Quality and Value of Chinese Patenting: An International Perspective

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This paper presents a novel analysis of the international dimension of the rapid growth of Chinese patenting and advances an econometric model to scrutinize the determinants of patent granting, prior-art searches, opposition to patents granted, and patent renewal decisions. Our results provide support for the "strategic patenting" hypothesis on the lower value and quality of Chinese patents compared to other patents on average, though a few caveats are in order. On the one hand, I find that the probability of grant for foreign multinational firms is negative although their patents are relative strong regarding the prior art. The low value effect on opposition and renewal decision is moderate. On the other hand, for Chinese indigenous patenting, I do not find ample evidence that there is lower probability of grant, but I do find support that these patents lack adequate prior art research, receive more oppositions, and have shorter renewal life cycle compared to other Chinese patents and other patents on average. The size and experience of the patent owner positively mediate these effects. Hence, the findings are consistent with the assumption that large and younger patenters concentrated in a few industries are responsible for the bulk of strategic patenting.

Keywords: Patent value, Quality, China, International patent filings, Firm level analysis

JEL Classification: O31, O34

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I. Introduction

In the last decade, Chinese patenting has grown impressively, and in 2011 the State Intellectual Property Office (SIPO) of China outperformed all other such entities in terms of patent applications published (*The Economist* October 14^{th}, 2010). However, little is known about trends in Chinese patenting outside national borders, with the exception of the study by Eberhardt *et al.* (2011). Our work attempts to fill this gap with focus on international patenting according to regulations of the European Patent Office and the World Patent Cooperation Treaty.

The growth of international patenting has paralleled internal reforms by the Chinese government. It is noteworthy that adoption of a modern patent system is a relatively new legislative change in China. Indeed, until the beginning of the 1980s, the development of intellectual property in China was limited, and the first patent law dates to 1985. Subsequently, the Chinese government promoted three reforms to harmonize Chinese patent law with international treaties, increase statutory protection for the private sector, and extend patentability in novel subject areas. The first revision of 1992 introduced some administrative changes in the regulation of the legal services sector. In 2001, China entered the WTO and its patent law was fully harmonized with the Patent Cooperation Treaty of the International Patent Cooperation Union (PCT) and the World Trade Organization agreement on trade-related aspects of intellectual property rights (TRIPS). In 2008, the Chinese government launched the "National Intellectual Property Strategy" to reduce bureaucratic costs, increase transparency in the patent system and enhance incentives for inventors who intend to carry out R&D in China.

According to the Joint Experts Group for Patent Examination of the trilateral cooperation commission among SIPO, Japan Patent Office (JPO), and Korean Intellectual Property Office (KIPO), there are no significant differences between China's patent authority and other major patent offices regarding the examination process and the criteria for the patentability of an invention (JEGPE 2010). In the Chinese patent law, article 22 paragraph 3 defines the criteria as novelty, inventiveness, and practical applicability. For the Chinese patent office, as for the JPO and European Patent Office (EPO), the patent application is published 18 months from filing and novelty is established according to a "first-to-file" principle. Instead, the Chinese regulations differ from the Japanese ones regarding when the validity of a patent can be challenged: in China, it can be opposed up to nine months from the date the patent was granted (OECD 2009). Recently, China's SIPO has announced initiatives under the aegis of the JEGPE to scrutinize and harmonize with the JPO and KIPO the procedures to be taken by patent examiners for the evaluation of the inventive steps in determining whether or not to grant a patent application.

Notwithstanding efforts to harmonize the patent-granting process internationally, patenters face substantial differences in fees for the process, according to the entity to whom they present their application. For example, in 2003 the average cost for obtaining a standard patent was estimated at €46,700 for Patent Cooperation Treaty (PCT), €30,530 for the EPO, €10,250 for the United States Patent and Trademark Office (USPTO), €14,018 for Germany, and €5,460 for the JPO (OECD 2009). In China, the full cost of a patent from filing to renewal with up to 20 years validity has been estimated at about €2,505 EUR.[1] It is worth remembering that since July 1st, 2010, China's SIPO can function as an International Search Authority (ISA) under the PCT agreement,[2] and here again, its fees differ substantially from those of other ISAs for patent searches and examination of inventions. The overall fee for patent search and preliminary examination of a Chinese-PCT is about 3,600 Chinese Yuan (RMB), which is about €424.[3]

These institutional and economic considerations and the spectacular growth of Chinese patenting at the domestic and international level prompt a number of questions. For example, what are the macro trends of Chinese patenting in the EPO/PCT systems compared to those of other countries? How do Chinese patents compare to patents from other countries in terms of quality and value? Do the characteristics of the patenter determine the quality and value of Chinese patenting, and if so, which characteristics are most important? How do Chinese companies benefit domestically and internationally from patenting?

