standards and is largely comparable with the patent systems of the US or Europe (Sun, 2003; Liegsalz and Wagner, 2013)

As described in Section 2.1, China is actively trying to increase the patent quantity, but also patent quality, albeit not as prominently. For example, China has recently introduced a subsidy program to establish world-class universities (“Project 985”), significantly increasing the quality of their patent output (Chapter 2). The efforts China is undertaking in this realm are rather recent. Therefore, a resulting value-enhancing effect should also be comparatively stronger in recent years. Therefore, we assume that patents filed more recently have a higher patent value than previously filed patents. Also, we suggest that this effect could be stronger for Chinese firms. Hence, we suppose:

H4.6: *The more recent a Chinese patent has been filed, the shorter the citation lag.*

4.3 Data

4.3.1 Data sources and sample

Our sample consists of patent data obtained from PATSTAT (November 2013 version). Because we are not only interested in Chinese patents, we draw a stratified probability sample of patents with priority years between 2000 and 2010 that were published by a patent office in one of five regions: China, the US, Europe, Japan, and Korea. We further include publications by the WIPO, representing PCT publications. With regard to Europe, we aggregate all patents that have their origin in one of the 38 member states. In order to establish international comparability between the patents, we exclude utility models and limit our analysis to invention patents. To avoid an overrepresentation of patents applied for in multiple jurisdictions, we aggregate all patent applications and publications on the patent family level, as documented in PATSTAT, and exclusively consider the first forward citation within a patent family to calculate the citation lag. We exclude self-citations within the same patent family, since self-citations can create bias in statistical analysis by over-evaluating the citations a patent receives (Gay et al., 2005). Finally, we excluded patents that contained missing values. Our final data set contains 10,000 patent families applied for by applicants from each of the five regions: US, Europe, Japan, China, and Korea, as well as 10,000 PCT applications, resulting in a total sample of 60,000 patent families. Because not all patent applicants could be classified atomically with regard to their country of origin or type, we manually filled in gaps in the sample by looking up missing entries on the internet and assigning the correct classification where possible.

4.3.2 Variables

Dependent variable: We use the *citation lag* as our dependent variable. We define the citation lag as the time elapsed from the earliest priority date until a patent receives its first citation, measured in months. We use the application date as the data point from which to measure citation lag. Because we base our empirical analysis on a patent family level, the effective application date is defined as the earliest priority date.

Independent variables: Our main independent variable represents the applicant's country of origin (*origin of applicant*). The variable indicates whether the applicant is from the US (*US*), Europe (*EP*), Japan (*JP*), China (*CN*), or South Korea (*KR*).

The scope of a patent is measured by using the variable *number of IPC4 classes* in which a patent is categorized (Lerner, 1994). As noted earlier, backward citations to both patent and non-patent literature are positively correlated with patent value, which is counted by the variable *patent references*. Additionally, patent claims determine the volume of the rights assigned by a patent. The exclusive rights claimed by a patent are legally protected and enforceable (Lanjouw and Schankerman, 2004). The variable *patent claims* counts the number of exclusive rights a patent has. We further include an interaction effect that measures whether a patent was applied for in the applicant's *area of residence* in order to assess a possible home advantage effect. Finally, we include a *time trend* that accounts for increasing patent value over time.

Control variables: We include the variable *patent family size* in our analysis that describes the number of different jurisdictions in which a patent family is applied. The number of inventors who are involved in a patent reflects the degree of specialization and the pool of knowledge on which a patent is based (Singh, 2008). Therefore, we include the variables *number of inventors* as well as *number of applicants* that count (respectively) the number of inventors who are involved in a patent and how many applicants are stated in the patent specification. Finally, the variable *applicant type* represents the type of the applicant of a patent. It is a dummy variable categorized into *company, university, institute, individua*l and *other* (Gay et al., 2005). For example, Cassiman et al. (2008) and Branstetter (2005) show that patents related or referring to scientific research are of significantly higher value. Similarly, Henderson et al. (1998) demonstrate that patents filed by universities and research institutes receive more citations than patents outside the academic field.

We include the *earliest priority year*, which indicates the year of the first patent application within the patent family. The control variable *main area* indicates the technological field to which a patent is assigned. It is possible that a patent is classed into several main areas. The variable consists of multiple dummy variables comprising six classes: *Chemistry, electrical engineering, instruments, process engineering, mechanical engineering,* and *consumer goods and construction*. Finally, we include the patent authority as a control variable, which measures in which jurisdiction the respective patent family was filed. This also includes patent applications filed through the WIPO (*PCT applications*).
An overview of the variables and their measurement is displayed in Table 4.A1 (Appendix). Table 4.A2 (Appendix) details the correlations between the variables and shows that multicollinearity should not be an issue in our analyses.

4.4 Results

4.4.1 Descriptive statistics

Table 4.1 presents descriptive statistics on the 60,000 patent families analyzed. Almost half of the patent families (45.0%) received at least one citation. The mean citation lag is 26.8 months (approx. 817 days). About 15.9% (9,569) of patent families have been applied for by Chinese applicants, 12.5% (7,519) by US applicants, 14.8% (8,856) by European applicants, 35.6% (21,366) by Japanese applicants, and 19.2% (11,541) by applicants from South Korea. The remaining 1.9% (1,149) of patents are from other countries. The minimum citation lag is 1 day, while the maximum citation lag is 141.5 months. On average, the patent families are categorized in 2.8 IPC4 classes with a standard deviation of 2.3. The mean of patent references is 7.5, whereas the maximum is 241. The mean patent family size is 2.9; however, the maximum family size is 108. The patent families typically comprise 2.4 patent claims; the maximum is 143. The average number of inventors is 1.9. The relatively low standard deviation of 1.4 suggests that there is usually a small number of inventors involved in a patent, while the maximum number is 23. The same is true for the number of applicants: the average is 1.4 applicants with a standard deviation of 0.5. The maximum number of applicants is 5, which shows collaboration in patenting is only small scale. Regarding the applicant type, companies have the biggest share with 74.6%, followed by individuals (17.3%), universities (4.7%), and institutes (2.5%).

Table 4.2 illustrates the distribution of different applicant types across regions as well as further descriptive statistics. The results show that companies have the lowest share of patent families in China by far (45.9%). Individual applicants, however, are comparatively common in China (26.0%). An enormous discrepancy between China and the other countries emerges when examining the applicant type *university*. China has by far the highest share of applicants within this category (19.3%), while the other countries range between 0.6% and 3.0%. This demonstrates that universities contribute enormously to the recent patent surge in China (Chapter 3).

Descriptive results on patent citations are also summarized in Table 4.2. Comparing the citation lags of the countries, it can be noted that Chinese applicants experience the largest citation lag (31.9 months). Korean applicants perform significantly better with 27.8 months in our sample, which is only 6 months longer than the citation lag of European patents. Patents from the US have the shortest citation lag with 21.7 months on average. Table 4.2 also shows that China has the lowest share (11.9%) of patents that received a citation. In Korea, that share is considerably higher (36.9%) but still far behind the shares of the other countries. In contrast, US patents received a citation in 67.1% of the cases. These descriptive results indicate a lower patent value of Chinese patents.

Table 4.1: Descriptive statistics.

Variable	Mean	SD	Min.	Max.
Citation received	0.450	-	0	1
Citation lag (months)[a]	26.75	19.72	0.033	141.51
Origin of applicant				
CN	0.159	-	0	1
US	0.125	-	0	1
EP	0.148	-	0	1
JP	0.356	-	0	1
KR	0.192	-	0	1
Rest of the world	0.019	-	0	1
Number of IPC4 classes	2.771	2.317	1	92
Patent references	7.490	11.58	0	241
Patent family size	2.928	3.237	1	108
Patent claims	2.445	6.483	0	143
Number of inventors	1.869	1.422	1	23
Number of applicants	1.371	0.498	1	5
Applicant type				
Company	0.746	-	0	1
Individual	0.173	-	0	1
Institute	0.025	-	0	1
University	0.047	-	0	1
Others	0.009	-	0	1
Main area				
Chemistry	0.219	0.414	0	1
Electrical engineering	0.435	0.496	0	1
Instrument	0.204	0.403	0	1
Process engineering	0.136	0.342	0	1
Mechanical engineering	0.147	0.354	0	1
Consumer goods, construction	0.075	0.264	0	1

Notes: N = 60,000 patent families. [a] = only for 27,041 observations that received at least one citation.

Data source: PATSTAT (version: November 2013).

Table 4.2: Distribution of applicant types and further descriptive statistics.

Variable	Patent families	Company	Individual	Institute	University	Others	Citation received	Citation lag
Origin of applicant								
CN	9,569	45.9%	26.0%	6.2%	19.3%	2.5%	11.9%	31.9
US	7,519	85.3%	11.0%	0.5%	2.5%	0.6%	67.1%	21.7
EP	8,856	78.3%	15.4%	1.8%	2.8%	1.7%	56.0%	27.2
JP	21,366	81.3%	17.2%	0.4%	0.6%	0.3%	51.8%	28.1
KR	11,541	76.7%	14.7%	5.1%	3.0%	0.4%	36.9%	27.8
Other	1,149	68.3%	28.5%	1.0%	2.3%	0.0%	48.7%	23.4
Patent authority								
CN	10,000	49.5%	23.5%	5.9%	18.6%	2.5%	13.7%	31.7
US	10,000	89.7%	7.6%	0.6%	1.6%	0.6%	70.2%	20.8
EP	10,000	86.8%	7.6%	1.8%	2.4%	1.5%	58.3%	26.4
JP	10,000	97.0%	2.2%	0.2%	0.2%	0.5%	43.2%	35.3
KR	10,000	81.2%	9.5%	5.7%	3.3%	0.4%	32.7%	29.0
WO	10,000	43.5%	53.6%	0.7%	1.9%	0.3%	52.2%	25.3
N	60000	44,704	7,072	815	2,401	5,008	27,021	in months

Notes: WO = PCT Patent application. Citation lag = mean citation lag in months.

Data source: PATSTAT (version: November 2013).

4.4.2 Multivariate analysis

We use a Cox regression (Cox, 1972) as our main analysis because it enables us to consider the specifics of the temporal distribution of forward citations (Marco, 2007). It allows an estimation of the hazard of a particular occurrence within a given time interval (Cox and Oakes, 1984). We use the initial forward citation of a patent as the particular occurrence. Therefore, the survival time is the time between the filing of a patent and the first citation of the patent in question. The Cox regression model is defined as follows:

$$h(t|x_i) = h_0(t)*exp(\beta_n x_i)$$

Index *i* describes an individual patent within the sample. The Cox model comprises no intercept as it is integrated in the baseline hazard $h_0(t)$. The coefficients $ß_1$–$ß_n$ represent the estimated coefficients of the respective variables. Formulated with regards to our empirical analysis the Cox regression model becomes:

$$h(t|x_i) = h_0(t)*exp(\beta_1 x_i+\beta_2 x_i+\beta_3 x_i+\ldots+\beta_n x_m)$$

The results of the hazard regression used to estimate the probability of a patent citation based on the citation lag are illustrated in Table 4.3. To assess our hypotheses, we estimate six regression models. All models include citation lag as the dependent variable. Model 1 tests Hypothesis H4.1. Models 2 through 6 examine how particular determinants influence the value of patents in different regions via the respective interaction effects.

Model 1 includes all control variables and focuses on assessing whether applicants of a different origin achieve different patent values. Indeed, the results indicate that patent families from China have a low hazard rate. Hazard rates below the baseline of 1 indicate that the hazard of the occurrence of a forward citation is less likely when the respective variable increases. The effect is highly significant ($p < 0.01$). Thus, patents by Chinese applicants (*CN*) take far longer (56.1% longer) to receive a citation than patents from other countries. In contrast, patents by US, Japanese, and Korean applicants have a significantly shorter citation lag, while the results from European applicants are insignificant. The effect of Chinese applicants experiencing a longer citation lag is robust across all models. Thus, Chinese patents suffer from larger citation lags, indicating an overall lower quality, supporting Hypothesis H4.1.

With regard to Hypothesis H4.2, our results show that a greater number of *IPC4 classes* have positive and highly significant impacts on the hazard ratio (i.e., the citation lag is shortened). When the number of IPC4 classes is interacted with the origin of the applicant to uncover differences across regions (Model 2), the results indicate that more IPC4 classes lead to a longer citation lag across most regions: The hazard ratios are reduced for patents by Chinese (2.8%), European (6.0%), and US applicants (6.2%). Thus, we find no support for H4.2.

Patent references exhibit a slight positive impact on the hazard ratios, as hypothesized in H4.3. As shown in Model 3, an increase in backward citations increases the hazard ratio significantly. When investigating the interaction effects, the results indicate that Chinese patents profit most from patent references and therefore have a ratio that is 8.0% higher than the baseline and highly significant ($p < 0.01$). Korea follows with 4.2%. Hence, the results support Hypothesis H4.3.

Model 4 examines the impact of *patent claims* on the hazard ratio (H4.4). A positive but fairly small effect can be observed. The interaction in Model 4 shows that the highest positive moderation is achieved at patents by Chinese applicants with a ratio of 4.6%, followed by Japan (1.8%), Korea (1.3%), and the US (1.2%). Thus, the results also support Hypothesis H4.4.

Hypothesis H4.5 assumed that there is a so called “home advantage effect”. With particular regard to China, we assume that Chinese applicants file patents domestically that are of lower quality. Patents of higher quality, in comparison, are more likely to be filed at a foreign, international patent office. The results (Model 5) support this argumentation: Patents filed in China by Chinese applicants have a much longer citation lag (increased by 45.8%). This effect is highly significant. However, we find that the same is true for US that file patents domestically, albeit to a much lesser extent. Hence, the results also support Hypothesis H4.5.

Finally, Model 6 investigates whether a trend of an increasing patent value can be observed in recent years. While the baseline effect (*time trend*) indicates that patent values are not increasing overall, the positive and highly significant interaction effect for patents by Chinese applicants indicates that their patent value is increasing (7.7%), supporting Hypothesis H4.6. Chinese applicants increased their patent value the most.

Regarding the control variables, *patent family size*, the *number of inventors*, and the *number of applicants* have an above-baseline effect, indicating that higher values lead to a shorter citation lag. The results on the different applicant types reveal only small differences between applicant types.

4.5 Discussion and conclusion

The rapid increase in Chinese patent applications naturally raises questions with regard to the value of these patents, which we proxy for by using a patent's citation lag. So far, there is little empirical research about the value of Chinese patents. Our results show that patents by Chinese applicants experience the longest citation lag by far, indicating that the overall value of Chinese patents is low in comparison with other countries, particularly for patents filed by Chinese applicants in China. For Chinese applicants, the longer citation lag is shortened by a higher number of patent references and patent claims, and significantly decreased in recent years. This suggests that the overall value of Chinese patents might be increasing.

Although Chinese patents have the lowest probability to receive a citation, their citation lag is considerably shortened when other moderating variables are taken into account (e.g., number of patent references, number of patent claims). However, the comparatively strong moderation effect should be interpreted cautiously, as it might have a partial institutional background: Patent references and patent claims are added by the patent examiner of the patent office. Ascribing political motivations, one could assume that the examiners at the SIPO are instructed to treat patents from Chinese applicants more favorably, for example by assigning them more patent references and patent claims.

Our empirical analysis offers several implications for theory and practice. Our findings show how the value of patents by Chinese applicants compares to applicants from other regions, thus providing an important contribution to research about the competitiveness of national economies. The results of our study also contribute to research about the determinants of patent value. Further, we are able to evaluate in which direction and to what extent each determinant influences the value of patents. In line with other studies, we can confirm that the scope of a patent (patent claims, patent family size, and backward citations) has a positive moderating effect (Squicciarini et al., 2013; Petruzzelli et al., 2014).

Table 4.3: Cox proportional hazards models (dependent variable: citation lag).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Origin of applicant (Ref: ROTW)						
CN (China)	0.439 (0.032) ***	0.541 (0.054) ***	0.298 (0.021) ***	0.412 (0.031) ***	0.718 (0.086) **	0.255 (0.035) ***
US (US)	1.243 (0.057) ***	1.501 (0.113) ***	1.177 (0.063) **	1.216 (0.061) ***	1.231 (0.064) ***	1.061 (0.110)
EP (Europe)	1.067 (0.050)	1.272 (0.096) **	0.942 (0.052)	0.994 (0.054) *	1.160 (0.064) **	0.813 (0.085) *
JP (Japan)	1.326 (0.060) ***	1.468 (0.109) ***	1.119 (0.059) *	1.260 (0.063) ***	1.350 (0.061) ***	1.183 (0.121)
KR (Korea)	1.373 (0.071) ***	1.312 (0.107) ***	0.878 (0.052) *	1.298 (0.073) ***	1.392 (0.074) ***	1.163 (0.126)
Number of IPC4 classes	1.029 (0.002) ***	1.078 (0.021) ***	1.027 (0.002) ***	1.029 (0.002) ***	1.029 (0.002) ***	1.023 (0.002) ***
IPC4 classes * CN		0.972 (0.024) **				
IPC4 classes * US		0.938 (0.019) **				
IPC4 classes * EP		0.940 (0.019) **				
IPC4 classes * JP		0.963 (0.019)				
IPC4 classes * KR		1.011 (0.022)				
Patent References	1.010 (0.000) ***	1.010 (0.000) ***	1.000 (0.002) ***	1.010 (0.000) ***	1.010 (0.000) ***	1.010 (0.000) ***
Patent references * CN			1.080 (0.004) ***			
Patent references * US			1.005 (0.002) *			
Patent references * EP			1.010 (0.002) ***			
Patent references * JP			1.013 (0.002) ***			
Patent references * KR			1.042 (0.003) ***			
Patent claims	1.008 (0.001) ***	1.008 (0.001) ***	1.009 (0.001) ***	0.998 (0.005)	1.008 (0.001) ***	1.008 (0.001) ***
Patent claims * CN				1.046 (0.017) **		
Patent claims * US				1.012 (0.005)*		
Patent claims * EP				1.003 (0.005)		
Patent claims * JP				1.018 (0.007) *		
Patent claims * KR				1.013 (0.005) *		

(Table 4.3 continues on the next page)

Table 4.3: (continued).

Domestic application						
Patent auth. CN * CN					0.542 (0.070) ***	
Patent auth. US * US					0.883 (0.040) **	
Patent auth. EP * EP					1.043 (0.041)	
Patent auth. JP * JP					1.005 (0.106)	
Patent auth. KR* KR					0.651 (0.266)	
Time trend						0.835 (0.012) ***
Time trend * CN						1.077 (0.020) ***
Time trend * US						1.025 (0.016)
Time trend * EP						1.047 (0.016) **
Time trend * JP						1.011 (0.015)
Time trend *KR						1.019 (0.016)
Controls						
Patent family size	1.043 (0.001) ***	1.044 (0.001) ***	1.045 (0.001) ***	1.042 (0.001) ***	1.043 (0.001) ***	1.046 (0.001) ***
Number of Inventors	1.049 (0.005) ***	1.049 (0.005) ***	1.047 (0.005) ***	1.049 (0.005) ***	1.048 (0.005) ***	1.047 (0.005) ***
Number of Applicants	1.194 (0.015) ***	1.192 (0.015) ***	1.179 (0.015) ***	1.186 (0.015) ***	1.187 (0.015) ***	1.251 (0.016) ***
Company	0.988 (0.071)	0.984 (0.070)	0.983 (0.070)	0.995 (0.071)	0.983 (0.070)	0.942 (0.067)
Individual	0.900 (0.066)	0.897 (0.066)	0.905 (0.066)	0.908 (0.067)	0.890 (0.065)	0.846 (0.062) *
Institute	1.075 (0.091)	1.066 (0.090)	1.094 (0.093)	1.082 (0.092)	1.074 (0.091)	1.024 (0.087)
University	0.875 (0.073)	0.863 (0.072)	0.895 (0.074)	0.877 (0.073)	0.881 (0.073)	0.814 (0.068) *
Earliest prio. year (dummies)	Yes	Yes	Yes	Yes	Yes	No
Main area (dummies)	Yes	Yes	Yes	Yes	Yes	Yes
Patent authority (dummies)	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo log-likelihood	-278,233.04	-278,189.20	-277,888.94	-278,218.44	-278,218.56	-279,431.32
Chi-squared	23,676.80 ***	23,764.48 ***	24,364.99 ***	23,706.00 ***	23,705.75 ***	21,280.24 ***

Notes: N = 60,000 patent families. Exponentiated coefficients (hazard ratios), standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Data source: PATSTAT (version: November 2013).

Our results also offer practical implications. This study provides policy makers and practitioners with a better understanding of the economic value of patents filed by Chinese applicants, which is crucial for a more specific evaluation of the sustainability and meaningfulness of Chinese innovations (e.g., Li, 2012). Our finding that Chinese patents filed more recently have a higher probability of receiving citations supports the view that the government's efforts to develop China into an innovation leader (Liang, 2012) are bearing fruit. This implies that in the midst of the artificially created explosion in the number of Chinese patents there are also valuable innovations in China, indicating that China might successfully be transitioning from an imitation- to an innovation-based economy. This study therefore provides a signaling function for actors who plan to engage on the Chinese patent market as well as for investors willing to invest in Chinese companies. Furthermore, this study provides insights about China's future technological capability, which might be catching-up to further developed countries in the near future. This is especially important for European policy makers who hope to maintain their countries' positions as the leading innovative economies in the world.

Our analysis is not without limitations. Forward citations involve the problems of truncation. Using the citation lag as dependent variable cannot completely avoid this problem. Further problems arise from the impact of the patent examiner on whether a patent gets a citation (Alcácer et al., 2009), from unobserved heterogeneity when comparing different industries (Gittelman, 2008), and the problem of citation inflation (Marco, 2007). Additionally, while our study uses the IPC classification, a new patent classification (the Cooperative Patent Classification, CPC) has recently been introduced. Major patent offices have already announced the decision to adopt the CPC, which means that it will become the internationally accepted standard. This will have a positive impact on innovation research in fields such as energy storage technologies (Mueller et al., 2015). Also note that the citation lag, like most other proxies of patent value, should only be understood as a limited and rather general indicator of a patent's real value. Finally, the indication of catching-up in terms of patent value has to be interpreted very cautiously. Because of the overall low patent value, it is not surprising that we find the positive moderators to be comparatively strong.