To the best of our knowledge, this paper is among the first attempts

[1] These significant differences persist even when PPP exchange rates are taken into account. In particular — according to statistics of the United Nations Industrial Development Organization (www.unido.org, December 2012), which take US price levels as a benchmark — PPP patent fees can be estimated at PPP €13,393 for Germany, €10,250 for USPTO, €4,213 for the JPO, and €5,047 for the SIPO.

[2] See for example http://www.wipo.int/export/sites/www/pct/en/texts/agreements/ag_cn.pdf, last visited in September, 2012.

[3] The reference date for the exchange rate RMB-EUR is July 1st, 2010.

to answer these questions with particular focus on PCT and EPO regulations. To do so, three goals were pursued. First, we sought to understand how new Chinese innovators emerge at the international level and compete with global players from developed countries and others. Second, we wanted to learn how the most innovative Chinese firms use the patents and the patent system to compete more successfully than their rivals. It is of great interest at the theoretical and empirical level to clarify how the Chinese economy has responded to recent changes in patent law. Third, we examined the value and quality of patents on Chinese inventions in order to compare them to other patents at the international level.

Previous studies have conducted extensive analyses at the country, regional or industry level, and a few have scrutinized the determinants of the growth of Chinese patenting at the firm level. These studies have found a significant strengthening of patent protection in China, and noted that pro-patent reforms were followed by a burst of patenting activities, which in turn accelerated when China joined the WTO [see Park (2008) and Hu and Mathews (2008) respectively]. In addition, the vast majority of patent applications originate from a small number of regions (Crescenzi *et al.* 2012), notably the Guangdong region, which accounts for two-thirds of all such applications, and certain industries tend to have a very high propensity to patent their inventions (Eberhardt *et al.* 2011). Many studies have posited a "strategic patenting" hypothesis, suggesting that both domestic and foreign firms file patents not only to protect real products in the market but also for strategic reasons (Hu 2010).

A few authors (Hu and Jefferson 2009; Liang and Xue 2010; Eberhardt *et al.* 2011) have begun to scrutinize the "strategic patenting" hypothesis at the firm level, along the lines of Hall and Ziedonis (2001). All these studies agree that R&D investment can only partially explain the surge in propensity to apply for patents. It has been shown that patenting takes place in industries which are more international, and that the growth of patenting in China's SIPO has also been accompanied by an increase in that done in other offices (*e.g.*, the USPTO). However, none of these studies has analyzed Chinese patenting at the international level (for example, according to EPO and PCT regulations) and no studies to date have explored the determinants of the quality and value of Chinese patents, which is a key topic of the "strategic patenting" literature [see Hall *et al.* (2009) for a detailed discussion on the topic]. This paper aims to fill this gap and attempts to identify how the nature of the patent owner (businesses, individuals, and non-business organizations including universities, hospitals, government, and other private-non-profit sectors) and its size and patenting experience impact patent quality and value.

To this end, we used a novel dataset including the whole population of EPO and PCT patents, and introduced a new taxonomy of Chinese patenting to take into account both the location of residence of the patent inventor(s) and the national origin of the patent owner(s) (Goldberg *et al.* 2008), thus making it possible to track cross-country knowledge flow and differentiate the investigation based on the twofold geographical dimension of the patenting activities: indigenous patenting by Chinese firms relying on the domestic inventor workforce and foreign multinational enterprises (hereafter also MNEs) employing Chinese inventors.

Next, an econometric model has been used to analyze prior-art searching, granting, opposition, and renewal decisions. The findings on Chinese patenting depict a broader picture than that proposed in the "strategic patenting" hypothesis. On the one hand, I find support that patents filed by foreign MNEs employing Chinese inventors are of lower economic value than other patents on average. In particular, they have about one-third less probability of being granted, whereas the patent value effect for these patents is smaller (about one percent) for opposition received and renewal decision. This result is consistent with the study of Hu and Jefferson (2009) who have claimed that foreign firms in China perform lower potential R&D, which can give birth to more incremental and less valuable innovations. However, patents by foreign MNEs in China are relatively strong regarding the patent quality because they receive fewer supplementary search reports from examiners. In this direction, it is important to estimate the value of the patent premium, that is, the proportional increment to the value of innovations realized by patenting them in order to have a clear picture of the underlying economic value of patenting in China for these firms.

On the other hand, for indigenous Chinese patenting, that in large extent takes place since year 2000, I do not find any differential probability on granting decision compared to other patents on average. Nevertheless, I do find support that these patents are of lower quality because they have 41.1 percent positive probability of getting a supplementary search report from examiners and they are considered more controversial because they receive four percent more often oppositions than other patents on average. In the same vein, the indigenous Chinese patents have two times shorter renewal life cycle compared to other Chinese patents. The size and patenting experience of the patent owner positively mediate these results. Thus, the findings are consistent with the assumption that larger and younger patenters concentrated in a few industries are responsible for the bulk of "strategic patenting" (Hall and Ziedonis 2001).

The paper is structured as follows. Section 2 summarizes the literature and advances the testable hypothesis, and Section 3 presents the dataset and the variables included in the econometric analysis. The descriptive trends are reported in Section 4, and the econometric model is developed and fully discussed in Section 5. The final remarks propose directions for further inquiry.

II. Background and Hypothesis

With only a few exceptions, patenting by businesses in China is an almost unexplored topic. Most of the studies present aggregate data at the country, regional or industry level.

To analyze patenting on the country level, numerous researchers have devised indices that rank and compare the patent legislation of many nations, including China. Park (2008) developed an indicator of the strength of national patent legislation based on five dimensions: extent of coverage, membership in international patent agreements, provisions for loss of protection, enforcement mechanisms, and duration of protection [for a fuller discussion see also Ginarte and Park (1997) and Fraser (1999)]. According to Park's findings, this indicator doubled in China during the decade 1995-2005, reaching the same level as that of member countries of the Organisation for Economic Co-Operation and Development (OECD), and thus indicating a remarkable strengthening of patent protection in this country. Papageorgiadis and Cross (2011) enhanced this index by adding the factors of trade search costs, servicing costs, property rights protection costs and monitoring costs, and claim that this indicator thus ranks China's patent protection status closer to that of the Central and East European countries and the other member countries of BRICS (Brazil, Russia, India, and South Africa) than does Park's model (2008). The increased strength of patents in China has been shown to be a key factor in the acceleration of overall patenting that took place in 2001 when China joined the WTO (Hu and Mathews 2008).

The growth of Chinese patenting has been found to be unevenly distributed geographically. The Guandong region accounts for about one-tenth of R&D investment in China and two-thirds of the overall patenting (OECD 2010), making it one of the top regions in the world for cumulative R&D spending in recent years; per capita R&D investment relative to GDP is 1.41%, not far from the average ratio for the OECD regions (1.59%). In terms of growth rates, R&D spending in Guangdong increased five-fold from 2000 to 2008. According to Crescenzi *et al.* (2012), the strong polarization of R&D in China is a typical symptom of the increasing return to scale in R&D, where regions better endowed with 'knowledge capital' have become even more R&D intensive over time. However, they claim that the new geography of innovation in China cannot be considered as a failure of government intervention in favor of less developed regions, but the outcome of a top-down policy in which patent reforms and attraction of foreign direct investment (FDI) have played a key role *via* the mechanism of labor mobility.[4]