Further research might find it interesting to examine other determinants of patent value across regions, such as number of applicants, or other factors that we have not considered. Likewise, differences between technological fields are not considered in our study, and the problem of unobserved heterogeneity in citation behavior between different industries is another issue for future research. As initiated by Marco (2007) and Gay et al. (2005), finding methods that are an improvement compared to the use of pure forward citations would also be a useful contribution to research in the field of innovation and patent value. Using hazard estimation can be a first step in the right direction. Finally, the differences between different types of applicants warrants further research. Even though the share of university patents has increased sharply, our results show that their value seems to be comparatively low, indicating that universities in particular fail to develop meaningful inventions.

4.6 Appendix

Table 4.A1: List of variables.

Variable	Description
Dependent variables	
Citation lag	Number of months between the filing of a patent and the first forward citation
Independent variables	
Origin of applicant	Dummy variable indicating the origin of the applicant [US, EP, JP, CN, KR, rest of the world]
Number of IPC4 classes	Number of IPC4 classes in which the patent is classified
Patent references	Number of citations referring to prior patents
Patent claims	Number of claims of the patent
Control variables	
Patent family size	Number of different jurisdictions in which the patent is filed
Number of inventors	Number of inventors of the patent
Number of applicants	Number of applicants of the patent
Applicant type	Type of the applicant categorized [company, university, institute, individual, other]
Year dummies	Dummy variable for the earliest priority year
Main area	Dummy variable for the main area of technology
Patent authority	Dummy variable indicating the patent authority, at which the application was filed [US, EP, JP, CN, KR, rest of the world]

Data Source: PATSTAT (version: November 2013).

Table 4.A2: Correlations.

	Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**
(1)	Citation lag[a]															
(2)	CN	0.05*														
(3)	US	-0.12*	-0.16*													
(4)	EP	0.01	-0.18*	-0.16*												
(5)	JP	0.06*	-0.32*	-0.28*	-0.31*											
(6)	KR	0.02*	-0.21*	-0.18*	-0.20*	-0.36*										
(7)	Number of IPC4 classes	-0.04*	-0.04*	0.01	0.00	0.16*	-0.17*									
(8)	Patent references	-0.18*	-0.25*	0.22*	0.21*	0.00	-0.16*	0.11*								
(9)	Patent family size	-0.12*	-0.15*	0.12*	0.33*	-0.11*	-0.11*	0.15*	0.39*							
(10)	Patent claims	-0.03*	-0.16*	0.03*	0.57*	-0.19*	-0.16*	0.03*	0.26*	0.31*						
(11)	Number of inventors	-0.11*	0.08*	0.09*	0.14*	-0.10*	-0.15*	0.08*	0.14*	0.18*	0.14*					
(12)	Number of applicants	-0.07*	0.12*	0.09*	-0.10*	-0.08*	-0.01	0.07*	0.05*	0.13*	-0.06*	0.11*				
(13)	Company	-0.02*	-0.29*	0.09*	0.04*	0.12*	0.02*	-0.03*	0.03*	0.07*	0.12*	-0.06*	0.04*			
(14)	Individual	0.01	0.10*	-0.06*	-0.02*	0.00	-0.03*	0.04*	0.05*	-0.04*	-0.12*	-0.01	-0.11*	-0.78*		
(15)	Institute	0.03*	0.11*	-0.05*	-0.02*	-0.10*	0.08*	-0.01	-0.06*	-0.02*	-0.01	0.05*	0.04*	-0.27*	-0.07*	
(16)	University	0.00	0.30*	-0.04*	-0.04*	-0.14*	-0.04*	-0.01	-0.10*	-0.06*	-0.03*	0.11*	0.09*	-0.38*	-0.10*	-0.04*

Notes: N = 60,000 patent families. * = Pearson correlation coefficient with significance level $p \leq 0.05$. [a] only for 27,041 observations.

Data source: PATSTAT (version: November 2013).

Chapter 5

The impact of acquisitions on Chinese acquirers' patent output

Acquisitions by Chinese firms have increased markedly in recent years. So far, we know little about the effects of these acquisitions on the acquirer's innovation performance. In this regard, we study two related research questions. First, to what extent can Chinese firms increase their patent output following an acquisition? Second, which factors influence the post-acquisition patent output? Using a comprehensive data set of Chinese manufacturing firms, we find no significant overall effect of acquisitions on patent output. However, we find that several acquisition-specific factors have a positive effect on post-acquisition patent output (e.g., characteristics of the acquired knowledge base, cross-border acquisitions), while other factors (e.g., state-ownership) have a negative effect. Our study extends prior research on post-acquisition innovation performance to the context of China.

This chapter is currently submitted to a journal.

5.1 Introduction

Acquisitions by Chinese firms have surged in recent years. In 2014, Chinese companies announced 4,502 acquisitions, an increase of 33% over the previous year. Access to technology is cited as an important reason for Chinese acquisitions (e.g., Deng, 2004; Morck et al., 2008; Buckley et al., 2014) and is frequently portrayed in the media. Chinese acquisitions, particularly those where the target is located in a developed country, are often associated with the fear of knowledge drains and a focus on a potential negative effect for the acquired companies.

So far, however, we know little about the effects of acquisitions on the Chinese acquirer's innovation performance. Although prior research has investigated these effects in developed countries, it is unclear whether the results obtained in the context of a Western country also apply to an emerging market context such as China (Zhao et al., 2011; Ramasamy et al., 2012; Barkema et al., 2015). In this regard, prior research has questioned the ability of Chinese firms to successfully integrate the acquired knowledge because they lack absorptive capacity (Rugman and Li, 2007; Anderson et al., 2015). Thus, we investigate the post-acquisition patent output of Chinese acquirers drawing on absorptive capacity theory. We study two research questions. First, to what extent can Chinese firms increase their patent output following an acquisition? Second, which acquisition-specific factors influence the post-acquisition patent output? Our study uses a comprehensive dataset of 1,545 acquisitions by publicly listed Chinese manufacturing firms from 2000 to 2013. Overall, we find no significant effect of acquisitions on patent output of Chinese acquirers. Assessing deal-specific variables, we find that a larger absolute size of the acquired knowledge base, technological relatedness, and cross-border acquisitions have a positive effect on post-acquisition patent output. In contrast, a larger relative size of the acquired knowledge base and acquisitions by state-owned enterprises have a negative effect.

The contribution of our study is twofold. First, we extend the previous literature on the effect of acquisitions on post-acquisition innovation performance (e.g., Ahuja and Katila, 2001; Cloodt et al., 2006; Desyllas and Hughes, 2010). Most of this research draws on absorptive capacity and organizational learning frameworks to explain increases in patent output, with scholars frequently stressing the need to better understand the contextual dimension surrounding the phenomenon (Muehlfeld et al., 2012; Argote, 2013). We contribute to this line of research by introducing the unique context of China. Previous research has relied on samples from developed countries, and it is unclear whether the post-acquisition effects in China are similar. Additionally, the applicability of theoretical frameworks developed in a Western context (i.e., absorptive capacity) to an emerging market context is unclear and has previously been questioned (e.g., Murray et al., 2005; Zhao et al., 2011; Barkema et al., 2015). We show that certain previous findings apply to the Chinese context but also show that characteristics unique to the Chinese environment, such as state ownership, shape acquisition outcomes.

Second, we add to the increasing and current literature on innovation in China. Previous studies have empirically analyzed the explosive increase in patenting by Chinese entities and its antecedents (e.g., Hu and Mathews, 2008; Li, 2012). Although there are studies that analyze Chinese acquisitions with regard to financial performance (Deng, 2009; Zhao et al., 2011; Buckley et al., 2014), an in-depth empirical investigation of the effects on innovative output and its antecedents is still lacking. This is particularly intriguing because access to technological know-how is one of the main reasons for Chinese acquisitions (e.g., Deng, 2004; Morck et al., 2008; Anderson et al., 2015).

The remainder of this chapter is structured as follows: Section 5.2 describes the theoretical framework and derives hypotheses about the effect of acquisitions on the acquirer's innovation performance. Section 5.3 describes the dataset, variables, and provides initial descriptive statistics. Section 5.4 presents the results of our multivariate analysis, while Section 5.5 discusses the findings in light of theory and practice.

5.2 Theory and hypotheses

5.2.1 Effect of acquisitions on Chinese acquirers' post-acquisition patent output

Acquisitions constitute a very prominent way for firms to access external knowledge (Ahuja and Katila, 2001). Firms try to increase their innovation performance by acquiring and utilizing the experiences of others (Cloodt et al., 2006). To successfully integrate outside knowledge, firms need absorptive capacity. Research on absorptive capacity is based on the assumption that a company that enhances its internal knowledge base also enhances its ability to recognize the value of external information, apply and exploit it (Cohen and Levinthal, 1990). Thus, firms can enhance their absorptive capacity by acquiring knowledge bases that include valuable intangible assets (Ahuja and Katila, 2001; Anderson et al., 2015). The absorption of new knowledge bases leads to potential economies of scale and scope, which may benefit an acquirer's capacity to produce innovation output (Henderson and Cockburn, 1996; Ahuja and Katila, 2001).

The external acquisition of knowledge through acquisitions is particularly attractive for companies with limited capabilities that are looking to expand their absorptive capacity and knowledge base quickly (Hitt et al., 2000; Zhao et al., 2011). China is a prominent example of a transition economy that still suffers from the rigidities of a planned, closed-market economy in which innovation was often neglected and is trying to extend its innovation-related capabilities quickly (Peng, 2003; Zhao et al., 2011). Because acquisitions can be a particularly useful vehicle for Chinese firms to increase their absorptive capacity, we expect that acquisitions serve to increase a Chinese acquirer's knowledge base and have a positive effect on their absorptive capacity, ultimately resulting in a higher patent output. Thus, we hypothesize:

H5.1: *Acquisitions have a positive effect on a Chinese acquirer's post-acquisition patent output.*

5.2.2 Deal-specific factors: Acquired knowledge base

Based on absorptive capacity theory, we postulate that the effect of acquisitions on acquirers' patent output is influenced by several deal-specific factors. Characteristics of the information being transferred are likely to affect the post-acquisition patent output. In particular, three dimensions of the acquired knowledge base have been shown to influence the post-acquisition innovation performance: the absolute size of the acquired knowledge base, the relative size of the acquired knowledge base, and the relatedness of the acquired knowledge base (e.g., Lubatkin, 1983; Ahuja and Katila, 2001).

Absolute size of the acquired knowledge base: Firms can enhance their absorptive capacity by acquiring knowledge bases, hence enabling initially limited Chinese firms to increase their innovation outputs. This increase is assumed to be larger with a large size of the acquired knowledge base. This is because the integration of a knowledge base leads to potential economies of scale and scope (Henderson and Cockburn, 1996; Ahuja and Katila, 2001). Following Schumpeterian logic, innovations are often a result of the recombination of existing elements of knowledge (Ahuja and Katila, 2001; Cloodt et al., 2006). Thus, the number of potential recombinations increases with an increasing knowledge base. If an acquired company has a very small or non-existent knowledge base, this suggests that access to technology was not a major motive for the acquisition and should thus not positively influence post-acquisition patent output (Ahuja and Katila, 2001).

Previous research has assumed the post-acquisition innovation performance to increase linearly with the acquisition of knowledge bases with a larger absolute size (e.g., Ahuja and Katila, 2001; Cloodt et al., 2006). However, the degree to which a company can integrate acquired knowledge and thereby increase its absorptive capacity is likely to suffer from diminishing returns. This is because the integration of very large knowledge bases demands considerable efforts and resources on the part of an acquirer. Indeed, previous research has indicated an inverted U-shaped relationship between increasing absorptive capacity and innovation performance (Stock et al., 2001; Nooteboom et al., 2007). Therefore, we expect the relation between the absolute size of the acquired knowledge base to be non-linear and rather follow a curvilinear form (inverted U-shape): Patent output will increase with an increasing absolute size of the acquired knowledge base, but will decrease beyond a certain point.

H5.2a: *The absolute size of the acquired knowledge base will be curvilinearly related to a Chinese acquirer's post-acquisition patent output.*

Relative size of the acquired knowledge base: Before recombination benefits can be achieved, the acquired information needs to be processed by the acquiring company. Thus, successful integration of the acquired knowledge also depends on the relative size of the acquired knowledge base (Ahuja and Katila, 2001). For example, if the acquired knowledge base is relatively large (as opposed to absolutely) compared to the existing knowledge base, the acquiring firm will have to devote a comparatively large amount of resources to integrate the acquired knowledge base, leading to fewer resources being available to perform actual innovation activities. Additionally, disruption of existing routines is likely because the acquiring company is faced with a comparatively large amount of new information and routines, which require substantial adaption on the part of the acquiring firm (Ahuja and Katila, 2001; Cloodt et al., 2006). Thus, we suggest that post-acquisition patent output of Chinese acquirers is negatively affected by an increased relative size of the acquired knowledge base.

H5.2b: *The relative size of the acquired knowledge base has a negative effect on a Chinese acquirer's post-acquisition patent output.*

Technological relatedness of the acquired knowledge base: A third characteristic is the relatedness of the acquired knowledge base, reflecting the content of the acquired knowledge. Based on absorptive capacity theory, related knowledge creates synergies as it enables Chinese firms to more easily apply new information to new environments, thus facilitating integration of the acquired knowledge base (Cohen and Levinthal, 1990; Makri et al., 2010). With regard to innovation, relatedness leads to common skills and a shared technical language. In contrast, innovation routines tend to be different if they originate from unrelated technological fields, thus rendering the integration of the knowledge bases more difficult and resource consuming (Cohen and Levinthal, 1989; Cloodt et al., 2006). However, unrelated knowledge can benefit the organization by providing new approaches to solve old problems or by allowing it to better process external information.

Because both arguments are valid, previous research has shown that the combination of knowledge bases with a moderate degree of relatedness provides benefits of increasing variety, while still providing enough common ground to build upon (Ahuja and Katila, 2001; Cloodt et al., 2006). For example, Ahuja and Katila (2001) find evidence for a non-monotonic and u-shaped relationship. The authors argue that performance will increase with increasing relatedness, but will decrease beyond a certain point. This effect has been confirmed by Cloodt et al. (2006). Applying a more fine-grained approach to measuring technological relatedness and complementarity, Makri et al. (2010) show that technological complementarity is an important factor in stimulating innovation output, while they also find knowledge similarities to have no effect on invention quantity or quality. The authors argue that while integration is facilitated, these similarities are not enough to spark innovation performance. Similar results are obtained by Cassiman et al. (2008). Thus, we expect a non-linear relationship that is curvilinear (inverted U-shape): Patent output will increase with increasing relatedness, but will decrease beyond a certain point.

H5.2c: *Technological relatedness will be curvilinearly related to a Chinese acquirer's post-acquisition patent output.*

5.2.3 Deal-specific factors: Cross-border acquisitions

The geographic context is an important factor shaping acquisition outcomes. Previous studies have often highlighted that cross-border acquisitions pose several obstacles to the acquiring firm that hinder post-acquisition performance. In contrast to domestic acquisitions, cross-border acquisitions often involve different legal systems, different national cultures, and higher transportation costs which can be major obstacles to achieving integration benefits (Olie, 1994; Barkema et al., 1996; Vaara, 2003; Björkman et al., 2007; Dikova et al., 2010). Also, differences in languages are a common source of friction (e.g., Muehlfeld et al., 2012). Cultural similarity, which is assumed to be greater in domestic than cross-border acquisitions, eliminates a common source of friction by facilitating negotiations (Adair and Brett, 2005) and the integrations of the acquired company (Björkmann et al., 2007). Another factor is the regulatory framework (Clougherty, 2005), which is also more similar in domestic acquisition, thus reducing the complexity of an acquisition.

On the other hand, cross-border acquisitions provide opportunities. With particular regard to innovation performance, Barkema and Vermeulen (1998) argue that an exposure to geographical diversity may lead to higher innovation levels because it exposes a firm to different environments, enabling it to profit from different experiences. This information leads to a richer knowledge structure and stronger technological capabilities (Ghoshal, 1987; Barkema and Vermeulen, 1998). A similar argument is put forward by Ahuja and Katila (2004), who find that firms expanding beyond national markets develop unique innovation search paths as a response to the changing environment. While a performance enhancing effect of domestic acquisitions is shown in some studies (e.g., Muehlfeld et al., 2012), other studies find negative or no effects (e.g., Ahuja and Katila, 2001; Desyllas and Hughes, 2010), prompting Björkmann et al. (2007) to describe the empirical evidence as inconclusive.

Companies from emerging markets such as China frequently lag behind companies from developed countries in terms of strong intangible resources (e.g., technological know-how). Thus, Chinese firms might particularly benefit from cross-border acquisitions to address this comparative disadvantage and access further developed knowledge. This access to knowledge from developed countries has frequently been described as one of the more important motivations for Chinese acquisitions (e.g., Deng, 2004; Morck et al., 2008; Buckley et al., 2014). Therefore, we suggest that cross-border acquisitions positively influence a Chinese acquirer's patent output.

H5.3: *Cross-border acquisitions have a positive effect on a Chinese acquirer's post-acquisition patent output.*

5.2.4 Deal-specific factors: Acquisition in a similar industry

Similar to the country context, the industrial context is an important factor that may influence an acquisition's outcome. Barkema and Vermeulen (1998) argue that a firm operating in multiple industries might profit from the increased diversity. For example, the firm will be able to gain more experience because it has to deal with a more diverse set of demands, rivals, and partners than a firm only operating in one industry. Also, a firm that is active in multiple industries may be able to realize economies of scale and scope and may thus profit more from its innovations.

However, most prior studies show that firms pursuing related, intra-industry acquisitions outperform unrelated, inter-industry ac-quisitions (e.g., Muehlfeld et al., 2012; Haleblian and Finkelstein, 1999). This is because of larger synergies: Firms can more likely build on existing practices and routines if the new industrial environment is similar to the environment in which prior knowledge was obtained and developed. In contrast, a transfer of routines may be impossible if a new environment is predominantly novel and characterized by different dominant logics which have to be learned. Companies can thus generalize their experience more easily if there is a greater similarity (Cohen and Bacdayan, 1994; Barkema and Vermeulen, 1998; Haleblian and Finkelstein, 1999; Finkelstein and Haleblian, 2002; Desyllas and Hughes, 2010). Conceptually, the argumentation follows Huff (1982), who argues that "shared concepts", for example on a how firm successfully operates, are developed within an industry and are not accessible for outsiders. Empirical evidence on how the industrial context guides strategic thinking was initially put forward by Spender (1987). Also, Barkema and Vermeulen (1998) describe that a firm that high levels of diversification force a firm to adapt are more fragmented organizational structure that will prevent learning.

Even though King et al. (2004) find no significant relation between related acquisitions and post-acquisition performance in general, with particular regard to the post-acquisition innovation performance, previous research indicates that R&D synergies are harder when two firms operate in different industries and that more diversified firms tend to be less innovative (Hoskisson and Hitt, 1988; Hitt et al., 1991; Ahuja and Katila, 2001; Hagedoorn and Duysters, 2002). We thus presume that Chinese acquirers tend to benefit more from related acquisitions in which the acquirer operates in a similar industry:

H5.4: *Acquisitions of a firm active in a similar industry have a positive effect on a Chinese acquirer's post-acquisition patent output.*

5.2.4 Deal-specific factors: State ownership

In transition economies, the institutional environment is characterized by strong governmental interference. This is particularly true for China, where governmental constraints and incentives influence M&A decisions in a major way (Deng, 2009). Often, corporate strategic decisions are influenced by political motives (Tsui et al., 2004). For example, the Chinese government has been stimulating Chinese companies to become competitive MNCs by formulating a series of policies for the acquisition of foreign knowledge (e.g., value-added taxes, favorable financing) (Deng, 2004; Deng, 2009). By this, various firms have become international players through aggressive international expansion. While this referred to strong manufacturing firms in the past, China now specifically encourages investment in R&D to enhance innovative capability and by focusing more on acquisition of intangible assets such as technology and managerial capabilities from global giants (Hitt et al., 2004; Deng, 2009).

The Chinese corporate landscape is very different from Western countries because the Chinese economy has been dominated by state-owned enterprises (Wang et al., 2007). In contrast to other former socialist countries, China never underwent a mass privatization. Thus, the share of enterprises directly or indirectly owned by the state is still large (albeit decreasing) (Wang et al., 2007). The boundaries separating these companies from the state are often blurred (Tsui et al., 2004). Chinese state-owned enterprises are typically large, resourceful, and heavily subsidized corporations. Previous research has characterized them as lacking dynamism, passive, less learning-, and not performance-oriented (White, 2000; Peng, 2003; Wang et al., 2007). Traditionally, state-owned enterprises relied on innovations that were administratively directed to them (White, 2000). Overall, these attributes indicate lower levels of absorptive capacity enabled by dynamic capabilities and a culture of learning. Ultimately, state ownership should thus lead to a negative effect on the acquirers' patent output. In contrast, a private organization should possess a larger absorptive capacity and should be able to profit from acquisitions to a larger extent.

H5.5: *State-ownership of the acquiring firm has a negative effect on a Chinese acquirer's post-acquisition patent output.*

5.3 Data and variables

5.3.1 Data

Studies on post-acquisition innovation performance often impose a range of restrictions on the sample, for example, with regard to industry, company size, deal value, or shares acquired (e.g., Makri et al., 2010; Desyllas and Hughes, 2010). Because the Chinese context remains unexplored so far, we keep our sample as unrestricted as possible and merge three databases to construct our sample: Compustat (company data), SDC Platinum (acquisition data), and PATSTAT (patent data). Our final sample includes 1,726 acquiring companies that conducted 1,545 acquisitions and filed 206,217 patents from 2000 to 2013.

Company data: Initially, we draw a sample of potential acquiring firms from Compustat international. Compustat includes all listed Chinese firms, is one of the most comprehensive databases on firm data, and has been used frequently used in related studies (e.g., Ahuja and Katila, 2001; Cloodt et al., 2006; Laamanen and Keil, 2008; Sears and Hoetker, 2014). Using Compustat effectively excludes smaller firms, which is however consistent with previous acquisition research focusing on large and publicly listed firms (Ahuja and Katila, 2001; Desyllas and Hughes, 2010; Makri et al., 2010). Consistent with previous research, we focus on manufacturing firms (SIC codes 20–39) (e.g., Puranam et al., 2006; Sears and Hoetker, 2014), which are also more prone towards formal IP protection and particularly patents (e.g., Block et al., 2015). Due to data unavailavility prior to 2000, we draw all data available for the period from 01.01.2000 until 31.12.2012. In total, this leads to a highly unbalanced panel of 1,726 companies with 13,858 company/year observations. Because of the unbalanced nature of our dataset, we perform our analyses at the deal level instead of the company level. However, we use the full dataset in several robustness checks. To exclude any sampling bias, we cross-validate our sample with the Chinese database CSMAR, which also covers all listed Chinese firms but lacks several financial indicators.

Acquisition data: Data on the acquisition activity of the sampled firms are obtained from SDC Platinum. SDC Platinum is one of the most comprehensive databases on acquisitions and has been frequently used in previous studies (e.g., Makri et al., 2010; Valentini, 2012; Sears and Hoetker, 2014). We draw a sample of all completed deals between January 1, 2000 and December 31, 2012 in which the acquirer is a Chinese company. Next, we match the data obtained from SDC and Compustat semi-manually based on the SEDOL number. Entries that could not be matched based on the SEDOL number were matched manually after conducting an in-depth search on the respective company homepage. In total, 1,545 acquisitions could be matched.

Patent data: Patent data is obtained from PATSTAT, one of the most comprehensive databases on patents to date that is provided by the EPO. PATSTAT comprises data from over 100 countries and contains more than 110 million patent documents. Furthermore, PATSTAT has been described as the most comprehensive database for Chinese patents (Liegsalz and Wagner, 2013). We use the version of March 2015. Because not all patents are immediately registered in PATSTAT, we only include patent applied for before 31.12.2013 (because we use a lag of one year, we can only include company and acquisition data until 31.12.2012). We identify patent documents in which one of the acquired or acquiring companies is listed as applicant or assignee. A particular problem of identifying Chinese patents refers to the often flawed and inconsistent depiction of the names of the applicants and their translation from Chinese into English. Therefore, we generated search patterns that included variant spellings, abbreviations, and applicant names (Chapters 2 and 3). The search patterns were refined in several iterations to improve the identification and matching of relevant patents. More specifically and in contrast to previous studies we use the measure of patent families to avoid an overrepresentation of patents filed at multiple patent offices (Li, 2012). We use the earliest application within each patent family to determine the date of the patent, as it is closest to the data of the actual innovation.

5.3.2 Variables

Dependent variable: Our dependent variable is the number of new *patent applications* per year, which measures a firm's patent output. Patents are frequently used to measure innovation output and are the most commonly used indicator to analyze post-acquisition innovation performance (e.g., Ahuja and Katila, 2001, Valentini, 2012). This is because patents are related to inventiveness, are an externally validated measure of technological novelty, and are of economic significance (Ahuja and Katila, 2001).

Independent variables: To measure the overall effect of an acquisition on post-acquisition patent output, we include a dummy variable that captures whether a company conducted an *acquisition* in the respective year (=1) or not (=0).

To analyze Hypothesis H5.2, we measure the *absolute size of the acquired knowledge base* by aggregating the patents of the acquired firm in the five years preceding its acquisition. Second, the *relative size of the acquired knowledge base* is calculated by dividing the absolute size of the acquired knowledge base by the knowledge base of the acquiring firm. This variable takes a value of zero if the acquiring firm did not file any patents. Third, we measure the *technological relatedness* of the acquired knowledge base by the difference between the proportion of patents filed in each IPC class between the acquiring and acquired firms patent portfolio in a given year. A large value indicates a low relatedness. To measure technological equality, we further include a dummy variable that takes a value of 1 if the acquired and acquiring company filed their patents in the same IPC classes, and 0 otherwise. The measurement of the variables follows the approach of Ahuja and Katila (2001) and Cloodt et al. (2006). The data is obtained from PATSTAT.

To analyze Hypothesis H5.3, we include a variable that captures whether the deal is a *cross-border* (= 1) or domestic (= 0) acquisition. To account for an acquisition of a company in a similar industry, we construct a dummy variable that takes a value of 1 if the acquired company operates in the same superordinate industrial category (2-digit SIC code), and 0 otherwise (H5.4). Finally, we include a dummy variable that measures whether the acquiring company is *state-owned* (H5.5). Because there is no consensual approach in the previous literature, we used information available in CSMAR. To validate these data, we manually searched two online databases that included information on state ownership (sina.com and cmbchina.com). If all three sources stated that the company is state owned, this variable takes a value of 1, and 0 otherwise.

Control variables: We control for several variables that might influence patent output (e.g., *total assets (log.)*, *total revenues (log.)*). More profitable firms should be able to devote more resources to innovation, which we want to control for. Similarly, we control for company size by including the number of *employees* in logged form. Because this variable is not reliably obtainable from Compustat, we draw it from the Chinese database CSMAR, which we used to validate the firms obtained from Compustat. Larger firms tend to be able to produce higher innovation outputs. To rule out the possibility our post-acquisition results are solely driven by a higher pre-acquisition innovativeness, we control for firms innovativeness by including its *patenting intensity* in logged form. Patenting intensity is constructed by dividing a firms' patents by its total assets per year and is a suitable replacement for the usually used R&D intensity, which was not available in Compustat (e.g., Sandner and Block, 2011). Finally, we include the *volume of shares* acquired in the deal. Comparatively large acquisitions should facilitate knowledge transfer. To account for inter-industry differences, we include industry dummies (2-SIC). To account for time differences, we include year dummies.

5.4 Results

Table 5.1 shows descriptive statistics and correlations. Values are reported per company per year. For example, companies filed 13.78 patents per year while employing 2,465 (log = 7.8) employees on average. On average, the acquired firms applied for 9.4 patents in the five years preceding the acquisition. Interestingly, only 5%of the acquisitions were cross-border (78 of 1,545), whereas 47% of the acquisitions were conducted in a similar or the same industry. Finally, 41% of the acquisitions were carried out by state-owned enterprises. Correlations and VIFs indicate that multicollinearity should not affect our results.

Because our dependent variable patent output is a count variable with only non-negative integers, we use count data regressions as our main method of analysis. The results are reported in Table 5.2. Following Pollock et al. (2008) and Muehlfeld et al. (2012), we account for within-firm variation by clustering standard errors at company level. This is similar to a random-effects regression and addresses a potential bias caused by multiple acquisitions by the same firm in the same year. Previous research has shown that an acquisition's impact on the acquiring firms' innovation performance is not immediate (e.g., Ahuja and Katila, 2001; Cloodt et al., 2006). Thus, we use different lag-structures of our variables. While patent data are included without lags, data firm and deal data are included with a lag of 1 year. Different lag structures have been used in previous literature. For example, Ahuja and Katila (2001) as well as Cloodt et al (2006) include the independent variables with no lag, and a lag of 1 to 3 years simultaneously. Their results show that, while there are differences between the different lag structures, the overall effects remain similar. Also, other studies only incorporate a lag of one year (e.g., Desyllas and Hughes, 2010). Also, using a lag of only 1 year enables us to keep more data points, as the most recent year would have to be excluded otherwise.

To analyze H5.1, we use the full sample to assess whether a deal has an effect on the post-acquisition patent output. Model 1 includes the basic model. Model 2 shows that, overall, an acquisition does not have a statistically significant effect on patent output (*deal dummy*). The following models introduce the independent, deal-specific variables and also shift our analysis to the deal level. With regard to H5.2a, we find that a higher *absolute size of the acquired knowledge base* has a highly significant and positive effect on the acquirer's post-acquisition innovation performance. We also find that this effect decreases at higher levels, as indicated by the squared term in Model 3 and the full Model 7. We also find support for H5.2b: A *higher relative size of the acquired knowledge base* leads is associated with a lower post-acquisition innovation output. With regard to H5.2c, we find that technological relatedness of the acquired knowledge base positively influences patent output. However, this effect decreases if the companies are too similar. These effects persist when all variables are entered simultaneously in Model 7. H5.3 analyzes differences between *cross-border* and domestic deals and suggests a positive effect of cross-border deals. Compared to a domestic deal, an international deal increases patent applications in subsequent years ($p < 0.01$). With regard to the industrial context, we assumed that *intra-industry deals* have a positive effect on post-acquisition patent output (H5.4). Our empirical analysis does not support this hypothesis and shows that neither an acquisition in a similar industry nor an acquisition in the same industry exhibits a consistent effect. Finally, we find support for H5.5. Because large and traditional Chinese state-owned enterprises are often more inflexible and not as prone to learning, we suspected them to profit less from acquisition. The effect is negative and significant ($p < 0.05$).

Table 5.1: Descriptive statistics, correlations and VIFs.

Variables	Mean	SD	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	VIF
(1) Patent applications	13.78	51.73	0.00	1,233												1.33
Control variables(t-1)																
(2) Total assets (log)	8.06	1.24	3.74	12.67	0.36*											5.15
(3) Total revenues (log)	7.52	1.53	0.00	12.98	0.33*	0.90*										5.06
(4) Employees (log)	7.81	1.39	3.04	11.59	0.30*	0.73*	0.79*									2.27
(5) Patent intensity (log)	0.73	1.55	0.00	19.11	0.23*	-0.14*	-0.10*	-0.05*								1.28
Deal-specific variables (t-1)																
(6) Shares acquired	0.59	0.34	0.00	1.00	0.00*	0.05*	0.04	0.04	-0.04							1.70
(7) Absolute size of acq. KB	9.42	111.4	0.00	3,633	0.25*	0.10*	0.07*	0.08*	0.05*	0.04						1.07
(8) Relative size of acq. KB	0.53	2.99	0.00	53.21	-0.03	0.03	0.04	0.02	-0.05*	0.01	0.22					1.11
(9) Technological relatedness	0.32	0.40	0.00	1.00	0.19*	0.22*	0.23*	0.20*	0.22*	-0.02	0.11*	0.18*				1.56
(10) Cross-border acquisition.	0.05	0.22	0.00	1.00	0.13*	0.15*	0.15*	0.15*	-0.01	0.05*	0.01	0.04	0.01			1.05
(11) Acq. in similar industry	0.47	0.50	0.00	1.00	0.04	0.08*	0.12*	0.18*	0.05*	0.02	0.05*	0.07*	0.19*	-0.02		1.67
(12) Acq. by state-owned ent.	0.41	0.49	0.00	1.00	0.08*	0.39*	0.39*	0.31*	-0.12*	0.03	0.03	-0.03	0.03	0.02	0.11*	1.10

Notes: KB = Knowledge base. N = 1,545. VIF = Variance inflation factor, estimated for Model 7 (Table 2) without quadratic terms. * $p < 0.05$.

Data sources: Compustat, SDC Platinum, PATSTAT (version: March 2015).

Table 5.2: Results of the negative binomial regression analysis (dependent variable: patent applications per year).

		Full sample	**Full sample**	**Reduced sample**	**Reduced sample**	**Reduced sample**	**Reduced sample**	**Reduced sample**
Variables	**Hyp.**	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Control variables (t-1)								
Total assets (log)		0.649***	0.645***	0.500***	0.552***	0.561***	0.595***	0.521***
		(0.080)	(0.080)	(0.107)	(0.103)	(0.103)	(0.105)	(0.108)
Total revenues (log)		0.215***	0.217***	0.261***	0.250***	0.250***	0.252***	0.263***
		(0.056)	(0.056)	(0.088)	(0.086)	(0.086)	(0.086)	(0.087)
Employees (log)		0.051	0.051	0.080	0.090	0.087	0.083	0.066
		(0.041)	(0.041)	(0.060)	(0.058)	(0.058)	(0.058)	(0.060)
Patent intensity (log)		0.834***	0.835***	0.788***	0.870***	0.868***	0.868***	0.784***
		(0.102)	(0.102)	(0.113)	(0.115)	(0.116)	(0.116)	(0.112)
Deal-specific variables (t-1)								
Deal dummy	*H5.1 (+)*		0.056					
			(0.040)					
Shares acquired				-0.079	-0.079	-0.088	-0.079	-0.080
				(0.098)	(0.097)	(0.097)	(0.097)	(0.099)
Absolute size of acquired KB	*H5.2a (+)*			0.002**				0.002**
				(0.001)				(0.001)
Absolute size of acquired KB²	*H5.2a (-)*			-0.000*				-0.000*
				(0.000)				(0.000)
Relative size of acquired KB	*H5.2b (-)*			-0.092***				-0.095***
				(0.020)				(0.021)
Technological relatedness	*H5.2c (+)*			1.241***				1.205***
				(0.414)				(0.424)
Technological relatedness²	*H5.2c (-)*			-0.878*				-0.817*
				(0.467)				(0.480)

(Table continues on the next page)

Table 5.2: (continued)

		Full sample	Full sample	Reduced sample	Reduced sample	Reduced sample	Reduced sample	Reduced sample
Variables	Hypothesis	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Cross-border acquisition	*H5.3 (+)*				0.268**			0.367***
					(0.122)			(0.125)
Acq. in similar industry (SIC 2)	*H5.4 (+)*					0.079		0.053
						(0.072)		(0.074)
Acq. by state-owned enterprise	*H5.5 (-)*						-0.183*	-0.190**
							(0.097)	(0.095)
Constant		-8.550***	-8.530***	-7.732***	-8.220***	-8.306***	-8.317***	-7.663***
		(0.325)	(0.321)	(0.795)	(0.752)	(0.771)	(0.757)	(0.794)
Year dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes
N		6,954	6,954	1,545	1,545	1,545	1,545	1,545
Companies		704	704	704	704	704	704	704
Pseudo R^2		0.178	0.178	0.168	0.162	0.162	0.162	0.169
Alpha		1.614	1.613	1.182	1.256	1.258	1.255	1.169

Notes: KB = Knowledge base. Standard errors clustered at company level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Data sources: Compustat international, SDC Platinum, PATSTAT (version: March 2015).

5.5 Discussion and conclusion

We analyze the effect of acquisitions on the acquirer's post-acquisition patent output in the emerging market context of China. We draw on absorptive capacity theory and find no significant effect of acquisitions on patent output of Chinese acquirers. Yet, several deal-specific variables, such as characteristics of the acquired knowledge base, cross-border acquisitions, and state-ownership do influence post-acquisition patent output. Our findings extend the previous literature on the effect of acquisitions on post-acquisition innovation performance (e.g., Ahuja and Katila, 2001; Cloodt et al., 2006; Desyllas and Hughes, 2010). Additionally, we contribute to the increasing literature on innovation in China. Previous studies have empirically analyzed the explosive increase in patenting by Chinese entities and its antecedents (e.g., Hu and Mathews, 2008; Li, 2012).

Previous research has assumed that emerging market firms may not profit from acquisitions because they lack the absorptive capacity to successfully exploit acquired knowledge (Narula, 2012; Anderson et al., 2015). However, we identify several deal-specific characteristics that significantly influence the post-acquisition patent output. Unsurprisingly, we find that a higher absolute knowledge base of the acquired firm increases post-acquisition patent output. Although this linear effect has been identified in previous research, our findings suggest that the effect decreases at higher levels and follows. We explain this in the acquisition context previously unexplored finding through the significant requirements that the integration of a very large knowledge base poses for an acquiring firm. Although potentially providing a huge potential to increase their own absorptive capacity, companies may be overwhelmed by very large knowledge bases. This implies that the most attractive targets for Chinese acquirers may not necessarily be firms with the largest possible knowledge base; rather, it should be more beneficial to choose targets with a moderate knowledge base.

In line with Hypothesis H5.3, we find that Chinese companies profit from international acquisitions. This indicates that Chinese firms successfully draw on the often more developed knowledge in technologically and culturally distant countries. Because a successful integration of more distant and potentially more advanced knowledge often requires a considerable amount of absorptive capacity, this finding largely contradicts the argument that Chinese firms lack absorptive capacity. Additionally, this finding supports the notion that Chinese companies use cross-border acquisitions to transition to an innovation-based economy and catch-up to developed countries (Morck et al., 2008; Anderson et al., 2015).

Finally, we find that state-owned firms profit less than other firms from acquisitions in terms of innovation. Although this is in line with Hypothesis H5.5, the literature also indicates that state-owned enterprises could be more innovative (Choi et al., 2011). For example, the successful catch-up of Taiwan and South Korea has been partially attributed to state-driven technological development aimed at fostering innovation capabilities. A similar effect could be expected for China because the government's long-term orientation and substantial financial support might lead to a better environment for innovation. However, our results show that the innovation-hampering aspects seem to overwhelm: inefficient structures, the absence of managerial knowledge and unhealthy ties between government and businesses (Choi et al., 2011).

In conclusion, our results show that Chinese companies seem to be able to successfully exploit acquisitions to increase their patent output under certain circumstances (e.g., in cross-border acquisitions). This contradicts studies assuming a comparatively limited absorptive capacity of Chinese firms (Rugman and Li, 2007; Anderson et al., 2015). A potential explanation lies in the transformative process China undergoes and the adaptability this process demands from companies, particularly in changing environments, such as during a transformation from imitation to innovation. For example, the industrial and institutional environment in China is highly dynamic and uncertain. This is because the transformation process leads to a variety of unique and often experimental industrial policies (Luo and Peng, 1999; Murray et al., 2005). This forces firms to adapt their products and strategies very quickly. Thus, this reality might prepare them for the hurdle of acquisitions and enable them, despite a potentially worse initial situation, to profit from acquisitions. Another explanation is that Chinese firms often exhibit a very inactive role when integrating acquired firms, which is contrary to public belief. Several studies indicate that Chinese firms often grant acquired firms considerable autonomy following an acquisition. This passive strategy aims to minimize integration problems while simultaneously keeping an acquired firm as functional as possible, for example by keeping the old management in place (Liu and Woywode, 2013; Anderson et al., 2015). This not only enables the Chinese firm to profit from the acquired firm as much as possible but also contradicts the public image of Chinese firms only acquiring firms to drain their knowledge.

This chapter is not without limitations. First, previous studies often try to consolidate companies and their subsidies, for example, using Dun & Bradseet's "Who Owns Whom" database (e.g., Valentini, 2012). This is helpful when trying to grasp a company's patent portfolio. However, the Chinese company landscape is very opaque and there is no common source for consolidation. To account for this, we generated and refined our search patterns in multiple iterations and are confident that we have identified an accurate patent portfolio through this process. A second limitation concerns our dependent variable (patent output). Patents suffer from the idiosyncrasies of the patenting process and other limitations. Despite these potential drawbacks, patents are by far the most frequently used measure of innovative performance in an acquisition context (e.g., Ahuja and Katila, 2001; Desyllas and Hughes, 2010).

This chapter also opens several avenues for further research. First, we focus on organizational learning in acquisitions, which is one option for inter-firm knowledge transfer, albeit an important one. Thus, further research might examine other mechanisms of knowledge acquisition, such as strategic alliances or joint ventures in the specific context of China (e.g., Kale et al., 2000; Duso et al., 2010). Second, various contributions have highlighted the fact that the increase of China's innovative capacity is remarkable in terms of quantity, but questionable in terms of quality (e.g., Li, 2012). Future research might find it interesting to assess patent quality in more detail. Due to the limitation in Chinese patent data, it might be interesting to assess patent quality in an already established context in which data are reliably available, such as the United States.

Chapter 6

Why do SMEs file trademarks? Insights from firms in innovative industries

Trademark filings have increased markedly over time. Although prior research has investigated the outcomes of trademark registration, including its effects on firm market valuation and productivity, little is known about why firms file trademarks. However, to interpret the increase in trademark filings and its economic effects, it is important to know and understand why firms file trademarks. Because trademarks are particularly important to SMEs, this study analyzes trademarking motives using a survey of 600 SMEs in innovative industries. An exploratory factor analysis yields three distinct motives: protection, marketing, and exchange. A cluster analysis reveals four distinct clusters of firms with respect to the three trademarking motives. A comparison of these clusters reveals significant differences in several industry- and firm-level characteristics, including participation in service industries and relation-ships with external parties. Implications for research on SMEs, trademarks, and intellectual property management are discussed.

This chapter is based on Block et al. (2015).

6.1 Introduction

Trademark applications have increased markedly in recent years. Statistics on trademark applications published by the WIPO indicate that trademarks are the most frequently filed form of intellectual property right (IPR) and that applications have nearly doubled over the last 10 years (WIPO, 2016a). Although the increasing importance of trademarks has spawned research investigating the effects of trademarks on the market valuation and productivity of firms (e.g., Krasnikov et al., 2009; Sandner and Block, 2011; Greenhalgh and Rogers, 2012), little is known about *why* firms file trademarks. However, to interpret the increase in trademark filings and its economic effects, it is crucial to know and understand why firms file trademarks. Previous research identifies various motives for trademarking, including the protection of marketing assets, brand building, and signaling quality (e.g., Ramello and Silva, 2006; Srinivasan et al., 2008; Sandner and Block, 2011). Nevertheless, an empirical investigation of trademarking motives remains lacking. We address this gap by analyzing the motives of firms to register trademarks using data from 600 SMEs in innovative industries.

SMEs differ from large firms with regard to trademarking. Previous research observes that SMEs are relatively more active in trademarking than large firms are (Rogers et al., 2007; Greenhalgh and Rogers, 2008). This difference can be explained by the specific context of SMEs. In particular, SMEs experience liabilities stemming from their small size, which hinders the pursuit of cost leadership strategies based on economies of scale. Accordingly, SMEs often focus on product differentiation or niche strategies (e.g., McDougall and Robinson, 1990; Carter et al., 1994; Lee et al., 1999). Trademarks can play a pivotal role in product differentiation by establishing and protecting brands and by distinguishing an SME's products from those of its competitors, which often follow SMEs into these niches (Lee et al., 1999). Furthermore, trademarks may especially suit resource-scarce firms, such as SMEs in innovative industries. Trademark registration is relatively inexpensive and non-complex and thus may serve an important appropriation function for SMEs interested in using IPRs. Additionally, one could expect that SMEs register trademarks for different reasons than large firms do. Resource scarcity often forces SMEs to engage in exchange relationships with external partners to leverage their assets, enter new markets, or obtain additional financial resources. In such exchange relationships, trademarks can strengthen the negotiating position of firms and serve as quality signals (e.g., Srinivasan et al., 2008; Block et al., 2014a).

Our empirical analysis comprises three steps. First, we theoretically develop and empirically validate the following set of three overarching trademarking motives: protection, marketing, and exchange. Second, these trademarking motives are employed as active cluster variables in a cluster analysis to explore empirical variation in the configuration of trademarking SMEs. The cluster analysis identifies four distinct clusters of SMEs based on trademarking motives; we label these four clusters as follows: trademark skeptics, marketing-focused trademarking SMEs, marketing- plus protection-focused trademarking SMEs, and trademark advocates. Third, we compare the industry and firm characteristics of firms in these four clusters to gain insights into the clusters' distinctions and characteristics.