The impact of FDI on patenting was thoroughly analyzed by Hu (2010) at the industry level. He compiled a dataset of 1.37 million patents from China's SIPO at the two digits industry level over the period 1985-2004, and categorized them on the basis of the field of technology they concern, using the International Patent Classification (IPC) list of fields, organizing the patent counts in a fixed concordance table.[5] Hu found that the growth of domestic patenting in China was highly correlated with foreign patenting in China in the same industries in which the foreign firm specialized in its home country. Moreover, the foreign patenting in China from a given focal country has been found to be significantly and negatively affected by foreign patenting done by other nations in competition with China. According to Hu (2010), this evidence strongly supports the competitive threat hypothesis, according to which the increase in the propensity to patent is caused by the fact that companies file patents not only to protect real products in the market but also for strategic reasons such as barriers to market competition, for reducing the risk of being held up by other patent owners and to gain stronger contractual power towards competitors in cross-licensing settings (Hall and Ziedonis 2001). Hence, the sustained patenting in China by foreign

[4] There are significant incentives for individual inventors who file patents (*The Economist* October 14th, 2010). Patents are used in public and private companies as evaluation indicators deciding on promotions and career enhancements. Also, the education system in China takes into the account patenting during the admission and grading process of students. Patents allow individuals to obtain fiscal bonuses from the government and ease some bureaucratic obligations, for example in obtaining a resident permit in a large and more modern urban area.

[5] See for example http://www.oecd-ilibrary.org/science-and-technology/the-oecd-technology-concordance-otc_521138670407, last visited in September, 2012.

firms has ballooned the propensity to patent even for domestic innovators: on the one hand, the value of patenting *per se* has increased in China with the advancement of internal reforms [the so-called patent premium: see Arora *et al.* (2008)], while on the other hand, foreign firms have conveyed new business practices in China where intellectual property strategies play a key role.

One of the first studies at the firm level was by Liang and Xue (2010), who scrutinized the strategic patenting hypothesis with a dataset of one thousand companies. In particular, they analyzed the patenting activities of Fortune 500 firms and a control sample of the 500 biggest Chinese companies. They showed that patenting by domestic firms essentially grew only after the year 2000, and is highly concentrated in the hands of a small group of firms. The growth of patenting by foreign firms in China began in 1996, well before that of domestic companies. On the basis of their investigation of the patent priorities of foreign companies, they concluded that the majority of the R&D investments that led to these patents was spent elsewhere and not in China. However, this study is limited by the fact that it that does not take into account the location of the inventors involved in the patents, a factor that has been found to be a powerful proxy where the invention process takes place (OECD 2009).

At the firm level, other hypotheses have been proposed to better understand the factors spurring the growth of patenting. Hu and Jefferson (2009) advanced two hypotheses in addition to the strategic patenting hypothesis. Firstly, they pointed to the numerous central government reforms to favour pro-patent legislation, including initiatives undertaken after the China's entrance into the WTO to harmonize Chinese regulations with those of important international standards. Secondly, they noted the acceleration of R&D investment in China from one-half percent of GDP in the mid 1990s to one percent in 2000, continuing to 1.3% in 2004.[6] To test these hypotheses, Hu and Jefferson analyzed a unique survey dataset from the National Bureau of Statistics of China for the seven year period 1995-2001, comprising over 29,525 firms that account for 38% of Chinese R&D spending and 8.5% of domestic patent applications. The main drawback of this dataset is that it does not distinguish whether the filings regarded invention patents, utility models or designs.

[6] The Chinese R&D effort is quite comparable even with some developed economies and puts Chinese economy as the R&D leader among the low income countries (OECD 2010).

In fact, for utility models or designs no examination is required, and hence the inventive steps can be more limited (Wright *et al.* 2011).

Econometric evidence suggests that the R&D push hypothesis can only explain 24% of the surge of Chinese patenting. The cross industry variation in the value added by the foreign firms (a proxy for foreign direct investments) in China accounts for another 20% of patenting growth. Quite interestingly, Hu and Jefferson found that FDI impact is significantly different for domestic firms than it is for foreign owned ones. They interpreted these results, on the one hand, as a strategic response by domestic firms to the entrance of new innovators from abroad, and on the other, they claim that foreign firms in China typically perform only low potential R&D which can yield on average more incremental innovations and thus less patenting. They also found that the dummy years 2000 and 2001 had a strong impact on patent propensity, explained by the anticipation of reforms in patent legislation related to China's entrance in the WTO. However, the limited time coverage of the sample does not allow for a full-fledged analysis of the impact of this latter hypothesis.