Our findings contribute to innovation and marketing research in three respects. First, we enrich research on SMEs' motives to file for IP protection. Previous empirical studies of why firms, and particularly SMEs, use IPRs focus mainly on patents (e.g., Cohen, 2000; Blind, 2006; De Rassenfosse, 2012). However, trademarks may also play an important role in the appropriation of innovation rents by SMEs (e.g., Helmers and Rogers, 2010; Flikkema et al., 2014). For example, the literature suggests that trademarks are complementary to patents and that the two are used in conjunction with each other to offer more complete protection of IP assets (Blind et al., 2006; Thomä and Bizer, 2013). Previous research in this area relies mainly on theoretical considerations and anecdotal evidence and does not provide a systematic empirical analysis of why firms file trademarks (e.g., Mendonça et al., 2004; Srinivasan et al., 2008; see Flikkema et al., 2014, for a notable exception). Against this backdrop, the theoretically backed and empirically validated set of trademarking motives developed in this study provides valuable insights into the motives of SMEs to file for trademarks.

Our second contribution is the empirical identification of four distinct clusters of SMEs with regard to trademarking motives. This finding is in line with prior research that underscores the uniqueness and diversity of SME IPR use (e.g., De Jong and Marsili, 2006; Thomä, 2009; De Rassenfosse, 2012; Thomä and Bizer, 2013). Our results suggest that with regard to trademarking, SMEs should neither be treated as scaled-down versions of large firms nor viewed as a single entity. The four clusters of SMEs follow a hierarchical structure. Trademark skeptics engage in trademarking without a specific motive. Marketing-focused trademarking SMEs emphasize marketing motives, whereas marketing- plus protection-focused trademarking SMEs combine marketing and protection motives. Trademark advocates are positive about all three trademarking motives (i.e., marketing, protection, and exchange).

Third, comparing the four identified clusters based on passive cluster variables contributes to previous trademark research, which focuses primarily on trademark (application) counts and their effects on market value, productivity, and firm survival (e.g., Srinivasan et al., 2008; Sandner and Block, 2011). Little is known about how industry and firm characteristics relate to trademarking motives. Although this study is not a causal investigation of contingency factors relating to trademarking motives, our analysis provides exploratory evidence of the factors by which trademarking SMEs differ. For instance, our results indicate that SMEs in the trademark skeptics cluster interact less with external parties compared with firms in the other three clusters, which suggests that their skepticism toward trademarks may stem from being somewhat inward oriented. In contrast, we observe that SMEs seeking external innovation partnerships are overrepresented among trademark advocates, which take a holistic view of trademarking motives.

The remainder of the Chapter is structured as follows: Section 6.2 provides a literature review of SMEs' potential motives for filing trademarks and presents the conceptual framework of this study. Section 6.3 describes the data. Section 6.4 provides the empirical results of the factor and cluster analyses and compares the clusters with each other through descriptive analysis. Section 6.5 discusses the implications of the study for theory and practice, details the limitations of the study, and suggests avenues for future research.

6.2 Literature review and conceptual framework

6.2.1 Existing research on motives for filing IPRs (especially patents)

A number of previous empirical studies have examined motives for filing IPRs. Most of this research concerns patents and is based on samples of large firms. One early study conducted by Cohen et al. (2000) analyzes the motives of large US manufacturing firms to file patents. The authors observe that although most patents are filed to prevent imitation, they are also filed to block competitors from patenting similar inventions. Other less important motives include preventing lawsuits, improving negotiations, and enhancing firm reputation. Blind et al. (2006) explore patenting motives in a sample of German firms of various sizes. Employing factor analysis, they identify the following five motives: protection, blocking, reputation, exchange, and incentive. Blind et al. (2006) observe that reputation motives (e.g., company image) are relatively more important for small firms than for large firms. However, protection and blocking motives remain the most important motives for patent applications, irrespective of firm size. This finding is consistent with the work of Keupp et al. (2009), which focuses on Swiss SMEs and observes that protection motives are the most important reasons for patenting, followed by piracy prevention. Financial motives (which Blind et al. (2006) refer to as exchange motives), such as attracting venture capital, are less important. In contrast, in a study that compares the patenting motives of SMEs and large firms, De Rassenfosse (2012) demonstrates that financial motives – specifically, attracting investors or licensees – are more important for SMEs because investors and licensees help SMEs to overcome financing constraints. Veer and Jell (2012) obtain similar results and highlight the importance of patents to SMEs that seek to generate licensing opportunities and to attract investors. Similarly, Holgersson (2013) studies a sample of Swedish SMEs and highlights the major role of patents in facilitating exchanges and improving a company's reputation. The author argues that patents improve a firm's reputation among customers and attract venture capital.

6.2.2 Existing research on the use, effects, and motives of trademarking

The number of studies that analyze the use and effects of trademarks is increasing. One of the first studies of trademarking, Mendonça et al. (2004), discusses the use of trademarks as a proxy for firms' innovation activities. Drawing on this study, subsequent research has demonstrated the effects of trademarking on firm value, productivity, and survival.

Sandner and Block (2011) analyze the effects of trademarks on firms' market values in a sample of 1,216 large firms and observe that trademarks have a positive effect on firm market value. Similar results are reported by Fosfuri and Giarratana (2009), Krasnikov et al. (2009), and Block et al. (2014b). Using a sample of 1,600 large firms in the UK, Greenhalgh and Rogers (2012) observe that trademarks have a greater effect on the market values of service firms than on the market values of manufacturing firms. Furthermore, Greenhalgh and Rogers (2012) observe that trademarks have a positive influence on firm productivity. Similar results are obtained by Greenhalgh and Longland (2005). Although these studies focus on large firms, the importance of trademarks for SMEs is often highlighted (e.g., Helmers and Rogers, 2010; Flikkema et al., 2014). Using a sample of 1,435 small and new firms, Srinivasan et al. (2008) analyze how trademarks influence firm survival (dissolutions and being acquired). They observe that diverse product portfolios combined with trademarks delay exit by dissolution (in contrast to patents) and accelerate exit by acquisition (as do patents). Similarly, Jensen et al. (2008) demonstrate that trademarks significantly increase the chances of firm survival. Furthermore, Helmers and Rogers (2010) analyze the survival of new and mostly small firms in a sample of nearly 162,000 UK firms. They find that patenting decreases the likelihood of exit only in certain sectors, whereas trademarking decreases the likelihood of exit across nearly all sectors. Finally, Block et al. (2014a) investigate the role of trademarks in start-up valuation by venture capitalists and demonstrate that the number and breadth of trademark applications exhibit an inverted U-shaped relationship with the financial valuation of start-ups.

Interesting results were also obtained by Amara et al. (2008), who investigate how firms combine different protection mechanisms. Their sample includes 2,625 Canadian knowledge-intensive business services (KIBS) of small as well as large size. In addition to analyzing the determinants of trademark filings (e.g., R&D investment, external knowledge sharing, and firm size), they observe that trademarks are complementary (rather than substitutive) to patents, copyrights, and confidentiality agreements and independent of secrecy, complex designs, and lead time advantages. Thomä and Bizer (2013) analyze the appropriation strategies of innovative small firms and demonstrate that the use of IPRs by these firms is highly selective and that trademarks are considered the second most important type of formal IP protection (after patents). Their results also indicate that trademarks can be combined effectively with patents.

Two particular studies provide first insights into the trademarking motives of SMEs. Keupp et al. (2009) study IPRs in Swiss SMEs and ask firms that frequently utilize trademarks about their primary reasons for trademarking. In a questionnaire, respondents were offered the following answers: “protection from competitors”, “protection from product pirates”, “advertising impact” (which the authors also refer to as “publicity”), “importance to financing”, and “importance when negotiating contracts”. The descriptive results show that 67.2% of the respondents indicated “protection from competitors” as their main reason to trademark, followed by “publicity”, which was indicated as important by 42.0% of the respondents (multiple answers were possible). In contrast, the least important reason for filing trademarks was their “importance to financing”. Flikkema et al. (2014) survey trademark applications filed by 660 SMEs in the Benelux countries, focusing on whether trademarks are a suitable indicator for measuring different types of innovation. Before analyzing the suitability of trademarks for measuring different forms of innovation (i.e., product vs. process innovations), the authors identify trademarking motives. The most important motives are “to avoid imitation”, “to support marketing activities”, “to protect IP”, and “to improve corporate image”. The authors show that building brand equity and signaling strategic change are more important to firms offering service and process innovations, whereas motives relating to formal protection are of greater importance to firms offering product innovations.

6.2.3 Conceptual framework: SMEs’ motives for filing trademarks

Our literature review shows that empirical studies of firms’ motives for registering trademarks are scarce relative to studies on patenting motives. Thus, we cannot base our empirical analysis on a widely accepted conceptual framework of trademarking motives. Therefore, we develop an own conceptual framework of trademarking motives by drawing on the established framework of patenting motives by Blind et al. (2006). The study of Blind et al. (2006) identifies five motives for filing patent applications: *protection*, *blocking*, *reputation*, *exchange*, and *incentive*. We discuss the applicability of each of these five motives to SME trademarking. Specifically, we argue that protection, reputation, and exchange motives are highly relevant to SME trademarking. Furthermore, we argue that reputation motives encompass more aspects in trademarking than in patenting and thus we refer to them as marketing motives. Additionally, we argue that blocking and incentive motives are of limited relevance in trademarking.

Protection motives: IPRs were originally established to offer firms a means of protecting their IP assets. Unsurprisingly, protection is often the most important reason for filing patent applications (Cohen et al., 2000; Blind et al., 2006). Whereas patents are granted for technological inventions, trademarks protect marketing assets (e.g., Srinivasan et al., 2008; Jensen et al., 2008; Sandner and Block, 2011). Specifically, trademarks (e.g., symbols and names) identify a firm's goods or services and distinguish them from those of competitors (Mendonça et al., 2004; Fosfuri and Giarratana, 2009; De Vries, 2013). Importantly, trademarks form the legal basis of brands and indicate a firm's willingness to protect its brands from free riding and adverse actions by competitors (Mendonça et al., 2004; Sandner and Block, 2011). Protection is crucial because strong brands are among a firm's most valuable assets and can generate various benefits, such as increased customer loyalty and enhanced marketing effectiveness (for an overview, see Keller and Lehmann, 2006). Prior innovation research focuses on this classic protection function of trademarks (e.g., Srinivasan et al., 2008; Fosfuri and Giarratana, 2009). In addition, studies that investigate multiple IP protection mechanisms, including trademarks, patents, and copyrights, highlight protection as a primary motive to file IPRs (e.g., Amara et al., 2008; Heimonen, 2012; Thomä and Bizer, 2013).

Marketing motives: Marketing motives reflect a firm's desire to improve its image among central stakeholders, such as customers. Whereas patents enhance the technological image of a firm, trademarks signal that a firm pursues a differentiation strategy and focuses on product quality. Trademarks help to reduce information asymmetry between sellers and buyers by providing information that facilitates the purchase of a product, thus reducing consumer search costs. Consequently, trademarks enable a company to sell larger quantities or charge higher prices for their products (Greenhalgh and Rogers, 2008; Srinivasan et al., 2008; Jensen et al., 2008). Although a company's reputation is established through brands, not directly through trademarks, marketing and innovation research highlight the pivotal role of trademarks in protecting and establishing the brands that support firms' marketing strategies (Von Graevenitz, 2007). Therefore, brand building, establishing customer loyalty, and pursuing differentiation constitute marketing motives (Mendonça et al., 2004). This motive is highly relevant for small firms because they are often unable to pursue cost leadership strategies based on economies of scale. Instead, small firms focus on differentiation and niche strategies that require a company to distinguish itself from its competitors to attract customers (McDougall and Robinson, 1990; Carter et al., 1994; Lee et al., 1999). Blind et al. (2006) and Holgersson (2013) highlight the particular importance of this motive for SMEs.

Exchange motives: Exchange motives reflect the desire of a company to improve its position relative to external partners who provide access to capital, licensing income, or collaboration. Trademarks may indicate firm innovativeness (Hipp and Grupp, 2005; Greenhalgh and Rogers, 2006) and market orientation (Srinivasan et al., 2008), and thus small, young firms may file trademark applications to signal such innovativeness and market orientation to investors (Block et al., 2014a). Consistent with this rationale, empirical research provides considerable and consistent evidence of a positive relationship between firms' trademarks and investor valuations for both small and large firms. Trademarks increase a firm's attractiveness to investors and reduce the cost of external capital (e.g., Ramello and Silva, 2006; Srinivasan et al., 2008; Block et al., 2014a). Exchange motives also include the licensing of trademarks to other firms (Mendonça et al., 2004). For SMEs, the extent of technology licensing may provide a motivation for trademark registration because small firms may lack the resources and capabilities to commercialize their innovations or market their products independently (Gans et al., 2002; Thomä and Bizer, 2013). Furthermore, SMEs may operate in a limited region and thus license their trademarks to firms in foreign markets or other regions. Trademark registration is also a prerequisite for franchising, which is often employed as a growth strategy by small and capital-scarce firms (Combs and Ketchen, 1999). Finally, trademarks facilitate exchange by providing a valuable asset in negotiations with other companies (such as suppliers) and increasing firm bargaining power (Mendonça et al., 2004). Due to the resource constraints of small firms – particularly with respect to finances – we expect exchange motives to play an important role for SME trademarking (e.g., De Rassenfosse, 2012; Veer and Jell, 2012).

The incentive and blocking motives introduced by Blind et al. (2006) for patents do *not* apply to trademarks. Blind et al. (2006) describe **incentive motives** as monetary or reputational rewards for employees who successfully patent their innovative ideas. In this respect, patents serve as an indicator of innovation performance because obtaining a patent requires substantial investments of money, time, and labor *before* an application can be filed and a patent can be granted. However, this is less true for trademarks, which do not require comparable ex-ante investments and are less complex. Indeed, the investments associated with trademarks (e.g., marketing to promote a brand) generally occur *after* registration (Sandner and Block, 2011). Thus, in contrast to a patent application, trademark registration is not a suitable performance indicator for the distribution of rewards. **Blocking** competitors from producing similar products, which is among the most important and common motives for patenting (Cohen et al., 2000; Blind et al., 2006), results from the specific mechanisms of patent law. A patent effectively prohibits the patenting of a similar invention because it would not pass the criteria of patentability (especially technological novelty and non-obviousness). Thus, a patent grants the holder technological room to operate by preventing competitors from producing and using the patented invention. This exclusion right can be used to block competitors. In contrast, trademarks do not possess comparable blocking power because they are subject to different criteria (Mendonça et al., 2004). The production and sale of very similar products cannot be prohibited by a trademark and competitors can simply sell similar products using different trademarks or brand names.

6.3 Empirical approach

6.3.1 Dataset and survey

We conducted an online survey of SMEs in innovative industries to gather data on their trademarking motives. A sample of 46,963 firms was selected from CrunchBase (formerly TechCrunch), a free US-based database founded in 2007 that provides comprehensive coverage of mostly US firms. [2] CrunchBase represents a relatively new data source but its use in entrepreneurship and innovation research is increasing (e.g., Block and Sandner, 2009; Sandner and Block, 2011; Alexy et al., 2012). CrunchBase focuses on the internet and technology sectors. In general, these sectors are active in trademarking and are therefore suitable for examining trademarking motives (Mendonça et al., 2004; Greenhalgh and Rogers, 2006; Amara et al., 2008). After retrieving the sample from CrunchBase in early 2012, we administered the survey through email by sending personal invitations to participate in the survey and providing a link. The survey was conducted in June and July 2012. We received responses from 1,891 firms. Because our sample contains mostly US firms, we follow common US practice and define SMEs as firms with fewer than 500 employees (USITC, 2010).[3] We did not introduce a minimum threshold because we are also interested in analyzing the smallest firms. Very small firms (i.e., firms with less than 10 employees) constitute an interesting subgroup of SMEs that is often overlooked (Thomä and Bizer, 2013). Because we are interested in the motives for trademarking, we excluded firms that did not file trademark applications. Finally, we excluded firms that failed to complete the questionnaire. Our final sample includes exactly 600 SMEs.

Because we conducted a survey, we assess the possibility of non-response bias. Late respondents resemble non-respondents, and if late respondents are significantly different from early respondents, the survey might be biased (Armstrong und Overton, 1977; Radhakrishna, et al., 2008). Therefore, we test for differences between early and late respondents following Miller and Smith (1983). We divide our sample of 600 firms into early respondents (first 150 respondents, 25% of the sample) and late respondents (last 150 respondents, 25% of the sample). No severe group differences could be identified.

6.3.2 Variables used in the factor analysis

The first empirical analysis comprises a factor analysis of firm trademarking motives. To measure the importance of these motives, we listed 10 items and asked participants to indicate the importance of each item on a 5-point Likert scale ranging from 1 (not important) to

[2] Although worldwide trademarking systems vary with respect to relatively small details, we are not aware of significant differences between the trademarking systems of the US and Europe. The overall function of trademarks, the application process, and the use of trademarks is very similar in both regions.

[3] Using another threshold (e.g., 250 employees) does not change our main results.

5 (very important). The items refer to the three trademarking motives described in Section 2: *protection* ("safeguarding revenues", "Trademark (TM) registration is presently seen as only way to protect the marked product or service", "preventing TM imitation", "when other IPRs expire, products or services are still protected"), *marketing* ("supporting marketing activities of products or services", "strengthening the company image", "enhancing customer loyalty"), and *exchange* ("increasing negotiation power with potential investors", "increasing attractiveness to potential licensees", "ability to sell the TM in the future"). Table 1 provides more details about the items and their measurement.

6.3.3 Variables used as passive cluster variables in the cluster analysis

The second empirical analysis constitutes a cluster analysis to explore different configurations of SMEs regarding trademarking motives. In addition to using the factors identified in the factor analysis as active cluster variables, we use passive cluster variables to further distinguish the identified clusters. In conceptually unexplored fields, such as ours, the cluster analysis literature advocates a selection of passive cluster variables that enables a rich description of the characteristics of the identified clusters (e.g., Ketchen and Shook, 1996; Homburg et al., 2008). Therefore, we select and capture internal and external contingencies by including several industry- and firm-level variables that previous research has linked to the usage of and motivation for trademark registration. Overall, previous research has revealed considerable differences in IPR filing motives across industries and across firm characteristics, such as firm size and age (Cohen et al., 2000; Blind et al., 2006; Amara et al., 2008). We also compiled data on firm- and industry-level characteristics from secondary data sources (CrunchBase and Compustat) and matched these with our survey data. In addition, we enriched the primary survey data with optional qualitative comments provided by the respondents. In the following we describe the passive cluster variables in detail.

Firm operates in service industry: The first industry-level variable captures whether the firm operates primarily in a service industry. We calculated a variable from our survey that takes a value of 1 if the firm is primarily active in services and a value of 0 otherwise. Innovation in manufacturing and service industries differs (Hipp and Grupp, 2005; Carree et al., 2015). Previous research has consistently shown that there is an overall lesser need for formal IP protection in service industries (e.g., Heimonen, 2012; Thomä and Bizer, 2013), and that trademarks are filed more frequently in manufacturing industries (e.g., Arundel et al., 2007; WIPO, 2016a). An explanation might be that manufacturing firms often protect a multitude of products with different trademarks, whereas service firms lack protectable products and are often restricted to a single trademark protecting their company brand. Furthermore, we expect trademarking motives to differ. Products in manufacturing industries are often more tangible than services and information asymmetry regarding quality is thus lower. This intangibility of services may increase the importance of reputation and quality signals established by trademarks to overcome this information asymmetry in service industries. We thus expect marketing motives to be of greater importance for service firms than for manufacturing firms when filing trademarks. Furthermore, we expect trademarks to be particularly important for service innovators, which constitute a particularly interesting subgroup of service firms. Several studies argue that trademarks are a particularly well-suited indicator for measuring innovation in the service sector (e.g., Gotsch and Hipp, 2012; Flikkema et al., 2014; Carree et al., 2015). Trademarks are particularly apt for service innovators because trademarks are often the only formal mechanism available to service firms (e.g., they do not require a technical invention or a tangible product) (Gotsch and Hipp, 2012). Therefore, innovative service firms that are interested in utilizing formal IP protection mechanisms often protect their IP assets through trademarks, and should thus increasingly value the protection motive when filing trademarks.

Importance of B2B and B2C markets: We measure the importance of business-to-business (B2B) and business-to-consumer (B2C) customers for firms on a 5-point Likert scale. Prior research in marketing frequently reveals differences in the buying behavior of B2B and B2C customers (Edwards et al., 2007). For example, Ahmed and D'Astous (1995) observe that country of origin, costs, and warranties are more important to B2B customers, whereas B2C customers consider branding to be more important. Although branding is useful to firms who must reach a larger customer base in B2C markets, B2B customers are more informed and not as easily affected or persuaded by strong brands (e.g., Ahmed and D'Astous, 1995; Edwards et al., 2007). Therefore, marketing motives to file trademarks might be more important to firms that operate primarily in B2C markets. However, the differences between the two groups are often overemphasized; brand equity also plays an important role in B2B exchanges (e.g., Gordon et al., 1993).

Industry R&D and advertising intensity: Because prior research finds that firms in technology-intensive industries tend to file trademark applications more often than firms in other industries do, we include the R&D intensity of the industry in which the firm is active as a contingency variable (Amara et al., 2008; Mendonça et al., 2004). Because marketing is especially relevant in technology-intensive markets (Mohr et al., 2010), we expect firms that are active in particularly R&D-intensive industries to find marketing motives more important. Furthermore, Fosfuri and Giarratana (2009) use trademarks to proxy for new advertising rather than for innovation. Because trademarks are related to branding and brand advertisement, we include the advertising intensity of the industry in which the firm operates. We expect firms in advertising-intensive industries to trademark more often, especially for marketing reasons. Data for both variables were obtained from Compustat. We compute R&D intensity at the industry level as the ratio of R&D expenditures to sales for four-digit Standard Industrial Classification (SIC) codes (e.g., Huselid et al., 1997; Heeley et al., 2007).

Similarly, we compute advertising intensity as the ratio of advertising expenditures to sales for four-digit SIC codes (e.g., Boyd et al., 2010).

Role of product and process innovation: Regarding firm characteristics, we include two variables to address firms' innovation activities. Specifically, we asked respondents to indicate the role of product and process innovations at their respective firms. Amara et al. (2008) indicate that product innovations involve a higher degree of knowledge codification and tangibility compared to process innovations. Therefore, formal protection mechanisms (e.g., trademarks) should be better suited to product innovations, whereas process innovations should rely more on informal protection mechanisms (e.g., secrecy) (Amara et al., 2008). Consistent with this rationale, Amara et al. (2008) empirically demonstrate that process innovation is negatively related to trademarking. Product innovations are often linked to market-related goals, such as increasing market shares or entering new markets. In contrast, process innovations focus on decreasing costs or increasing efficiency, neither of which are susceptible to trademarking because they are not market-related and thus require neither protection nor distinction in the eyes of customers. As stated above, process innovations are often protected by secrecy and other informal mechanisms. As a result of the differences between product and process innovations, we expect that the protection and reputation motives for trademarking are more prevalent at firms where product innovations play an important role.

Number of employees: We also include firm size as measured by the number of employees reported in CrunchBase in our analysis. Previous research has shown that the motives to file IPRs differ by firm size (e.g., Blind et al., 2006; De Rassenfosse, 2012; Veer and Jell, 2012). Unlike large firms, smaller firms face resource constraints and are often unable to realize economies of scale. Although we only consider SMEs, we expect to observe size differences in trademarking motives within our sample. For example, previous research on patenting has identified marketing and exchange motives as more important to small firms than they are to medium-sized firms (e.g., Blind et al., 2006; De Rassenfosse, 2012). We expect to find similar relationships for trademarking motives.

Firm age: Data on firm age are also obtained from CrunchBase. Firm age can be considered a proxy for the life cycle of a firm. For example, Block et al. (2014a) indicate that trademarks as quality signals to investors might become less valuable to older firms, which are typically further along in their life cycle. This is because other, more credible signals are available (e.g., product prototypes), suggesting that the exchange function of trademarks becomes less relevant with increasing firm age. Therefore, older firms should not file trademarks for exchange motives as often as young firms do. Also, older firms are likely to operate in more mature markets. In mature markets, product offerings tend to be similar with regard to their technical attributes. Because of this, other attributes, such as price, appearance, or the associated brand may play a more important role in consumers' buying decisions. Therefore, establishing product differentiation and reputation via trademarks should be more important for older firms. Consequently, older firms should more often file trademarks for marketing reasons than younger firms. Taken together, we expect protection and marketing motives to become more important with increasing firm age, while exchange motives become less important.

Importance of external knowledge acquisition: We also include the extent of firms' external knowledge sharing in our analysis. Because SMEs typically experience resource constraints and have limited knowledge bases, they often rely on external knowledge acquisition. Amara et al. (2008) demonstrate that knowledge sharing with external research organizations positively influences the probability that knowledge-intensive service firms file trademark applications. Thus, we expect firms attributing high levels of importance to external knowledge acquisition to file trademark applications for exchange reasons. To measure this aspect, we asked each respondent to indicate the importance of external knowledge acquisition on a 5-point Likert scale.

Firm received external capital funding: The acquisition of external capital, particularly venture capital (VC), is critical to SMEs operating in innovative industries because such firms often face challenges obtaining financing (e.g., De Rassenfosse, 2012). Additionally, previous research has observed that trademarks are important to the valuation of start-ups by VC investors, although the positive, value-enhancing effects of trademarks decrease as start-ups progress into later phases of the venture cycle (Block et al., 2014a). Because exchange motives specifically reflect start-ups' intentions to acquire such financing, we expect firms that received external capital to emphasize exchange motives. A binary variable created from CrunchBase data captures whether the firm received external capital from, for example, venture capital firms, incubators, accelerators, or angel groups.

Extent of technology licensing: Finally, we include a variable that measures the extent of technology licensing in our analysis. Respondents were asked to indicate the percentage of firm technologies that are licensed to other firms. SMEs often license their products and technologies to achieve growth (Alkhafaji, 1990). Trademarks can support SMEs in technology licensing activities. Because licensing is also captured by exchange motives, we expect firms with more licensing to value exchange motives to a higher degree compared to companies with less licensing.

Table 6.1: Description of variables, coding, and data sources.

Variables and survey items	Coding	Data source
Variables used in factor analysis		
How important were the following factors for your decision to register a trademark (TM)?		
P: Safeguarding revenues	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
P: TM reg. is presently seen as only way to protect the marked product or service	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
P: Preventing TM imitation	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
P: When other IPRs expire, products or services are still protected	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
M: Supporting marketing activities of products or services	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
M: Strengthening the company image	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
M: Enhancing customer loyalty	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
E: Increasing negotiation power with potential investors	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
E: Increasing attractiveness to potential licensees	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
E: Ability to sell the TM in the future	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
Variables used for cluster description		
Industry characteristics		
Firm operates in service industry	1 if company operates in service industry, 0 otherwise	Survey
Imp. of B2B markets ("To what extent are B2B trans. central to your business?")	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
Imp. of B2C markets ("To what extent are B2C trans. central to your business?")	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
Industry R&D intensity	Ratio of the firms' R&D expenditure to sales in industry	Compustat
Industry advertising intensity	Ratio of firms' advertising expenditure to sales in industry	Compustat
Firm characteristics		
Importance of product/process innovation ("How important is the development and improvement of products/production processes for your company?")	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
Number of employees	Number of employees	CrunchBase
Firm age	Number of years from firm's founding until June 1, 2012.	CrunchBase
Importance of external knowledge acquisition	5-point Likert scale: 1 ('not important'), 5 ('very important')	Survey
Firm received external capital funding	1 if company received external capital, 0 otherwise	CrunchBase
Extent of technology licensing	Share of technology a company licenses out, 25% interval: 1 (0%), 5 (100%)	Survey

Notes: P = protection motives, M = marketing motives, E = exchange motives.

6.3.3 Descriptive statistics

Table 6.2 (a) provides descriptive statistics for firm trademarking motives. The results indicate that the most important motive for filing trademarks is to protect product and service offerings from imitation (mean = 4.2). Other important motives include the support of firm marketing efforts (mean = 4.3) and image (mean = 4.0). The least important motive is the sale of the trademark in the future (mean = 2.7). We observe considerable variance in the reported importance of specific trademarking motives, which supports our premise that SMEs have various underlying intentions for filing trademarks. In general, all motives are considered important to a certain degree. Therefore, all items were included in the exploratory factor analysis.

Descriptive statistics for the industry and firm characteristics of the 600 firms in our sample are provided in Table 6.2 (b). Due to missing data in Compustat or CrunchBase, some variables contain fewer observations (*industry R&D*/*advertising intensity*, *number of employees*, and *firm age*). With regard to industry characteristics, 34.2% of firms indicate that they primarily operate in a service industry. The firms in our sample report that B2B markets (mean = 4.1) are more important than B2C markets (mean = 3.5). The average R&D intensity of the industries in which our firms operate is 6.1%, and the corresponding advertising intensity is 2.9%. To further describe the industries in which the firms in our sample operate, we draw on industry data available from CrunchBase. Many firms in our sample operate in the software industry (21.0%), closely followed by the web industry (15.5%) and e-commerce (7.5%). The remaining firms are distributed across various other industries, including biotech (4.0%) and advertising (4.9%). Overall, the industry distribution reflects the focus of CrunchBase on firms that are active in internet and technology sectors.

With regard to firm characteristics, Table 6.2 (b) indicates that product innovations (mean = 4.4) are very important to the firms in our sample and are more important than process innovations (mean = 3.7). On average, the firms in our sample employ 15.5 people. However, the distribution is skewed toward smaller firms (median = 6). The maximum firm size is 435, whereas some firms report having only 1 employee (i.e., they are most likely operated by the owner). Similarly, our sample includes relatively young firms, with ages that range from 0.6 years to 33.4 years, with a mean of 3.8 years. As expected, external knowledge acquisition is of high importance to the sampled firms (mean = 4.0); SMEs seem to overcome their resource constraints by the acquisition of external knowledge. Furthermore, 27.8% of the firms in our sample have previously received external funding. Finally, the firms indicated an average extent of technology licensing of approximately 25.0%.

Table 6.2: (a) Descriptive statistics: trademarking motives.

Variable	N	M	SD	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9).
(1) Safeguarding revenues	600	3.45	1.26	1	5									
(2) TM reg. seen as only way to protect product/service	600	3.29	1.31	1	5	0.39*								
(3) Preventing TM imitation	600	4.16	0.99	1	5	0.28*	0.35*							
(4) When other IPRs expire, products/services still protected	600	3.06	1.32	1	5	0.41*	0.33*	0.29*						
(5) Supporting marketing activities of products/services	600	4.03	1.13	1	5	0.27*	0.20*	0.16*	0.26*					
(6) Strengthening the company image	600	4.00	1.07	1	5	0.23*	0.13*	0.10*	0.27*	0.41*				
(7) Enhancing customer loyalty	600	3.26	1.32	1	5	0.27*	0.14*	0.04	0.32*	0.38*	0.64*			
(8) Increasing negotiation power with potential investors	600	3.13	1.35	1	5	0.38*	0.26*	0.13*	0.39*	0.24*	0.45*	0.42*		
(9) Increasing attractiveness to potential licensees	600	3.14	1.38	1	5	0.31*	0.21*	0.08*	0.38*	0.26*	0.45*	0.50*	0.55*	
(10) Ability to sell the TM in the future	600	2.69	1.43	1	5	0.29*	0.28*	0.13*	0.31*	0.14*	0.31*	0.27*	0.44*	0.49*

Notes: M = mean.* Pearson correlation coefficient with significance level $p \leq 0.05$.

Table 6.2: (b) Descriptive statistics: industry and firm characteristics.

Variable	N	M	SD	Min.	Max.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Industry characteristics																
(1) Firm operates in service industry	600	0.34	-	0	1											
(2) Importance of B2B markets	599	4.14	1.22	1	5	-0.06										
(3) Importance of B2C markets	597	3.46	1.58	1	5	0.13*	-0.40*									
(4) Industry R&D intensity	421	0.06	0.04	0	0.20	-0.18*	-0.10*	-0.08								
(5) Industry advertising intensity	421	0.03	0.02	0	0.09	-0.03	-0.25*	0.26*	-0.01							
Firm characteristics																
(6) Importance of product innovation	597	4.35	1.17	1	5	-0.45*	0.12*	-0.05	0.11*	0.08						
(7) Importance of process innovation	599	3.67	1.35	1	5	-0.19*	0.09*	0.03	0.08	0.09	0.47*					
(8) Number of employees	413	15.54	34.23	1	435	0.01	0.08*	-0.18*	-0.10	-0.10	-0.03	0.02				
(9) Firm age	382	3.84	3.24	0.58	33.39	-0.04	0.16*	-0.25*	0.02*	-0.06*	-0.03	-0.00	0.37*			
(10) Imp. of ext. knowledge acquisition	600	3.95	1.00	1	5	0.05	0.07	0.04	-0.01	-0.13*	-0.01	0.12*	-0.06	-0.09		
(11) Firm received ext. capital funding	600	0.27	-	0	1	-0.17*	0.01	-0.06	0.21*	0.02	0.12*	0.09*	-0.05*	-0.10	0.05	
(12) Extent of technology licensing	600	1.99	1.28	1	5	-0.15*	0.16*	-0.01	0.01	-0.04	0.12*	0.12*	0.01	-0.04	0.08	0.02

Notes: M = mean.* Pearson correlation coefficient with significance level $p \leq 0.05$.

6.4 Empirical analysis

6.4.1 Motives for filing trademarks: results of an exploratory factor analysis

We conduct an exploratory factor analysis to categorize and aggregate the items describing the motivation of firms to file trademark applications into underlying and distinct dimensions of trademarking motives.

We conduct a principal component factor analysis with varimax rotation. The results indicate a three-factor solution according to the latent root criterion (i.e., three factors have eigenvalues greater than 1) (e.g., Ozer, 2007; Thomä and Bizer, 2013). To assign items to specific factors, we employ a threshold of 0.50 for the varimax-rotated factor loadings. Table 3 depicts the rotated factor loadings and extracted variances. Each item loads unambiguously onto one of the three factors and is thus assigned to only one factor. In sum, the three factors account for 63.6% of the total variance. A main assumption of factor analysis is that the factor variables are correlated. To test this assumption, we calculate Bartlett's test of sphericity (1,816.2, $p < 0.01$) and the Kaiser-Meyer-Olkin measure (KMO = 0.84). According to Kaiser and Rice (1974), the KMO measure leads to "meritorious" results. Furthermore, Bartlett's test indicates that the variables used in the factor analysis are not independent. Therefore, our dataset is appropriate for factor analysis (Dziuban and Shirkey, 1974).

Table 6.3: Factor analysis of motives for filing trademarks.

Variable	Factor 1	Factor 2	Factor 3
Interpretation	*Exchange motives*	*Marketing motives*	*Protection motives*
1. Safeguarding revenues	0.31	0.17	**0.64**
2. TM reg. seen as only way to protect product/service	0.22	0.02	**0.74**
3. Preventing TM imitation	-0.07	0.07	**0.78**
4. When other IPRs expire, products/services still protected	0.35	0.26	**0.57**
5. Supporting marketing activities of products/services	-0.09	**0.77**	0.27
6. Strengthening the company image	0.32	**0.79**	0.01
7. Enhancing customer loyalty	0.35	**0.77**	0.02
8. Increasing negotiation power with potential investors	**0.71**	0.33	0.15
9. Increasing attractiveness to potential licensees	**0.73**	0.39	0.06
10. Ability to sell the TM in the future	**0.80**	0.02	0.17
Variance explained	21.8%	21.6%	20.2%
Cronbach's α	0.71	0.74	0.75

Notes: N = 617 firms. The number of observations reaches a maximum of 600 in the other analyses because 17 observations were excluded as outliers in the cluster analysis. Principal component analysis, varimax-rotated factor loadings. Kaiser–Meyer–Olkin Measure: 0.84, Bartlett's test of sphericity: 1,816.20, $p < 0.01$.

Our empirical results unambiguously support the theoretically derived distinction among protection, marketing, and exchange motives. Factor 1 represents *exchange motives* and includes increasing negotiating power relative to potential investors to obtain capital, increasing attractiveness to potential licensees to gain higher royalty fees, and generating future cash flows by selling trademarks. Thus, this factor focuses on facilitating exchanges with external stakeholders, namely, potential investors, licensees, and trademark acquirers. Although the group of external stakeholders is heterogeneous, the common underlying rationale is that SMEs file trademark applications to engage in external exchange relationships to generate financial resources.

Factor 2 represents *marketing motives* and includes supporting marketing activities, strengthening the company image, and enhancing customer loyalty. These motives reflect companies' goals to pursue a product differentiation strategy fortified by an emphasis on brand building. This factor focuses on trademarks as the foundation of strong brands that generate brand awareness and brand association and thereby enhance a company's image, attract and retain valuable customers, and generate premium prices.

Factor 3 represents *protection motives* and includes safeguarding revenues, preventing trademark imitation, protecting firm offerings, and accounting for expiring IPR mechanisms (e.g., patents). This factor reflects the traditional protection function of trademarks.

6.4.2 Identifying a typology of SMEs based on trademarking motives: results of a cluster analysis

We build on the results of the factor analysis and conduct a cluster analysis to identify a typology of SMEs based on their trademarking motives. Cluster analysis is a powerful tool to investigate heterogeneity in trademarking motivations among SMEs. Whereas factor analysis allows us to combine several (sub)motives into three main motives (i.e., protection, marketing, and exchange), the cluster analysis helps us to identify groups of SMEs based on these trademarking motives and facilitates the comparison of the identified groups. The three factors identified by the exploratory factor analysis constitute the active cluster variables. The factor values for each SME were generated by weighting the items assigned to each factor by their respective factor loadings. Combining factor and cluster analysis has two important advantages. First and foremost, grouping the highly correlated questionnaire items into combined factors avoids an overrepresentation of individual items in the cluster analysis. For example, we measure the protection motive using four items, whereas the other two motives are each measured with only three items. Thus, if each variable was weighted equally in the cluster analysis, the results would be driven by the protection motives (e.g., Hair et al., 2008; Thomä and Bizer, 2013). Second, weighting the individual variables derived through the factor analysis is likely to lead to more robust results, in part because cluster analysis is not robust to outliers but also because factor analysis reduces multicollinearity problems. This is important because the 10 items that we use to measure trademarking motives are by construction highly correlated with each other (e.g., Hair et al., 2008; Thomä and Bizer, 2013).

We employ a two-step clustering procedure. First, we determine the most appropriate number of clusters. Second, we assign the firms to specific clusters. We begin by identifying outliers using single-linkage clustering and eliminate 17 firms as outliers because they form clusters on their own (Punj and Stewart, 1983). Next, we determine an appropriate number of clusters using Ward's (1963) algorithm. Because Ward's algorithm is sensitive to scaling, we standardize the three trademarking factors used as active cluster variables by means of a z-transformation (Milligan and Hirtle, 2003). Various test statistics are used to determine an appropriate number of clusters: Duda and Hart's (1973) Je(2)/Je(1) index suggests a four-cluster solution, the pseudo-T-squared index suggests a three-cluster solution, and Caliński and Harabasz's (1974) pseudo-F index suggests a four-cluster solution. Consistent with cluster analysis methodology, we also examine the face validity of these cluster solutions by visually inspecting the respective dendrograms. We opt for a four-cluster solution because it is suggested by two of the three stopping rules and exhibits the highest face validity when displayed in a dendrogram. To test the stability of the results, we randomly selected 20 subsamples containing two-thirds of the sample and reapplied the procedure. A four-cluster solution is supported by this test.

In the second step of the cluster analysis, we assign observations to clusters using a hybrid approach. We employ Ward's algorithm to obtain a starting solution and then employ a k-means algorithm to optimize this solution (Arabie and Hubert, 1994; Punj and Stewart, 1983). Next, we test for the distinctiveness of the cluster solution. Kruskal-Wallis tests demonstrate that the means of the three factor variables used as active cluster variables differ significantly across clusters ($p < 0.01$). Moreover, a multivariate analysis of variance yields additional evidence of cluster distinctiveness because it indicates that the means of the groups are not equal ($p < 0.01$).

When interpreting the cluster solution for content validation, we focus on the means of the active cluster variables (i.e., the three trademarking motives). The results of this comparison are presented in Table 6.4.

Table 6.4: Results of cluster analysis.

Factors	Clusters				χ^2 (Kruskal-Wallis test)
	Trademark skeptics	**Marketing-focused trademarking SMEs**	**Marketing- plus protection-focused trademarking SMEs**	**Trademark advocates**	
Protection motives	3.02	2.59	3.85	4.31	371.58***
Marketing motives	2.13	3.81	3.81	4.65	333.87***
Exchange motives	1.65	2.56	3.03	4.44	380.01***
N	95	169	198	138	
Percentage of firms	15.83	28.17	33.00	23.00	
Description	Firms that have a passive approach towards trademarks.	Firms that use trademarks *mainly* for marketing purposes.	Firms that use trademarks for marketing *and* protection purposes.	Firms that apply a holistic view on trademark purposes.	

Notes: N = 600 firms. Values in cells refer to cluster means. *** p < 0.01.

Cluster 1 (Trademark skeptics): Although the firms in the first cluster engage in trademark filing, they exhibit low mean values for each motive and appear to have no specific motive for trademark registration. We call this group of firms *trademark skeptics*. This cluster is the smallest cluster and includes 95 (15.8%) of the 600 firms in the sample. The low mean values for each motive combined with statements provided by firms belonging to this cluster indicate a passive approach to trademarking.

A passive approach to trademarking is further reflected in the qualitative statements provided in the survey. For example, several respondents state that they use trademarks only to “prevent someone from taking our domain name away.” Internet domains are usually transferred to the person holding the trademark. These comments were also made with regard to Facebook and Twitter, both of which also tend to assign websites to trademark-holders and are viewed as important tools for firms in the internet and web industries. Other firms indicate that they register trademarks to avoid litigation and that they do not actively pursue other functions. Underlining this passive approach to trademarks, one respondent stated that “[trademarking] is a deterrent. Most start-ups cannot afford legal wrangling so they are unlikely to put these things to use.” Another respondent stated: “We have a funder who specifically requires us to register trademarks as they are trying to increase intellectual property ownership in our company.” Although firms in this cluster exhibit an overall indifference toward trademarking, their main motive for trademarking is protection, which is the purpose for which trademarks were initially introduced (i.e., as a means of formal IP protection). Another reason why these firms file trademark applications might be that they want to imitate the behavior of other industry participants. This firm behavior resembles mimetic isomorphism motives rather than strategic motives (DiMaggio and Powell, 1983), which indicates that firms file trademark applications to imitate competitors. If a company fails to imitate a competitor, it risks losing innovative potential and legitimacy (Semadeni and Anderson, 2010). Therefore, firms might file trademarks not for strategic reasons but to imitate competitors, especially when leading companies in the industry use trademarks to a significant extent (Flikkema et al., 2014).

Cluster 2 (Marketing-focused trademarking SMEs). Firms in this cluster exhibit high values for marketing motives (mean = 3.8) but low or medium values for exchange and protection motives relative to the other three clusters. We label this cluster the *marketing-focused trademarking SMEs* because these firms view trademarks as the foundation of a differentiation strategy but neglect the other trademarking motives (i.e., protection and exchange). Firms in this cluster manifest the dominant view in marketing research that trademarks are proxies for firms' brand-building efforts (e.g., Krasnikov et al., 2009; Fosfuri and Giarratana, 2009).

This orientation is also reflected in the qualitative statements provided by the firms in this cluster. For example, respondents state that they file trademark applications "in order to create a defensible brand, and leverage it in the marketplace to effectively market a service, draw customer affinity and loyalty", for "clearly identifying a technology based product", or to "minimize consumer confusion as to product identity." These comments refer to the branding function of trademarks, which allows companies to create perceptions of distinctiveness among their customers.

Cluster 3 (Marketing- plus protection-focused trademarking SMEs). The third cluster refers to the largest group of SMEs, which includes 198 firms (33.0%). This cluster exhibits high mean values for protection (mean = 3.9) and marketing motives (mean = 3.8). Thus, this cluster includes *the marketing- plus protection-focused trademarking SMEs*.

Although these SMEs demonstrate both protection and marketing motives, they do not indicate intentions to leverage their respective trademarks in exchange relationships. In their qualitative comments, firms in this cluster highlight the protection function of trademarks (e.g., "why NOT protect your brand?") and emphasize marketing motives (e.g., "branding", "make us look like a bigger company"). Furthermore, most firms in this cluster refer explicitly to brands when asked about trademarks because a firm's reputation is established through its brands and not directly via trademarks. The significant interconnection between protection and marketing motives is also reflected in prior innovation research on trademarks, which frequently describes brand protection as the main function of trademarks (e.g., Krasnikov et al., 2009; Fosfuri and Giarratana, 2009; Sandner and Block, 2011; Block et al., 2014b). In addition, the different trademarking motives may have reinforcing effects on each other. Although the value of exchange motives is significantly lower than the values of the other two motives for this cluster, it is the second highest value for exchange motives among all clusters.