Another way institutional reforms can affect patent propensity is through public subsidies to compensate application fees.[7] In China, since the introduction of the first compensation program in the Shanghai area in 1999, these policies have been typically managed by the local government. Wright and Lei (2011) quantified the impact of a policy change at the provincial level in 2005 using a matched dataset of 2,634 firms from six provinces. They found that doubling the fee compensation encouraged an impact of about 28% in the patent propensity for firms participating in the program. It is noteworthy that they did not find a statistically significant effect for utility models, which does not contradict the anecdotal claim that the major stakes are in the utility patents.

Eberhardt *et al.* (2011) provided the first evidence on patenting strategies of Chinese firms outside the domestic market, in particular in the USPTO. For this task, they developed a novel dataset of companies with a portfolio of Chinese and US patents: they matched company records with patents using a compressive dataset of 19,956 Chinese firms over the period 1999-2006, and found that a small number of industries and patenters accounted for the bulk of patenting in the SIPO and USPTO:

[7] In addition large patenting companies could obtain significant discounts on the profit tax and improve their likehood to be selected in public procurement tenders.

the lion's share of patenting was done in the "Instruments and Office Machinery" sector — 75.1% of the matched patents were with the SIPO and 88.9% with the USPTO. On the other hand, in the same period the top 10 patent owners accounted for 86.7% of patenting in the US and 75.0% of patenting in the SIPO.

They then analyzed the determinants of patent productivity and the decision to apply for a patent abroad (*i.e.*, filing in the USPTO) using an econometric model. Export-intensity, firm size, and experience are particularly relevant in understanding the variability in the patent portfolio size in US and China. Put differently, firms that patent in the US are larger, younger, and more export-oriented than firms that seek protection for their inventions solely in the domestic market. Lastly, R&D investment does not have a large differential impact on US patent counts compared to those filed with the SIPO; however, R&D investment matters positively in the decision to file patents in the USPTO, although the effect is relatively small.

Based on these considerations in the literature on the growth of strategic patenting, the following *ceteris paribus* testable hypotheses can be posited:

Hypothesis 1: Chinese patents are of lower economic value than other patents on average.

In developing the hypothesis on patent quality, this study also draws upon anecdotal information about the development of the labor market for patent agents and examiners, from primary sources. Indeed, to the best of our knowledge, no previous studies have scrutinized the determinants of patent quality with respect to Chinese patenting.

One factor that could hamper patent quality in China is the fact that the legal services market is still in its infancy (China IP 2011). The exceptional growth of patenting has meant a squeeze in the supply of patent agents. According to one estimate, because of heavy workload, a patent agent only devotes about 2.3 days of work to drafting a patent application, which is considered too little to produce a good patent filing.[8] In the same vein, firms generally chose legal services mainly on the

[8] Estimates from China IP (2011) that elaborates on statistics from China Patent Agent Association (http://www.acpaa.cn/englishnew/content.asp?id=181): in 2009 there were active about 6,022 patent agents in China and about 976 thousands applications were filed at SIPO. This means that each agent took about 162.1 documents on an annual basis and she had to draft one patent every 2.3 days.

basis of cost, and thus patent agents have little incentive to invest in drafting skills and tools in order to produce high quality patents.

Secondly, this boom in patent applications and squeeze in the supply of examiners has also created problems for the Chinese patent office (*The Economist* October 14th, 2010). Hiring a large number of high quality examiners in a short period of time is a serious challenge for any patent office. Given this dearth of qualified examiners, the large number of applications can lead to bureaucratic and managerial bottlenecks for the patent office, generating a large backlog of applications which demand examination. Thus, the following *ceteris paribus* testable hypothesis can be put forward:

Hypothesis 2: Chinese patent are of lower quality than other patents on average, because they lack suitable prior-art research.

In conclusion, it is worth mentioning that in this study, the comparison group used for scrutinizing the testable hypothesis is not limited to a specific subset of patents, originating from some countries, technology fields, time period or other criteria for two reasons. Firstly, we sought to avoid any selection bias that could be present in a reduced sample dataset, even for a random choice sample setting. Secondly, comparison of our focal group of patents to an average benchmark should help us draw some conclusions on the patenting strategies of the patent owners, in terms of their institutional characteristics (whether they are businesses, individuals, or non-business organizations, including universities, hospitals, government, and other private-non-profit sectors), their size, and their previous experience in patenting.