Cluster 4 (Trademark advocates). The fourth cluster includes 138 of the 600 firms in the sample (23.0%) and exhibits high mean values for each trademarking motive (all three means > 4.3). Among all clusters, each trademarking motive reaches its maximum mean value in this cluster. We label this cluster *trademark advocates* because firms in this cluster seem to register trademarks to pursue a holistic set of motives: to support a differentiation strategy based on brands, to signal firm attractiveness to external stakeholders (i.e., exchange motives) and to protect their IP. The high mean values across all trademarking motives suggest that firms in this cluster have an overall positive opinion of trademarks and recognize their numerous potential benefits.

The overall high importance of trademarks to these firms is also reflected in their qualitative responses. One respondent indicated that "our brand is the key asset that the business owns", and another stated that brands are the company's "road to success." Because trademarks and brands are closely intertwined, both statements highlight that these companies view the overall effects of trademarks as positive. Rather than emphasizing particular aspects of trademarks as most important, the respondents indicate that the interplay of these motives is crucial. Furthermore, this cluster is the only cluster that exhibits a high mean for exchange motives. This indicates that SMEs striving to acquire external capital from investors, licensees, or trademarks sales tend to view trademarking holistically. Furthermore, our results suggest that SMEs do not file trademark applications solely to acquire financial resources; rather, the acquisition of financial resources appears to be a positive side effect for firms that file trademark applications in pursuit of other motives. Because of their overall positive attitude, these different motives are likely to reinforce each other, which explains the very high value of each motive.

Interestingly, the SMEs in these four clusters exhibit a hierarchical structure of motives for trademarking. Whereas trademark skeptics have low mean values for all three motives, marketing-focused trademarking SMEs focus on only one motive, namely, marketing. Marketing- plus protection-focused trademarking SMEs focus on protection as well as marketing. This mechanism of consistently enriching motives results in trademark advocates, which are motivated by all three factors – i.e., they are also motivated by exchange. This pattern suggests that SMEs that file trademark applications for specific reasons always consider marketing motives and that certain SMEs do not focus on exchange or protection motives alone. Thus, the marketing motive is a cornerstone of each SME trademarking strategy, whereas exchange and protection are enriching and complementary motives.

6.4.3 Profiling and describing the typology: a comparison of the four clusters based on industry- and firm-level characteristics

In this section, we further explore the specific characteristics of the four clusters by profiling differences in industry- and firm-level variables (i.e., passive cluster variables), as described in Section 6.2. This profiling provides valuable information on how different characteristics at the firm, market, and industry levels relate to trademarking motives and on how the trademarking motives are (potentially) determined and shaped by those characteristics. Table 5 provides the means and proportions of these variables for each cluster. First, we empirically test whether SMEs significantly differ with respect to these profiling variables by assessing differences in within-cluster values as well as across clusters and interpreting these results at the variable level (Thomä and Bizer, 2013). Second, we interpret these findings at the cluster level to further describe and differentiate the individual clusters. Notice however, that this approach and the developed taxonomy are of descriptive nature. Hence, even though we assume a logical pathway from industry and firm level characteristics to the trademarking motives, strictly speaking, we are not able to uncover such causalities.

Within-cluster results: For metric and quasi-metric variables, such as firm age, we conduct an analysis of variance (ANOVA) to test for differences among within-cluster means (Table 6.5 (a)). A significant test statistic indicates that the within-cluster mean of the continuous variable differs from cluster to cluster, which supports the assumption that this variable is related to a specific trademarking motive. Variables that differ significantly therefore enable us to profile the clusters and to confine them more clearly. If a variable differs significantly among clusters, we compare each cluster mean to the overall sample mean to interpret whether the firms in a cluster exhibit above-average mean values (e.g., they are older than the other firms in the sample) or below-average mean values (e.g., they are younger than the other firms in the sample).

Across-cluster results: For binary variables, such as whether a firm has received external financing or operates in a service industry, we test whether the distribution across the four clusters differs significantly from its distribution in the total sample (using a χ^2 goodness-of-fit test) (Table 6.5 (b)). If this is the case, we suggest that the dummy variable is related to a specific trademarking motive. We compare the observed proportion of firms to the expected proportion based on the cluster size. Higher-than-expected proportions indicate that we observe more firms with a particular characteristic in this cluster than expected based on the size of the cluster and vice versa. The across-cluster values are especially helpful when profiling the clusters in a holistic way.

Industry characteristics: As Table 6.5 (b) indicates, the four clusters are not equally represented in service industries ($p < 0.01$). For example, firms that are active in service industries are overrepresented in the trademark advocates cluster and underrepresented in the marketing-focused trademarking SMEs cluster. Additionally, the results indicate significant differences between the various clusters with respect to the within-cluster means of the importance of B2C markets ($p < 0.01$). Table 6.5 (a) shows that firms that are more intensively inclined toward B2C markets are more often assigned to the trademark advocates cluster (mean = 4.0), whereas firms that are comparatively less inclined toward B2C markets are overrepresented among marketing-focused trademarking SMEs (mean = 3.1). Finally, the clusters differ significantly by industry R&D intensity ($p < 0.01$). Firms that are active in more R&D-intensive industries are overrepresented in the marketing-focused trademarking SMEs cluster, whereas firms active in less R&D-intensive markets are found more frequently in the trademark advocates cluster.

Firm characteristics: We observe significant differences in the role and importance of process innovations between clusters ($p < 0.01$). Firms that place more emphasis on process innovations are more often assigned to the trademark advocates and marketing-focused SMEs clusters and less often present in the trademark skeptics cluster. This indicates that firms which attribute a high importance to process innovations more often register trademarks as a result of all three motives (trademark advocates cluster), whereas firms that rate process innovations as less important do not find any trademarking motive important (trademark skeptics cluster). We also observe differences in the importance of the acquisition of external knowledge across clusters ($p < 0.01$). Firms that assign high importance to external knowledge sources are overrepresented in the trademark advocates cluster relative to the other three clusters. Similarly, the share of companies that received external funding is not evenly distributed across the clusters ($p < 0.01$); rather, firms that received external funding are underrepresented in the trademark advocates cluster and overrepresented in the cluster of trademark skeptics and marketing-focused trademarking SMEs. The across-cluster results indicate that firms which received external capital funding are most often assigned to the marketing-focused trademarking SMEs cluster (34.9% as opposed to the expected 28.2%), while only 16.9% of the firms that are assigned to the trademark advocates cluster received external capital (expected proportion: 23.0%). Finally, significant differences emerge in the extent of technology licensing ($p < 0.01$). Similar to the results relating to the acquisition of external knowledge, firms licensing their technology to external licensees to commercialize their knowledge are more frequently assigned to the trademark advocates cluster, whereas firms that are less engaged in licensing are overrepresented in the trademark skeptics cluster and thus exhibit a rather passive approach to trademarking.

The within-cluster means for the importance of B2B markets, industry advertising intensity, the role of product innovations, number of employees, and firm age do not differ significantly between the clusters, which means that these variables should be treated carefully when describing differences across clusters. After reporting the differences at the variable level, we subsequently profile each cluster.

Cluster 1 (Trademark skeptics): We observe that firms in the trademark skeptics cluster attach less importance to both product and process innovations compared with firms in the other three clusters. In addition, we find that trademark skeptics are characterized by a comparatively stronger inward orientation, reflected by the significantly lower values attributed to the acquisition of external knowledge and technology licensing. Overall, a greater openness to external parties can positively influence a firm's innovativeness (e.g., Laursen and Salter, 2006; Cheng and Huizingh, 2014). Although there is no coherent evidence on whether the benefits derived from openness to external parties differ between service and manufacturing firms (Huizingh, 2011), Arbussà and Coenders (2007) show that manufacturing firms often conduct internal R&D, whereas service firms often acquire external knowledge to improve their innovativeness. This suggests that the overrepresentation of service firms in the trademarks skeptics cluster should be associated with higher importance attached to external knowledge acquisition and technology licensing. However, we find that the opposite is true. Innovation seems to play a different (and maybe lower) role for firms in the trademark skeptics cluster, thus partially explaining their skepticism toward trademarks. Such firms might not value or appreciate trademarks as much as firms in the other three clusters do because they have relatively less knowledge or marketing assets that could be protected or leveraged in exchange relationships through trademarks. For example, the sales of trademark skeptics could be based primarily on low prices, thus requiring less marketing and less trademark protection. Additionally, the exchange motive for filing trademarks plays a smaller role for trademark skeptics because they have little engagement with external parties. The fact that firms in this cluster file trademark applications despite their skepticism toward trademarks could be explained by imitation of industry norms. Another explanation for why these firms still file trademarks could be the involvement of external investors in the formulation of their IP strategies, thus pressuring firms to file trademarks. Investors have been shown to value trademarks as quality signals and as signals of market orientation, specifically in firms in early stages of their venture cycle (Block et al., 2014). The results in Table 5 indicate that firms that received external capital are overrepresented among the group of trademark skeptics. Also, the fact that firms in the trademark skeptics cluster are the smallest and youngest firms in the sample (although this difference is not statistically significant) supports this argument.

Cluster 2 (Marketing-focused trademarking SMEs): Firms in this cluster file trademarks exclusively for marketing reasons. Our results show that manufacturing firms are overrepresented among this cluster of marketing-focused trademarking SMEs. Trademarks can be particularly important for firms in manufacturing industries (e.g., Arundel et al., 2007; WIPO, 2016a), mainly because manufacturing firms often produce tangible products, which are more suitable for formal IP protection than intangible products are. However, manufacturing firms are more often able to use patents and trademarks in combination. In such cases, it can be argued that the protection function is fulfilled largely by patents, explaining why firms in this cluster do not value the protection function of trademarks. The results further indicate that firms in this cluster tend to be older and larger than firms in the other three clusters. As mentioned earlier, firms in more mature markets more often face the need to distinguish themselves from their competitors via brands, which might explain why these firms particularly file trademarks for marketing reasons. Adding to this, marketing-focused trademarking SMEs report that B2C markets are less important. This result is consistent with recent research on B2B branding that highlights the important function of brands for reducing the purchasing risk of industrial buyers (Homburg et al., 2010). The need for protection to avoid free riding by other firms is lower in B2B than in B2C markets because B2B relationships are often highly intertwined, more relational, less transactional, and less anonymous than firm-consumer relationships (Cannon and Perreault, 1999). For instance, industrial customers often are very familiar with their suppliers and thus would recognize free riding by a third firm easily. Additionally, B2B buyers are often well-informed customers, which makes imitation by a third party difficult (Edwards et al., 2007). These arguments are particularly true for SMEs active in innovative and technology-intense B2B markets, which often have only few customers (Yli-Renko and Janakiraman, 2008) and thus build strong linkages with their industrial customers.

Firms that received external capital are also overrepresented in this cluster. This could be because many of the firms in this cluster are manufacturing firms. Relative to service firms, manufacturing firms require significantly higher levels of financial investment, for example, in facilities, equipment and/or inventory (Erramilli and Rao, 1993; Brouthers and Brouthers, 2003). Also, firms in the marketing-focused trademarking SMEs cluster are found to be active in R&D intensive industries, where firms must undertake large investments in R&D, which again underscores the high need for external capital by firms in this cluster. While these firms may have used external capital to establish their firms, they do not rely on trademarks to attract such funding. These firms seem to use other signals for this purpose, for example patents or prototypes, as indicated by their overrepresentation in manufacturing industries.

Cluster 3 (Marketing- plus protection-focused trademarking SMEs): This cluster resembles the cluster of marketing-focused trademarking SMEs in many passive cluster variables. Still, some differences can be observed. Firms in this third cluster are smaller and younger (although not statistically significant), more often operate in service industries, and are active in less R&D intensive industries. This, as well as the additional emphasis on protection motives in addition to marketing motives, suggests that these firms could be described as service innovators. As outlined earlier, trademarks are important in the context of service innovation (Gotsch and Hipp, 2012). Particularly for service innovators, trademarks may function as the most important formal IP protection mechanism, thus explaining the higher value of protection motives when compared with the second cluster. As indicated earlier, the marketing function of trademarks enables service firms to overcome the information asymmetries associated with intangible services, hence explaining the high importance of marketing motives in this cluster.

A further difference is that the firms in this cluster place a relatively stronger emphasis on licensing their technology. This tendency can help to explain their strong emphasis on both protection and marketing motives. Licensing technology and sharing knowledge about technology and products requires protection. The risk of imitation and other adverse effects increases if the licensed assets are not sufficiently protected. Trademarks can help to protect relationships with customers and thus reduce the risk of free riding by (former) licensees. Employing trademarks enables SMEs to benefit from licensing while simultaneously protecting their underlying knowledge and marketing assets. This argument holds true especially for resource-scarce SMEs that cannot afford to implement other protection mechanisms, such as expensive legal contracts or patent infringement lawsuits.

Cluster 4 (Trademark advocates): Our cluster comparison indicates that service firms are overrepresented in the cluster of trademark advocates. This underscores the potentially high value of trademarks in innovative service settings and industries, in which trademarks are critical to differentiation and protection strategies. Acknowledging this important role, SMEs in the trademark advocates cluster emphasize marketing and protection motives for filing trademarks. The characteristics of the other passive cluster variables reflect to some degree the strong service orientation of firms in this cluster. For instance, the cluster comparison indicates that SMEs in the trademark advocates cluster consider external cooperation to be important (Tether, 2005; Leiponen, 2005). We observe that SMEs in the trademark advocates cluster rate the acquisition of external knowledge as very important and rely on technology licensing. This is in line with the findings of, for example, Arbussà and Coenders (2007), who show that service firms tend to acquire knowledge from external sources more often than manufacturing firms do; manufacturing firms often rely on internal R&D. Relationships with external partners underscore the need to enhance firms' negotiating positions in exchange relationships. Hence, SMEs in the trademark advocates cluster emphasize exchange motives, in addition to marketing and protection motives, for filing trademark applications. It is surprising, however, that these firms did not receive external capital funding even though they file trademarks for exchange motives. This indicates that these firms use trademarks primarily as signals in the context of licensing, selling, or negotiations, which are also regarded as exchange motives. These firms do not rely as much on external capital funding because they are less capital-intensive, as indicated by their underrepresentation in manufacturing industries. In summary, trademark advocates can be described as innovation-oriented SMEs that are active in knowledge-intensive (service) industries. They pursue an outward-focused firm strategy and engage in exchange relationships with external partners to create and capture the value of their innovations.

6.5 Discussion and conclusion

6.5.1 Summary of main findings and implications for theory and practice

Our study derives three motives for filing trademarks from a sample of 600 SMEs using factor analysis. Next, we conduct a cluster analysis to identify four clusters of SMEs with regard to trademarking motives. Finally, we compare these four clusters using industry-, market- and firm-level variables. The implications for theory and practice are outlined below.

First, we empirically identify three trademarking motives, namely, protection, marketing, and exchange motives. Thus, we extend patent-focused research on firm motives for filing IPRs to trademarking (e.g., Cohen, 2000; Blind, 2006). Our findings indicate that SME decisions to file trademark applications depend on multiple factors rather than on a single factor. Previous research has mainly relied on theoretical considerations and tended to highlight only one main motivating factor of filing trademark applications. Our findings suggest that this approach is too simplistic because these motives are integrated in a hierarchical structure in our sample of trademarking SMEs.

Stimulating usage of IP protection plays an important role in SME innovation policy (Thomä and Bizer, 2013). Our findings can help policy makers understand the motivations of SMEs to file trademark applications. Policy makers will be better able to develop policies that help SMEs strengthen their usage of IP protection and IP strategy. Often, policies addressing SME trademarking focus on simplifying registration or reducing costs. For example, the USPTO stated in a May 2014 press release that it aims to provide trademark protection in the most cost-efficient way possible, especially to “lessen the burden for entrepreneurs to obtain the crucial trademark protection they need to grow their businesses” (USPTO, 2014). Our findings suggest that policies of this kind might not be well suited to all SMEs. Consider, for example, a firm that files trademarks to signal to investors that it cares about marketing and produces valuable products or services. This quality-signaling function of trademarks is undermined if trademarks are increasingly cheap and easy to obtain.

Table 6.5: Comparison of clusters: (a) within-cluster means and (b) across-cluster shares and their differences.

Passive cluster variable	Total sample (mean)	N	Trademark skeptics	Marketing-focused trademarking SMEs	Marketing- plus protection-focused trademarking SMEs	Trademark advocates	Test statistic[a]
(a) Within-cluster results							
Industry characteristics							
Importance of B2B markets	4.14	599	3.98	4.22	4.13	4.15	0.84
Importance of B2C markets	3.46	597	3.61	3.05	3.40	3.96	9.05***
Industry R&D intensity	0.06	421	0.06	0.07	0.06	0.05	3.40**
Industry advertising intensity	0.03	421	0.03	0.03	0.03	0.03	0.52
Firm characteristics							
Importance of product innovation	4.35	597	4.10	4.46	4.31	4.46	2.37*
Importance of process innovation	3.67	599	3.20	3.70	3.61	4.05	7.90***
Number of employees	15.54	413	13.56	19.36	14.23	14.84	0.59
Firm age	3.84	382	3.59	4.20	3.80	3.70	0.58
Importance of external knowledge acquisition	3.95	600	3.63	3.88	3.91	4.31	9.99***
Extent of technology licensing	1.99	600	1.56	1.98	2.03	2.26	5.87***

(Table continued on next page)

Table 6.5: (continued).

Passive cluster variable	Total sample (mean)	N	Trademark skeptics	Marketing-focused trademarking SMEs	Marketing- plus protection-focused trademarking SMEs	Trademark advocates	Test statistic[a]
(b) Across-cluster results							
Firm operates in service industry							
Observed proportion	-	205	19.51%	20.49%	31.71%	28.29%	13.13***
Expected proportion	-	600	15.83%	28.17%	33.00%	23.00 %	
Firm received external capital funding							
Observed proportion	-	166	19.28%	34.94%	28.92%	16.87%	10.37**
Expected proportion	-	600	15.83%	28.17%	33.00%	23.00%	

Notes: [a] = Pearson's chi-square test for categorical variables and analysis of variance F-test for continuous variables. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Reading example within-cluster results: Firms which rate B2C markets as important are more often assigned to the trademark advocates cluster (mean = 3.96). Firms which rate B2C markets as less important are more often assigned to the marketing-focused trademarking SMEs cluster (mean = 3.05). Overall, the mean importance of B2C markets is 3.46. Firms which value B2C markets slightly more important are more often assigned to the trademark skeptics cluster (mean = 3.61), while firms which value it slightly less important are more often assigned to the marketing- plus protection-focused trademarking SMEs cluster (mean = 3.40). Overall, the clusters differ significantly with regard to the importance of B2C markets within each cluster.

Reading example across-cluster results: 19.5% of the service firms in our sample are trademark skeptics; 31.7% are marketing- plus protection-focused SMEs. However, when compared with the expected population of 33.0%, service firms are underrepresented in the marketing- plus protection-focused cluster. Across all clusters, the share of service firms differs significantly.

Second, we perform a cluster analysis to explore the combinations and relationships among trademarking motives in this sample of SMEs. By providing a typology of firms according to their trademarking motives, we extend existing trademark research with a focus on SMEs (e.g., Helmers and Rogers, 2010; Amara et al., 2008; Block et al., 2014a). We distinguish among trademark advocates, marketing-focused trademarking SMEs, marketing- plus protection-focused trademarking SMEs, and trademark skeptics. We observe a hierarchical structure across the four clusters with regard to trademarking motives. For example, trademark advocates value all motives highly, while marketing-focused trademarking SMEs prioritize marketing motives and do not file trademark applications for exchange or protection. The results of our cluster analysis thus provide a holistic view of the combinations of motives that trigger SME trademarking. Heterogeneity in trademarking motives is evident even though we analyze firms facing similar environmental conditions, i.e., firms in a limited set of industries, in one country, of a certain size.

Knowledge of these trademarking clusters can improve the understanding of policy makers how trademark motives interact, allowing trademarking policies to be better aligned with cluster-specific needs. For example, improving the protection offered by a trademark will not lead marketing-focused trademarking SMEs to file more or broader trademarks. Additionally, some trademarking SMEs have negative opinions or passive approaches towards trademarking. These SMEs are an interesting target group for policy makers because they engage in trademark filings but may not understand or fully utilize their trademarks. SME IP policy could address this shortcoming and provide instruction on employing trademarks to protect marketing assets and appropriate innovation rents.

The cluster analysis indicates that exchange motives are not a singular and overly important motive for SME trademark applications. This motive is only important for trademark advocates who also file applications for marketing and protection reasons. This finding conflicts with research on patents, in which exchange is an important motivator of patent applications (De Rassenfosse, 2012; Veer and Jell, 2012). However, often exchange motives are also not an autonomous motive to file patent applications. While SMEs may not consider their trademarks as quality signals to potential investors, research indicates that investors actually do pay attention to trademarks, especially during the early phases of the firm life cycle (Block et al, 2014a). Thus, SMEs may emphasize on their trademarks when negotiating with external investors.

Third, we use industry- and firm-level variables to profile each cluster. We extend trademark research by providing an initial assessment of how these variables differ among clusters and how they relate to trademarking motives. For example, we note considerable differences with regard to whether firms operate in service industries or rely on innovation, external knowledge, or financial capital. Although we are not able to analyze the causal effects of these profiling variables on trademarking motives, our results indicate considerable heterogeneity among the identified clusters. For example, trademark advocates tend to be SMEs active in knowledge intensive service industries, while marketing-focused trademarking occurs more often in R&D-intensive manufacturing industries with B2B customer relationships. These findings will inform future research about which trademarking motives matter by industry or firm context. Policy makers can use these cluster-specific industry and firm characteristics to develop industry-level IP policies.

6.5.2 Limitations and future research

The limitations of this study suggest fruitful avenues for future research. Our study employs survey data, which can lead to a common method bias. To mitigate this bias, we draw upon secondary data from Compustat and CrunchBase. Supplementing survey data regarding trademarking motives with secondary data is a promising area for further research. For example, future research could combine survey data on trademarking motives with performance data (e.g., sales growth, profitability, or innovation output) to enable an investigation of important performance-related questions, such as the link between trademarking motives and firm performance and how internal and external contingencies moderate this relationship. In addition to performance variables, we were unable to include firm-level R&D expenditures or innovation strategies.

We explore the role of trademarks independent of alternative IP protection mechanisms, such as patents and secrecy, which often either complement or displace trademarking (e.g., Amara et al., 2008; Thomä and Bizer, 2013). Although trademarks are a viable IP protection mechanism for SMEs, previous research has demonstrated that informal protection mechanisms, especially lead time advantages and secrecy, are more important to SMEs than formal protection mechanisms are (Thomä and Bizer, 2013). Thus, future research could investigate the interplay among different IP protection mechanisms, trademarking motives, and types of trademarks. For example, trademark advocates might be affected by positive experiences with other formal protection methods, such as patents. Firms in this cluster might have an overall positive opinion toward formal IP protection mechanisms that is not determined by trademarking alone; that is, they are formal IP advocates rather than simply trademark advocates. Similarly, Thomä and Bizer (2013) note that trademarks can be effectively combined with patents to establish technology brands that help firms to protect and leverage their technological assets. An analogous argument exists for trademark skeptics. Firms in this cluster might not be skeptical about trademarks in particular but skeptical with regard to formal IP protection mechanisms in general.

Future research could validate or modify the identified set of motives for large, established firms. Both large and small firms are important parts of a national economy and innovation system. Prior research on patenting motives has demonstrated differences in motives between small and large firms. Reputation and exchange motives have been found to be relatively more important to small firms than to large firms (e.g., Blind et al., 2006; De Rassenfosse, 2012; Veer and Jell, 2012); we expect a similar pattern to hold for trademarking motives. Following De Rassenfosse (2012), we expect exchange motives for trademarking to be more important for small firms than for large firms. In contrast to large firms, small firms face resource constraints and can use trademarks to attract outside (financial) resources. In addition to validating the identified motives in other samples, future research could further validate our cluster distinction and profiling. For example, our results indicate that innovation plays a different role for trademark skeptics who – despite being active in innovative industries – do not use trademarks for any of the reasons that we identified. Future research could try to gain a better understanding of the differences between the identified clusters. Also, our approach used to distinguish the identified clusters is descriptive. As this study is of an exploratory nature, we are not able to validate causalities, which limits the implications of our study. Future research could build upon this and try to validate our findings using methods that allow for greater causal inferences.

Finally, we observe a hierarchical structure in trademarking motives. Future research could try to identify whether there is a connection between this particular structure of trademarking motives and the development of a firm along its life cycle. For example, protection motives might become more relevant for firms with developed products and a larger, more diversified product portfolio. For protection motives to be highly relevant, firms must first establish products or services that are worth protecting.

Chapter 7

Conclusion

This final chapter (Chapter 7) provides a conclusion to the thesis. In Section 7.1, the main results of the previous chapters are outlined with regard to the research questions presented in Chapter 1, section 1.2. Section 7.2 discusses the main findings of this thesis. Implications for both theory and practice are outlined in Section 7.3. This thesis concludes with a brief description of limitations and an outline for future research.

7.1 Findings per chapter

This section provides a brief overview of the main findings of this thesis. The research questions addressed in the individual chapters are again displayed in Figure 7.1.

Table 7.1: Research questions addressed in this thesis.

#	Research question	Answered in
RQ 2.1	*How do universities worldwide compare with regard to their patenting output?*	Chapter 2
RQ 2.2	*How do university characteristics (e.g., location, size, publication record) affect a university's patent output?*	Chapter 2
RQ 3.1	*How did Chinese university patenting develop in terms of patent quantity and quality over the past 20 years?*	Chapter 3
RQ 3.2	*What are the effects of two types of governmental subsidy programs on Chinese universities' patent quantity and quality?*	Chapter 3
RQ 4	*How does the value of Chinese patents compare to the value of international patents?*	Chapter 4
RQ 5.1	*To what extent can Chinese firms increase their patent output following an acquisition?*	Chapter 5
RQ 5.2	*Which acquisition-specific factors influence the post-acquisition patent output?*	Chapter 5
RQ 6	*Why do SMEs file trademarks?*	Chapter 6

7.1.1 University patenting: A comparison of 300 leading universities worldwide (Chapter 2)

Chapter 2 examines whether and how university characteristics affect a university's patent output using a sample of 316,393 patents filed between 2001 and 2011 by 300 leading universities worldwide. With regard to **RQ 2.1**, Chapter 2 provides a comparative overview of the universities' patent applications: While the ranking shows a huge predominance of US universities when investigating PCT applications (which provide a greater international comparability), Chinese universities take the top spots when only considering the total number of patent applications.

With regard to **RQ 2.2** the results reveal that patent applications by US and Asian (especially Chinese) universities increased strongly, while European universities lagged behind. Additionally, universities across all regions applied for significantly more patents in their home country, indicating a "home advantage effect". Regarding other university specific characteristics, the results show that university's with a technological focus in the areas of chemistry, electrical engineering, and mechanical engineering file more patent applications. However, the size of a university (measured by number of R&D staff) as well as the quality of its scientific publications do not significantly influence the number of patent applications.

7.1.2 Chinese university patents: Quantity, quality, and the role of subsidy programs (Chapter 3)

As shown in Chapter 2, university patenting in China has gained tremendous momentum. In order to increase university patenting, the Chinese government has issued various initiatives in recent years. Chapter 3 focuses on two particular types of subsidy programs: First, China introduced cost-reimbursement subsidy programs at the regional level, which enables patent applicants to receive a (partial) reimbursement of the costs of the patent application. Second, the Chinese government introduced a large subsidy program to promote research excellence at selected leading Chinese universities and establish world-class universities ("Project 985").

Chapter 3 uses a panel dataset of 155 leading universities from 1991 to 2009 that includes 121,184 patent families and is extended by regional data on Chinese provinces. With regard to **RQ 3.1**, the results of Chapter 3 reveal a strong increase in patent applications (patent quantity). However, when investigating the accompanying development of patent quality, the results indicate that the development of patent quality lags behind the increase in patent quantity. With regard to **RQ 3.2**, the results show that both subsidy programs contributed significantly to this increase in patent quantity. Furthermore, the research excellence subsidy increases patent quality, while the cost reimbursement subsidy does not affect patent quality.

7.1.3 The value of Chinese patents: An empirical investigation of citation lags (Chapter 4)

Using a dataset of 60,000 patent families, Chapter 4 deals with the economic value of Chinese patents in a more detailed way. Chapter 4 analyzes the hazard ratio of a patent receiving forward citations using survival time analysis. Addressing **RQ 4**, the results show that the citation lag is largest for Chinese patents, especially when compared to US and European patents, indicating an overall lower patent value. This is particularly true for patents filed domestically (i.e., Chinese applicants that file a patent in China).

However, by analyzing further patent characteristics, the findings show that the longer citation lag is considerably shortened by a higher number of patent references. This is particularly true for Chinese patents, where the moderation effect is the most pronounced. More patent claims also shorten the citation lag. Again, the highest positive moderation is achieved with patents by Chinese applicants. Finally, the results also show that patents applied for more recently have a higher patent value, indicating a recent and positive development in China.

7.1.4 The impact of acquisitions on Chinese acquirers' patent output (Chapter 5)

To assess whether Chinese firms profit from acquisitions in terms of their innovation performance and the acquisition-specific factors that influence the outcome, Chapter 5 uses a sample that contains publicly listed Chinese firms in the manufacturing sector. The sample combines financial data, patent data, and data on acquisitions from the period 2000 until 2013. Drawing on an absorptive capacity framework, the results show that, overall, acquisitions do not have a statistically significant effect on the acquirers' patent output (**RQ 5.1**).

Investigating deal-specific factors (**RQ 5.2**), the results show that a higher absolute size of the acquired knowledge base has a positive effect that decreases at higher levels. The results show a similar effect with regard to the technological relatedness of the acquirer knowledge base. A larger relative size of the acquired knowledge base decreases the post-acquisition patent output. Additionally, the results show that cross-border deals positively influence the post-acquisition outcome, while state-owned enterprises are not able to benefit from acquisition in a way that private enterprises do, for example, because they are more inflexible and not as prone to learning.

7.1.5 Why do SMEs file trademarks? Insights from firms in innovative industries (Chapter 6)

While the previous chapters deal with patenting in China, Chapter 6 explores the question of why SMEs file trademarks (**RQ 6**). To provide a systematic investigation of SMEs' trademarking motives, an empirical analysis, comprising three steps, using data from 600 SMEs in innovative industries was conducted.

First, Chapter 6 draws on the extensive literature on patenting motives (e.g., Cohen et al., 2000; Blind et al., 2006) and develops a set of potential trademarking motives. Three trademarking motives are identified and empirically validated using factor analysis: protection, marketing, and exchange. Second, these trademarking motives are used as active cluster variables in a cluster analysis to explore the empirical variation in the sample firms. The cluster analysis reveals four different clusters that follow a hierarchical structure with regard to the trademarking motives: Trademark skeptics file trademarks without a specific motive, marketing-focused trademarking SMEs primarily file trademarks for marketing motives, while marketing- plus protection-focused trademarking SMEs pursue marketing and protection motives. Finally, trademark advocates find all three motives important. Third, the identified clusters are compared with regard to passive cluster variables in order to provide a more detailed and nuanced description of the companies within these clusters (e.g., with regard to market, industry, and firm characteristics).

7.2 Discussion of the main findings of the thesis

The first research topic addressed in this thesis refers to the antecedents of patenting in China as well as the value of the patents. This thesis finds that an increase in patenting in China is partly due to increases in university patenting, which in turn is fostered by two subsidy programs. Also, the results show that Chinese companies profit from acquisitions by increasing their innovation performance under certain conditions, thereby contributing to the overall increase in patenting. For example, Chinese firms successfully draw on the often more developed knowledge in foreign countries and use cross-border acquisitions to catch-up to developed countries in terms of innovation (Anderson et al., 2015; Morck et al., 2008). While the increase in patent applications in China is remarkable, several findings in this thesis also indicate that patent quality and patent value did not rise to a similar degree.

As outlined in Chapters 2 and 3, university patenting is an important source of technology transfer that can positively influence a nation's innovative capacity (Etzkowitz and Leydesdorff, 2000; Mowery and Sampat, 2005b). Chapter 2 finds that this is particularly true for China when compared to other countries. While this quantitative increase in patenting is fostered by several governmental initiatives (i.e., cost-reimbursement subsidy programs and research excellence subsidy), these initiatives partially fail to increase patent quality (Chapter 3). However, the development of patent applications of high-quality is important to realize a meaningful and sustainable increase in a nation's innovative capacity, and to ultimately become a leading innovative nation, which is one of China's main goals (Hu and Mathews, 2008; Liang, 2012).

This finding is directly related to the findings of Chapter 4, which show that the value of patents filed by Chinese applicants is, overall, lower than that of patents from the US, Europe, Japan, or Korea. The rather quantitative orientation of China in terms of patents is reflected in several ways. For example, Huang and Wu (2012) describe a general interest in China in receiving a patent, not necessarily its quality or usage. Providing another quantitative incentive, the cost-reimbursement subsidy assessed in Chapter 3 subsidizes patent applications and disregards whether the patent is eventually granted or upheld (Li, 2012). Additionally, Shapira and Wang (2009) describe that researchers at universities have clear incentives to engage in patenting: Similar to peer-reviewed scientific publications, patent applications can be relevant for their scholarly careers, for example, as part of the criteria for a tenure track position. This intention of China to produce measurable outcomes in terms of innovation is also reflected at the national level: As part of the "National Patent Development Strategy", China states that its primary interest in terms of patents is to increase patent applications multiple times by 2020. An increase in patent quality is only mentioned vaguely. Taken together, these findings indicate that even though China is trying to become a leading innovative nation, it has not yet reached its goal.

Even though China has a strong interest in producing measurable outputs, this thesis also finds some evidence that patent quality and patent value in China are increasing, albeit more slowly than patent quantity. First, Chapter 3 shows that the research excellence subsidy ("Project 985"), which was issued by the government in 1998 and aims to strengthen the overall research performance of selected leading universities, led to significant increases in both patent quantity and patent quality. In contrast to the cost reimbursement subsidies, this indicates that general investments in universities seem to be useful in fostering innovation more comprehensively. Second, Chapter 4 shows that the value of Chinese patents is increasing in recent years. While the value is still lower overall, this suggests that there is some dynamic underway in China that indicates China is also catching-up in terms of the value of its patents. This is a necessary condition for China to meet its goal of reaching the world's innovation frontier and becoming one of the leading nations in terms of innovation.

The second research topic of this thesis refers to trademarking motives. Chapter 6 shows that SMEs file trademarks for protection, marketing, and exchange motives. The findings indicate that there is considerable variation among trademarking firms. In addition to revealing the three trademarking motives, the results of our cluster analysis show that trademarking firms often combine these motives when filing trademarks instead of relying on a single factor. This is an important finding, because previous research on trademarking has often only focused on the classic protection or marketing function of trademarks (e.g., Srinivasan et al., 2008; Fosfuri and Giarratana, 2009; De Vries et al., in press), which other studies have also highlighted as the main motive to file IPRs (e.g., Amara et al., 2008; Heimonen, 2012; Thomä and Bizer, 2013). While the results of Chapter 6 also underline the importance of the protection function for trademarking in general, they further show that the protection motive is not the sole motive, nor is it always the most important motive for filing trademarks. Thus, reducing trademarks to the protection function is an approach that is too simplistic and underestimates the variety of reasons for why firms file trademarks. This finding is of particular interest for policy makers and has important implications that are discussed in the following section.

7.3 Implications for theory and practice

7.3.1 Implications for theory

The main contribution of this thesis with regard to patenting in China can be divided into three subcategories.

University patenting (Chapters 2 and 3): The findings contribute to the literature on patenting in China in multiple ways. While universities are acknowledged to be an important part of China's innovation system (e.g., Li, 2012), previous literature on university patenting has been focused on the US and Europe (e.g., Henderson et al., 1998; Sampat et al., 2003;

Geuna and Rossi, 2011). By taking an international perspective (Chapter 2) and focusing on China in particular (Chapter 3), the findings extend previous research and provide new and interesting insights on university patenting as a whole. Specifically, previous literature on university patenting has often focused on the impact of regulatory changes or other forms of governmental initiatives in trying to stimulate university patenting (e.g., Henderson et al., 1998; Mowery et al., 2002; Geuna and Nesta, 2006; Geuna and Rossi, 2011). This thesis adds to the literature by analyzing and comparing the effects of two different types of subsidy programs introduced in China on universities' patent quantity and quality. Chapters 2 and 3 also underline the importance of university patenting for the overall increase in patenting by providing a detailed account of the patenting performance of Chinese universities, for example in comparison with universities from other countries.

Patent value (Chapters 3 and 4): The impressive increase in patent quantity might hide the fact that the catch-up of China in terms of innovation is rather superficial. Thus, this thesis contributes to the literature on patenting in China by providing an initial assessment of the patent quality of Chinese university patents (Chapter 3) as well as by analyzing the value of Chinese patents in general and in comparison to other international patents (Chapter 4). By providing empirical evidence for an increasing divergence between patent quantity and quality (Chapter 3) as well as an overall lower patent value (Chapter 4), the results question the meaningfulness and substantiality of the increase in patenting in China, but also indicate that patent value is increasing in recent years.

Acquisitions (Chapter 5): Access to technology and knowledge is often named as an important motivation for Chinese companies that engage in acquisitions (e.g., Deng, 2004; Morck et al., 2008; Buckley et al., 2014). This thesis shows under which circumstances Chinese acquirers' are able to profit from acquisitions in terms of innovation performance. Previous research has relied on samples from developed countries (e.g., Ahuja and Katila, 2001; Cloodt et al., 2006; Desyllas and Hughes, 2010), and it is unclear whether the post-acquisition effects in China are similar. This thesis contributes to this line of research by introducing the unique context of China, for which the applicability of results from other contexts has previously been questioned (e.g., Murray et al., 2005; Zhao et al., 2011; Barkema et al., 2015). The results show that certain previous findings do apply to the Chinese context, but further show that characteristics which are unique to the Chinese environment, such as state ownership, also shape acquisition outcomes.

With regard to **SMEs' trademarking motives (Chapter 6)**, this thesis makes several important contributions to trademark research. First, previous research on the motives to file IPRs has been focused on patents (e.g., Cohen et al. 2000; Blind et al., 2006; De Rassenfosse, 2012). However, trademarks play a very important role for the appropriation of innovation rents, particularly when considering SMEs in innovative industries (e.g., Helmers and Rogers, 2010; Flikkema et al., 2014). Chapter 6 provides the first comparable, empirically validated set of motives to file trademarks. The results enrich previous research and add a new layer of discussion to the existing trademark literature, which has often analyzed trademarks as a determinant of different firm characteristics (e.g., Srinivasan et al., 2008; Krasnikov et al., 2009; Sandner and Block, 2011). In addition, the results contribute to previous literature on trademarks by further exploring clusters of firms according to their trademarking motives. As such, four different clusters are identified (i.e., trademark skeptics, marketing-focused trademarking SMEs, marketing- plus protection-focused trademarking SMEs, and trademark advocates) and analyzed further with regard to firm and industry characteristics to better distinguish these companies. The results contribute to previous research on trademarks and IPRs in general by showing the uniqueness and variability of SMEs with regard to their usage of IPRs (e.g., De Jong and Marsili, 2006; Thomä, 2009; De Rassenfosse, 2012; Thomä and Bizer, 2013).

7.3.2 Implications for practice

This thesis's findings have several implications for practitioners and policy makers. First, stimulating university technology transfer and thus university patenting has been one of the main goals for policy makers in recent years (Henderson et al., 1998; Siegel et al., 2003b; Geuna and Rossi, 2011). As such, various regulations to facilitate technology transfer and increase university patenting have been implemented worldwide. Prominent examples include the US (Mowery and Sampat, 2005a), France (Malva et al., 2013), Germany (Czarnitzki et al., 2011) and Italy (Baldini et al., 2006). Previous research in this domain has largely analyzed the effects of these regulations and has provided important information on how policy makers can stimulate university patenting. However, the overall effect of these policies is not always straightforward across countries and with regard to its effects on patent quantity and quality (e.g., Henderson et al., 1998; Sampat et al., 2003). By investigating two different types of subsidy programs in China, this thesis provides policy makers with information on the effects of different types of subsidies. The results indicate that policies intended to increase innovation in a whole and sustainable way (i.e. increasing innovation quantity and quality), should take the form of general investments into universities. In contrast to subsidizing application fees, which only stimulate patent quantity, these general investments to promote research excellence can play an important role in developing a functional national innovation system in which universities play a more pronounced role. Hence, innovation policies that also intend to stimulate patent value and quality should concentrate on increasing university R&D instead of cutting the cost of patenting. This finding is of particular relevance to Chinese policy makers, as China might still be interested in further increasing patenting by stimulating university patenting.

In addition, previous research indicates that these initiatives cannot be adapted in the same way to different countries, and university IPR regulations remain extremely differentiated worldwide (e.g., Geuna and Rossi, 2011). However, previous research has also indicated that considerable differences exist between universities within the same country. This heterogeneity is likely to be at least partially reflected in their technology transfer activities and is thus likely to influence university patenting (Hewitt-Dundas, 2012). Policy makers should take this heterogeneity into account. For example, the results of Chapter 2 suggest that a university's characteristics, such as whether the university is a technical university or whether it specializes in the area of chemistry (for example), play an important role for a universities' patent output. Policy makers aiming to stimulate university patenting should thus take these university specific characteristics into account when developing initiatives, as they are unlikely to affect universities within a country in a uniform way. For example, policy makers might be interested in further stimulating patenting by technical universities, which are typically already stronger in this regard, or might choose to promote initiatives at non-technological universities to help them catch up in terms of technology transfer.

Second, this thesis provides practitioners and policy makers with a better understanding of the economic value of Chinese innovations, which is a crucial characteristic when evaluating the sustainability and meaningfulness of innovations from China (e.g., Li, 2012). The finding that more recently filed Chinese patents are of higher value (Chapter 4) shows that China is likely to further catch-up to developed countries in terms of innovation. This development can be seen as an indication that China is slowly but successfully undergoing a transformation from an imitation- to an innovation-based economy. This finding informs practitioners that Chinese patents may become more meaningful in the near future and can be attractive investment opportunities for firms interested in acquiring or sustaining a very large, high-value patent portfolio. An overall higher patent value can also serve as a signal function for actors who plan to invest in Chinese companies. Furthermore, the results are of particular interest for policy makers in the US and Europe, as they show that engagement is needed in order to remain in the lead in terms of innovation, as China is not only catching-up and surpassing them in terms of quantity, but maybe also do so in terms of quality in the future.

Third, access to technology is one of the primary motives of acquisitions by Chinese companies (e.g., Deng, 2004; Morck et al., 2008). Moreover, these acquisitions are frequently negatively portrayed in the media: Chinese acquisitions, particularly those where the target is located in a developed country, are often associated with the fear of knowledge drains, and focus on a potential negative effect for the acquired companies (e.g., "Being eaten by the dragon" (Economist, 2010a), "China buys up the world" (Economist, 2010b)). While Chapter 5 cannot address this question fully because it does not observe knowledge drains in the acquired companies in detail, previous research has assumed that emerging market firms may not profit from acquisitions because they lack the absorptive capacity to successfully exploit acquired knowledge (Narula, 2012; Anderson et al., 2015). However, the results show that Chinese companies are able to profit from acquisition by increasing their own post-acquisition innovation performance under certain circumstances. This contradicts the public image of Chinese firms only acquiring firms to drain their knowledge. More importantly, Chapter 5 also shows that the phenomenon of Chinese acquisitions is not as large as its portrayal often suggests: Only 5 percent of the acquisitions were cross-border acquisitions (78 of 1,545), indicating that Western companies' fears might be exaggerated. Managers in Asian countries might find the results interesting because they provide information about important deal characteristics that facilitate learning from acquisitions. Policy makers in China and western countries might find the results interesting because they indicate that acquisitions can be a profitable catch-up strategy with regard to innovation performance.

Fourth, because stimulating IPR usage by small firms is of particular interest for innovation policies (Thomä and Bizer, 2013), this thesis' findings on SMEs' trademarking motives have important practical implications. Often, policy makers try to reduce the costs of IPR protection and provide a cost-effective protection to small firms (USPTO, 2014). However, while the costs of IPRs might be important to some firms (e.g., trademark skeptics), other firms (e.g., trademark advocates) would likely not find these initiatives very appealing. For example, the efforts of a firm that is using trademarks as an asset in exchange relationships to acquire financing would be undermined if trademarks become increasingly cheap and easy to obtain. Furthermore, policies aimed at improving the protection offered by a trademark will not lead marketing-focused trademarking SMEs to file more trademarks. Rather, policy makers could use the findings to provide the heterogeneous group of small firms interested in trademarking with more nuanced initiatives that better motivate them to increasingly engage in trademarking. The findings from Chapter 6 suggest that policies of this kind might not appeal to all SMEs in the same way.