III. Dataset and Measures

This study used a novel dataset based on EPO and PCT patent applications. The unit of analysis is the patent family as defined by the INPADOC (International Patent Documentation Center), with at least one patent application under the EPO and PCT regulations. Typically, these patent families are also known as international patent families (Martinez 2010).

The main source of data is the EPO Worldwide Patent Database (PatStat 2012) and the related Patent Register Data regarding procedural information. For PatStat, bibliometric information has been extracted regarding claims, references, patent classifications, inventors, opposition received, and renewal decisions.

PatStat was also used to extract full information on the addresses of inventors and patenters, which served to identify the geographic origin of inventions. For the purposes of this paper, both types of addresses could reveal different aspects of the geography of invention processes in China. On the one hand, the addresses of inventors, which are most often the address of their workplace, or more rarely, their personal address, reflect the place where the research leading to the patent was done. On the other hand, the country origin of the patenter indicates the location where the R&D investor of the patent comes from, and hence if properly combined with information on the location of inventors can document the existence of any cross-country and cross-regional dimension of the invention process [see Harhoff and Thoma (2010) for a fuller discussion on this topic].

In this direction, to identify Chinese patents, the study advances a threefold taxonomy (Goldberg *et al.* 2008). Firstly, indigenous inventions (SET 1) are those patents that have at least one inventor and at least one patenter originating in China. Secondly, SET 2 is made up of those patents that have at least one Chinese patenter, but none of the inventors are located in China, *i.e.*, it includes inventions from Chinese patenters hiring foreign inventors working outside China. Lastly, SET 3 considers multinational enterprises performing R&D in China, when at least one inventor in the patent is from China. In other words, SET 2 and 3 could be considered respectively a proxy for the outward and inward R&D foreign direct investments (FDIs) in China whose innovation output has been patented at the international level.

Table 1 depicts Chinese patenting by types along the two geographical dimensions, that of the location of the patenter and that of the inventor. It identifies about 48,207 INPADOC families relating to Chinese patenting activities with EPO and PCT regulations. Slightly more than half of the patents can be considered indigenous inventions involving both Chinese inventors and patenters, whereas patents from MNEs performing R&D in China constitute about 44.2%. The outward FDIs (SET 2) matter only for about 3.5% of all Chinese patents.

Due to data availability, in the econometric analysis, the sample was limited to patent families with at least an EPO equivalent. In fact, for this dataset I have complete procedural information on applications, grants, oppositions, and renewals. Limiting our sample to one single patent office allows more homogeneity and precision in the definitions

TABLE 1
DEFINING CHINESE PATENTS
(48,207 INPADOC patent families)

		CHINESE PATENTER	
		YES	NO
CHINESE INVENTOR	YES	SET 1 – Indigenous R&D 25,210 (52.3%)	SET 3 – Inward FDIs 21,327 (44.2%)
	NO	SET 2 – Outward FDIs 1,670 (3.5%)	----

Sources: PatStat Database (release April, 2012).
Notes: SET 1 relies on the indigenous inventions when both the inventors and patenters originate from China. SET 2 is made up of outward R&D FDIs when Chinese firms employ foreign inventors. SET 3 is based on inward R&D FDIs when MNEs employ Chinese inventors.

and computations of the variables. In this direction, focusing the econometric analysis on the EPO dataset alone is not a serious drawback of this kind.

Our sample is made up of 2,192,793 patent families with EPO equivalent during the period 1978-2007, which is the whole population of patent families published by the EPO. According to the combined definition of Table 1, there are 30,738 Chinese patents, which constitute a sufficient number of positive outcomes in our dataset to allow analysis of the whole population of INPADOC patent families with EPO equivalents (see also the Appendix for the descriptive statistics on the dataset).

In the econometric analysis, I divided the sample into two subsets, taking as the reference year 2001, when China entered the WTO. As discussed in the literature section, several studies found that the acceleration of Chinese patenting took place in this year. In addition, Hu and Jefferson (2009) claimed that China's entrance into the WTO was anticipated in the patenting decisions of one year because the negotiations had started and were active long before that date. In this direction, the timeline of our subsets are the periods 1978-1999 and 2000-2007 corresponding to 1,215,987 and 976,806 patents respectively.