7.4 Limitations and avenues for future research

This thesis is not without limitations. First, patents are the mostly frequently used measure for innovation (outputs). This is because patents have multiple advantages. For example, patents are only granted for the development of a new technology that is commercially useful and thus of economic significance (e.g., Ahuja and Katila, 2001; Alcaide-Marzal and Tortajada-Esparza, 2007; Godinho and Ferreira, 2012). Also, patents provide a lot of additional information that is frequently used in innovation research (e.g., patent citations, patent claims, family size) and patent data are fairly accessible and easy to use compared with other innovation indicators (e.g., survey-based measures) (Alcaide-Marzal and Tortajada-Esparza, 2007). In spite of its widespread usage, the reliance upon patents as a proxy for innovation is not without limitations: Not all inventions are patentable, not all inventions are patented, and patented inventions differ greatly with respect to the technological progress they entail, especially with respect to the industry sector or company size (e.g., Levin et al., 1987; Pavitt, 1988; Griliches, 1990; Trajtenberg, 1990). This limitation applies to Chapters 2 through 5, which use patent data as a proxy for innovative outputs.

Second, Chapters 3 and 4 use forward citations to measure patent quality and patent value (i.e., the citation lag used in Chapter 4 is calculated based on the first forward citation a patent receives). Even though patent citations are the most frequently used proxy of patent quality and value (e.g., Harhoff et al., 2003; Acosta et al., 2012), citation-based measures have several caveats. For example, citations can be added by the inventors themselves or by the patent examiner (e.g., Criscuolo and Verspagen, 2008; Azagra-Caro et al., 2011; Alcácer et al., 2009). Also, forward citations involve the problem of right truncation. To ensure a better comparability, forward citations are usually collected within five years of the patent application or grant (e.g., Mowery and Ziedonis, 2002). This most notably leads to a data loss in recent years (Chapter 3). While Chapter 4 uses the measure of the citation lag to circumvent this limitation, information on very recent years is still lost. This is particularly unfortunate because the most recent years provide a lot of new information on the very recent development of patent quality.

Third, patent information on the respective applicants (e.g., universities, companies) is extracted on the basis of their name. Specifically, search patterns are manually generated that search the PASTAT database, which is currently the most comprehensive international database on patents, especially with respect to China (Liegsalz and Wagner, 2013). These search patterns are refined in multiple iterations and account for different spellings of the entities name or name changes. Even though this approach yields valid results (see Chapter 3), only patents that explicitly name the respective university or company as an applicant could be identified. This approach excludes patents that are owned by a university or a company but list an individual (e.g., employee, professor) as the inventor. Additionally, this does not include patents that were applied for in joint research collaborations, joint ventures, or in spin-offs. As a consequence, the estimates for each entity's patent portfolio should be interpreted as a rather conservative estimate that could be extended if more information was available.

In spite of these limitations, this thesis also opens a number of avenues for future research. First, the upsurge in Chinese patenting is a very recent phenomenon that is still ongoing. Because the Chinese patenting surge has not ceased, it will be interesting to continue the analysis of this development. While this thesis investigates the contribution of two previously unexplored antecedents, universities and acquisitions, this development is still far from completely explored. For example, little is known on the role of public research institutes with respect to the overall increase in patenting. Historically, these research institutes have played an important role in the Chinese innovation system. It would be very interesting to conduct a similar analysis to Chapter 3 on these research institutes. Similar to Chapter 5, future research might also look at other mechanisms of knowledge acquisition, such as strategic alliances or joint ventures, which might serve as vehicles for firms to considerably increase their innovation performance.

Second, this thesis finds some evidence of slowly increasing patent quality. Because China is still actively trying to become a leading innovative nation, it would be very interesting to assess patent quality from very recent years. However, due to the limitations of citation data, this requires additional data that is not currently available. Future research might take the findings of this thesis as a starting point to provide a more far-reaching analysis of the development of patent quality or patent value. Additionally, using citation-based data to assess patent value and quality has limitations (as outlined in Chapter 3 and 4). Therefore, future research could conduct a more thorough investigation of patent value and consider other potentially interesting determinants, such as patent claims (Tong and Frame, 1994) or patent renewal data (Lanjouw et al. 1998; Bessen 2008). Chapter 4 indicates considerable differences between different kinds of applicants in China. Because of their commercial impact, it might be particularly interesting to investigate the patent quality and patent value of patents applied for by Chinese companies.

An important limitation of Chapter 6 is that the role of trademarks is studied in isolation from other protection mechanisms. Previous research has shown that other formal (e.g., patents) or informal protection mechanisms (e.g., secrecy, lead time advantages) are often used in conjunction with trademarks or are used to replace trademarks (e.g., Amara et al., 2008; Thomä and Bizer, 2013). With particular regard to SMEs, they more often draw on informal protection mechanisms to protect their IP assets (Thomä and Bizer, 2013). In light of this limitation, future research could focus on investigating the interplay of these protection mechanisms with regard to the motivation for filing IPRs. For example, trademark skeptics might prefer other informal protection mechanisms and thus only file trademarks to complement these mechanisms. In particular, they might not be skeptical towards trademarks, but skeptical towards formal IPRs in general. In contrast, trademark advocates might be affected positively by a prior successful usage of formal protection mechanisms.

A second limitation concerns the focus of Chapter 6 on small firms in innovative industries. While this group of firms is particularly interesting with regard to their IP usage, the generalizability of the results to the population of all firms is questionable. Previous research on patenting motives has indeed identified differences between the patenting motives of small and large firms (e.g., Blind et al., 2006; De Rassenfosse, 2012; Veer and Jell, 2012). Particularly large firms might have additional motives for filing IPRs or weigh these motives differently. Therefore, future research could try to validate or extend the identified set of motives for large, established firms. Also, trademarking motives might differ across industries. While the sample covers a lot of industries, classical “non-innovative” industries are missing from the sample. Thus, future research might find it interesting to apply the findings of this thesis to more traditional industries.

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Summary in Dutch (Samenvatting)

Intellectuele eigendomsrechten (engl. *intellectual property rights, of IPR's*) spelen een zeer belangrijke rol bij innovaties. Ze dienen als mechanisme om het intellectuele eigendom van vernieuwers (bijvoorbeeld particulieren, bedrijven, universiteiten) te beschermen, en zorgen ervoor dat de houder van een IPR van de innovatie profiteert. De twee belangrijkste en meest gebruikte IPR's zijn patenten en handelsmerken (engl. *trademarks*). Dit proefschrift bevat vijf empirische studies die ingaan op ontbrekende elementen in het recente onderzoek naar octrooien en handelsmerken.

Wat patenten betreft richt dit proefschrift zich op patentaanvragen in China. Hier heeft zich recentelijk een opmerkelijke en explosieve groei voorgedaan: nog maar 15 jaar geleden vroegen Chinezen slechts 1,9% van het aantal patenten in 2014 aan. De belangrijkste oorzaak van toename is China's streven om zich te ontwikkelen van een economie gebaseerd op imitaties, tot een economie gebaseerd op innovaties. Hoewel China zich nadrukkelijk en actief inzet om innovaties aan te moedigen en op dit gebied toonaangevend te worden, is het wereldwijd gezien nog verre van een innovatiekoploper. In het licht van dit groeiende en nog relatief weinig onderzochte fenomeen, behandelt dit proefschrift een aantal belangrijke aspecten rondom de achtergrond en de waarde van patenten in China. Hoewel kennis over deze aspecten van cruciaal belang is, is hier tot dusverre weinig aandacht aan besteed. Dit proefschrift gaat in het bijzonder in op de volgende specifieke onderwerpen: het verkrijgen van patenten door universiteiten, de impact van acquisities op innovatieresultaten, en de waarde van patenten in China.

De resultaten laten zien dat het hogere aantal patentaanvragen door Chinese universiteiten, aangemoedigd door twee subsidieprogramma's, een belangrijke drijver is van de meer algemene toename van het aantal patenten in China (hoofdstukken 2 en 3). Ook laat dit proefschrift zien dat Chinese bedrijven profiteren van acquisities waarmee ze na de overname

onder bepaalde omstandigheden hun innovatieresultaten verbeteren, wat weer zorgt voor een hoger aantal patenten (hoofdstuk 5). Zo maken Chinese bedrijven met succes gebruik van de vaak meer ontwikkelde kennis in het buitenland, en nemen ze bedrijven in het buitenland over om op patentgebied de achterstand op ontwikkelde landen in te halen. Hoewel China een opmerkelijke toename van het aantal patentaanvragen heeft doorgemaakt, laten verschillende resultaten in dit proefschrift tegelijkertijd zien dat de kwaliteit van deze patenten niet evenredig is toegenomen (hoofdstuk 3), en dat de waarde van een Chinees patent over het algemeen lager is dan die van patenten in andere landen (hoofdstuk 4). Als China een koploperrol wil spelen op het gebied van innovatie zijn patentaanvragen van hoge kwaliteit en waarde echter wel belangrijk bij het zinvol en duurzaam verbeteren van het innovatievermogen.

Vergeleken met het onderzoek naar patent, waarbij het merendeel van de basale vragen al grondig is onderzocht en er vraag is naar een genuanceerder perspectief (bijvoorbeeld door zich te richten op het proces rondom octrooien in China), staat het onderzoek naar handelsmerken nog relatief in de kinderschoenen. Handelsmerken zijn voor bedrijven zeer belangrijke IPR's om zich van de concurrentie te kunnen onderscheiden, en worden op positieve wijze geassocieerd met de marktwaardering, overlevingskansen, en productiviteit van een onderneming. Er is echter maar weinig bekend over de redenen waarom bedrijven handelsmerken vast laten leggen. Het laatste onderzoek in dit proefschrift (hoofdstuk 6) richt zich daarom op deze redenen.

Een beter begrip van de redenen voor het vastleggen van handelsmerken is erg belangrijk om de zinvolheid en het belang van handelsmerken goed te kunnen begrijpen. Dit proefschrift analyseert daarom de redenen van bedrijven om handelsmerken vast te leggen, en maakt daarbij gebruik van gegevens van kleine en middelgrote bedrijven (MKB) in innovatieve branches. Door middel van deze analyse worden er drie redenen voor het vastleggen van handelsmerken geïdentificeerd en op empirische wijze gevalideerd: bescherming, marketing en uitwisseling. Dit proefschrift maakt ook duidelijk dat bedrijven op basis van hun redenen voor het vastleggen van handelsmerken kunnen worden ingedeeld in vier groepen (te weten: bedrijven die sceptisch staan tegenover handelsmerken, MKB-bedrijven die handelsmerken vastleggen voor marketingdoeleinden, MKB-bedrijven die handelsmerken vastleggen met het oog op marketing en bescherming, en voorstanders van handelsmerken). Deze resultaten, waaruit de unieke en onderscheiden wijze blijkt waarop MKB-bedrijven omgaan met hun IPR's, verrijken eerdere bevindingen, en dragen bij aan nieuwe discussies over handelsmerken. De implicaties van deze vondsten zijn belangrijk, aangezien innovatiebeleid zich vooral richt op het stimuleren van het gebruik van IPR's door kleine bedrijven. Met deze kennis kunnen beleidsmakers beleid ontwikkelen dat beter aansluit bij de heterogene groep MKB-bedrijven, en deze bedrijven doelgerichter motiveren meer werk te maken van handelsmerken.

Summary in German (Zusammenfassung)

Rechte an geistigem Eigentum (engl. *intellectual property rights, IPRs*) spielen eine große Rolle für Innovationen. Sie stellen einen Mechanismus dar, mit dem Innovatoren (z. B. Individuen, Unternehmen, Universitäten) ihr geistiges Eigentum schützen können. Gleichzeitig ermöglichen sie es dem Rechteinhaber von der Innovation zu profitieren. Patente und Markenrechte (engl. *trademarks*) sind die beiden wichtigsten und am meisten genutzten Rechte an geistigem Eigentum. Die vorliegende Dissertation besteht aus fünf empirischen Studien, die aktuelle Forschungslücken rund um Patente und Markenrechte adressieren.

Bezogen auf Patente beschäftigt sich diese Dissertation spezifischer mit Patenten in China. In den letzten Jahren kam es in China zu einem bemerkenswerten und explosionsartigen Wachstum bei Patentanmeldungen: Vor 15 Jahren haben chinesische Entitäten nur 1,9% der Patente angemeldet, die sie im Jahr 2014 angemeldet haben. Hierin spiegelt sich das chinesische Bestreben wieder, sich von einer imitationsbasierten zu einer innovationsbasierten Volkswirtschaft zu entwickeln. Obwohl China aktiv und intensiv versucht Innovationen zu fördern und eine bei Innovationen führende Nation zu werden, hat China den Anschluss an weltweit führende Volkswirtschaften bisher nicht hergestellt. Auf Grund der aktuellen und andauernden Entwicklung im chinesischen Patentgeschehen adressiert diese Dissertation verschiedene wichtige und bisher weitgehend unbeachtete Fragestellungen rund um die Ursachen dieses Anstiegs sowie bezogen auf den Wert chinesischer Patente. Im Speziellen betrachtet die Dissertation die Entwicklung chinesischer Universitätspatente, den Einfluss von Akquisitionen auf das Patentgeschehenl sowie den Wert chinesischer Patente.

Die Dissertation zeigt, dass ein Anstieg chinesischer Universitätspatente, die durch verschiedene staatliche Programme stark geördert werden (Kapitel 2 und 3), entscheidend zum Gesamtanstieg von Patenten in China beiträgt. Neben einer steigenden Anzahl an Universitätspatenten tragen auch Akquisitionen zu diesem Gesamtanstieg bei (Kapitel 5). So zeigt diese Dissertation, dass Chinesische Unternehmen nach Akquisitionen unter bestimmten Vorraussetzungen mehr Patente anmelden: Beispielsweise profitieren chinesische Unternehmen insbesondere von Akquisitionen von ausländischen Unternehmen, die ihnen einen Zugang oftmals weiter entwickelten und bisher unbekanntem Wissen ermöglichen. Während der Anstieg an Patentanmeldungen bemerkenswert ist, zeigen verschiedene Ergebnisse dieser Dissertation jedoch, dass die Qualität der Patente nicht im gleichen Ausmaß angestiegen ist, wie deren Quantität (Kapitel 3) und das der Wert von chinesischen Patenten insgesamt niedriger ist als der Wert von Patenten aus anderen Ländern (Kapitel 4). Die Entwicklung von qualitativ hochwertigen Patenten ist jedoch ebefalls wichtig um eine nachhaltige Entwicklung der nationalen Innovationskraft zu erreichen.

Im Gegensatz zur Forschung über Patente ist die Forschung über Markenrechte noch wenig entwickelt und vergleichweise jung. Markenrechte stellen ein sehr wichtiges Recht dar, mit dem sich Unternehmen von ihren Wettbewerbern differenzieren können. Die bisherige Forschung hat gezeigt, dass sich Markenrechte positiv auf den Marktwert, das Überleben und die Produktivität von Unternehmen auswirken können. Trotz dieser positiven Effekte ist wenig darüber bekannt, warum Unternehmen überhaupt Markenrechte anmelden. Diese Frage steht daher im Mittelpunkt der letzten Studie dieser Dissertation (Kapitel 6).

Um die Bedeutung und Wichtigkeit von Markenrechten besser zu verstehen, ist ein besseres Verständnis der Motive von Unternehmen Markenrechte anzumelden erforderlich. Anhand von Daten von von kleinen und mittleren Unternehmen (KMUs) in innovativen Industrien werden im Rahmen dieser Dissertation drei Motive identifiziert und empirisch validiert: Schutz, Marketing, und Austausch. Weiterhin können die Unternehmen auf Basis ihrer Motive in verschiedene Gruppen (engl. *cluster*) eingeteilt werden: Skeptiker gegebüber Markenrechten, marketing-fokussierte KMUs, marketing- und schutz-fokussierte KMUs und Befürworter von Markenrechten. Diese Ergebnisse unterstreichen die große Varianz in KMUs mit Berzug auf deren Nutzung von Rechten an geistigem Eigentum. Die Stärkung der Nutzung von Rechten an geistigem Eigentum durch KMUs ist häufig ein Ziel von staatlichen Förderprogrammen. Daher ermöglichen die Ergebnisse dieser Dissertation die Entwicklung von besser auf individuellen Bedürfnise der heterogenen Gruppe der KMUs zugeschnittenen Förderprogrammen und -initiativen.

About the author

Christian O. Fisch (1987) obtained his Master degree from Trier University (Germany) in 2012. He then started his PhD research at the department of Applied Economics Erasmus School of Economics, Erasmus University Rotterdam under the supervision of professors Joern Block, Roy Thurik, and Enrico Pennings. Simultaneously, he was a research associate at Trier University's Chair of Management, held by Joern Block.

His research interests revolve around topics in the areas of innovation and entrepreneurship and focus on intellectual property rights. His research has been published in international peer-reviewed journals, for example, *Research Policy*, *Journal of Technology Transfer*, and *Journal of Brand Management*. He has presented his work at various international conferences including the 76th annual meeting of the *Academy of Management* in 2016. Christian Fisch is also currently a member of the editorial review board of *Small Business Economics*.

In addition to his academic activities, Christian Fisch is a part-time entrepreneur: In 2015, he became the manager and co-founder of *Block & Partner*, a small consulting company specialized in providing consulting to SMEs on the topics of innovation and strategy.

Portfolio

Publications in journals

(1) De Vries, G., Pennings, H.P.G., Block, J.H., Fisch, C. (in press). Trademark or patent? The effects of market concentration, customer type, and venture capital financing on start-ups' initial IP applications. *Industry and Innovation*, forthcoming.

(2) Block, J.H., Fisch, C., Van Praag, M. (in press). The Schumpeterian entrepreneur: A review of the empirical evidence on the antecedents, behavior, and consequences of innovative entrepreneurship. *Industry and Innovation*, forthcoming.

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(1) Fisch, C., Block, J.H., Sandner, P.G. (2016). The impact of acquisitions on Chinese acquirers' patent output.

(2) Fisch, C., Sandner, P.G., Regner, L. (2016). The value of Chinese patents: an empirical investigation of citation lags.

(3) Block, J.H., Fisch, C., Lau, J., Obschonka, M., Presse, A. (2016). Labor market institutions and the preference to work in family firms: A cross-country, multi-level investigation.

Conference presentations and research talks

(1) Block, J.H., Fisch, C., Lau, J., Obschonka, M., Presse, A. (2016). Labor market institutions and the preference to work in family firms: A cross-country, multi-level investigation. *G-Forum 2016*, Leipzig (DE), 2016.

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(3) Block, J.H., Fisch, C., Lau, J., Obschonka, M., Presse, A. (2016). Who prefers working in a family firm? An exploratory study of individuals' organizational preferences across 40 countries. *FIFU Conference DACHLi*, Siegen (DE), 2016.

(4) Fisch, C., Block, J.H., Sandner, P.G. (2015–2016). The impact of acquisitions on Chinese acquirers' patent output. *Lunch Seminar in Economics*, University of Luxemburg (LUX), 2016; *Research Seminar*, GGS Heilbronn (DE), 2016; *Research Seminar*, HHU Düsseldorf (DE), 2015; *Workshop "Economics of Innovation"*, Trier (DE), 2015; *G-Forum*, Kassel (DE), 2015.

(5) Adam-Müller, A., Andres, R., Block, J.H., Fisch, C., Socialist heritage and the image of entrepreneurs in Europe. *G-Forum*, Oldenburg (DE), nominated for the "Entrepreneurship Research Newcomer Award 2014", 2014; *RENT Conference*, Luxembourg (LUX), 2014.

(6) Fisch, C., Block, J.H., Sandner, P.G., Chinese university patents: Quantity, quality, and the role of subsidy programs. *Research Seminar*, Faculty of Economics and Business, University of Groningen (NL), 2014; *T2S Conference*, Bergamo (IT), 2013; *TIE Conference*, St. Gallen (CH), 2013*; *Research Seminar Erasmus School of Economics*, Erasmus University Rotterdam (EUR) (NL), 2013; *Research Seminar Erasmus Research Institute of Management*, EUR (NL), 2013; *Jena Economic Research Seminar*, Friedrich Schiller University Jena (DE), 2013*.

** Presentation by co-author*

Teaching: Lectures and exercise sessions

(1) *"Strategy and organization"* (2015–2016, Trier University, DE)
(2) *"Economics of innovation"* (2016, EUR, NL)
(3) *"Introduction to entrepreneurship and strategy economics"* (2014–2016, EUR, NL)
(4) *"Empirical research"* (2013–2016, Trier University, DE)
(5) *"Entrepreneurship and innovation"* (2012–2016, Trier University, DE)
(6) *"Entrepreneurship in the modern economy"* (2013–2014, EUR, NL)

Teaching: Seminars and workshops

(1) *"Research seminar on innovation"* (2016, Trier University, DE)
(2) *"Case study seminar on innovation"* (2016, Trier University, DE)
(3) *"Case study seminar on innovation"* (2016, EUR, NL)
(4) *"Business models for start-ups"* (2015, Technology Transfer Office Trier, DE)

Teaching: Guest lectures

(1) *"Part-time entrepreneurship"* (2016, Tech. Transfer Office Saarbrücken, DE)
(2) *"Intellectual property rights"* (2015, HHL Leipzig, DE)
(3) *"International management"* (2014, Trier University, DE)
(4) *"Entrepreneurship and innovation research"* (2014, Trier University, DE)
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With regard to patents, this thesis focuses on patenting in China, which underwent a remarkable and explosive growth recently: Only 15 years ago, Chinese applicants filed 1.9% of the patents they filed in 2014. This is because China is trying to transition itself from an imitation-based to innovation-based economy. However, even though China is actively and prominently fostering innovation in trying to become a leading innovator, China is still far away from reaching the world's innovation frontier. In light of this ongoing and still relatively unexplored phenomenon, this thesis addresses several important issues regarding the antecedents of patenting and the value of patents in China that are crucial, but have received little attention so far. In particular, this thesis addresses the more specific topics of university patenting, the impact of acquisitions on innovation performance, and patent value in China.

In contrast to research on patenting, research on trademarking is in comparatively early stages. Trademarks are a very important IPR for firms to distinguish themselves from competitors and have been linked positively to the market valuation, survival, and productivity of firms. However, little is known on why firms file trademarks, which is the focus of the final study in this thesis.

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