Our analysis integrated the patent dataset with additional information. Firstly, in order to explore the technological specialization of China during the two time periods considered, we assigned patents to 30 aggregated technological fields (see descriptions in Table 2B). Indeed, these aggregations allows for a more accurate definition of technological fields com-

TABLE 2A

MAIN VARIABLES INCLUDED IN THE MULTIVARIATE ANALYSIS

Variable Name	Variable Description
	Dependent variables on patent quality and value
Supplementary search report	A binary variable if the patent was accompanied by a supplementary search report by the examiner. In the EPO the examiner can optionally choose to elaborate an additional prior art search when she thinks that the patent application still lacks relevant prior art in the matter.
Granted	Binary variable: 1 if the patent application has been granted by the EPO, 0 otherwise. It measures the complexity and uncertainty of the examination process (Harhoff and Wagner 2009).
Opposition	A binary variable that takes the value 1 if a patent was opposed at the EPO. Oppositions can be filed at the EPO within nine months from the granting date and they are proxy of economic potential of a patent (Harhoff and Reitzig 2004).
Renewals	The patent scope year index measured for the EPO member countries and the renewal decisions during the patent life cycle in each country (Van Pottelsberghe and Van Zeebroeck 2008). Renewal decisions are considered a direct measure of the lower tail of the patent value distribution (Bessen 2008). The patent scope index is weighted by the real GDP of the country where the protection is sought and renewed (US GDP=1).[9]
	Independent variables at the patent owner
Patenter is an individual	Binary variable: 1 if the patent is owned by a sole inventor, zero otherwise.
Patenter is an NBO	Binary variable: 1 if the patent is owned by a non business organization, zero otherwise.
Chinese indigenous inventions	Binary variable: 1 if at least one inventor and at least one patenter originate from China (SET 1), zero otherwise.
Outward FDIs from China	Binary variable: 1 if at least one patenter and none of the inventors originate from China (SET 2), zero otherwise.
Inward FDIs in China	Binary variable: 1 if at least one inventor and none of the patenters originate from China (SET 3), zero otherwise.
Patenter portfolio size	Number of patents owned by the patenter in the previous five years before the reference year. The variable is in logs.
Age of the patenter	Year of the first patent by the patenter. The variable is in logs of the difference from year 2010.

[9] I relied on the Penn Tables dataset (see https://pwt.sas.upenn.edu/php_site/pwt_index.php, last visited in September, 2012).

TABLE 2B
CONTROL VARIABLES AT THE PATENT LEVEL INCLUDED IN THE MULTIVARIATE ANALYSIS

	Prior art and background of the invention
Inventors	Number of inventors in a patent (Guellec and Van Pottelsberghe de la Poterie 2000).
Backward Citations	Number of citations of other patent documents. A bigger number of citations indicates that the invention relies on a broader knowledge base and hence is more important (Lanjouw and Schankerman 2004).
XY Backward Citations	A count variable of citations made of other patents whose claims overlap completely or partially with at least one claim of the focal patent (Hall *et al.* 2009). This variable measures the degree of importance of prior art to the focal patent and it is normalized by the number of claims.
Non patent references	Number of citations to the non-patent references prior art, which proxies the closeness to 'science' knowledge (Meyer 2000).
	Scope and technology potential
Patent family	Number of patents that share the same INPADOC priority. Economic value is related to the willingness of the owner to seek protection for the same invention across multiple jurisdictions (Putnam 1996). For EPO patents, I include all the designated countries of the filing.
Patent family weighted by the market size	As the patent family where each jurisdiction has been weighted by the GDP of the country where the protection is sought.
Claims	A count variable of the number of claims of the patent at the moment of grant or application (Lanjouw and Schankerman 2004).
Patent classes	Number of technology classes (with reference to EPO Classifications model) in which the patent was classified by the patent office (Lerner 1994).
Forward citations	The number of forward citations received by the patent or its equivalents during the first 5 years (Hall *et al.* 2007).
PCT route	A binary variable that signals whether the patent owner has filed an international application *via* the Patent Cooperation Treaty agreement.
Divisional application	A binary variable if the patent has at least one divisional application with a common priority patent.

(continued)

TABLE 2B
(CONTINUED)

	Other control variables
Time dummies	Year dummies based on the priority year of the patent.
Technological aggregation dummies	Dummies based on aggregated technological fields that are articulated in 30 categories: 1 Electrical engineering; 2 Audiovisual technology; 3 Telecommunications; 4 Information technology; 5 Semiconductors; 6 Optics; 7 Measurement and control; 8 Medical engineering; 9 Nuclear engineering; 10 Organic fine chemicals; 11 Macromolecular chemistry, polymers; 12 Basic chemical processing, petrol; 13 Surfaces, coatings; 14 Materials, metallurgy; 15 Biotechnology; 16 Pharmaceuticals, cosmetics; 17 Agriculture, food; 18 General processes; 19 Handling, printing; 20 Material processing; 21 Agriculture & food machinery; 22 Environment, pollution; 23 Mechanical tools; 24 Engines, pumps, turbines; 25 Thermal techniques; 26 Mechanical elements; 27 Transport; 28 Space technology, weapons; 29 Consumer goods & equipment; 30 Civil engineering, building, mining.

pared to the international patent classification (IPC) system. The algorithm to obtain the 30 aggregated technological fields from the IPC system is available under request.

Due to the lack of data, our analysis cannot account for the R&D investment done by the owner and other financial information originating from company books. Previous studies have shown that R&D investment can only partially explain the growth of patenting by Chinese firms. Moreover, extending the investigation beyond the companies that report R&D expenditures avoids potential selection biases in the analysis, such as patenters that perform R&D but do not report it in the company books, patenters that do not perform R&D in a formalized and systematic matter, and business patenters compared to the non business ones.

To account for the characteristics of the patent owner, the patenters are fully indexed according to their institutional context, namely whether they are businesses, individuals, non-business organizations (hereafter also NBOs) including universities, hospitals, government, and other private-non-profit sectors (Thoma *et al.* 2010). Considering also individual inventors and the non-business sector affords a more complete picture of different incentives to patenting in China. The non-business sector can be considered a proxy for government intervention in the Chinese innovation system (Eun *et al.* 2006).

In conclusion, Table 2A depicts the definition of the main variables computed at the patent owner level included in the multivariate analysis, whereas Table 2B summarizes the control variables measured at the patent level.

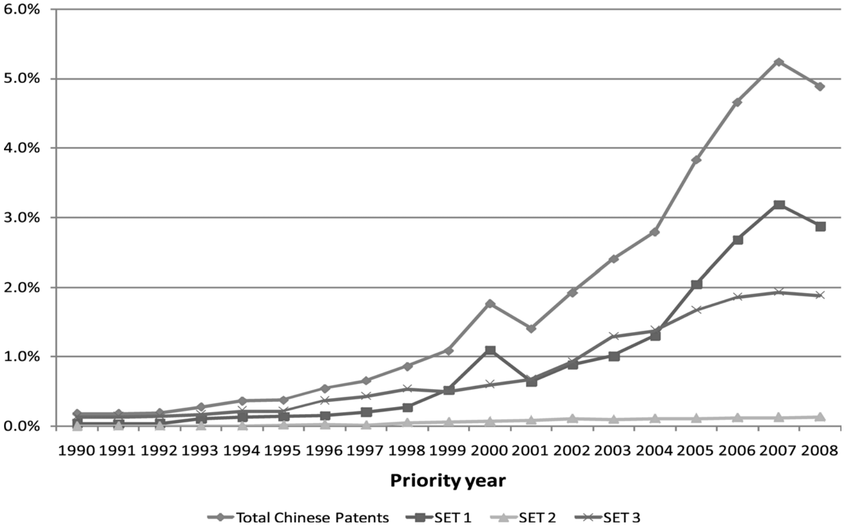
IV. Descriptive Trends

As in the case of the Chinese government patent office (SIPO), there is a strong growth of Chinese patents obtained in the international context. Figure 1 depicts the share of Chinese patents as share of the overall patenting from all countries. As can be seen in the figure, there is a continuous growth of Chinese patents from about 0.5% in 1995 to about 2% in the year 2000, and then to 5% in 2007. The growth is even more spectacular if one considers that this period is characterized by a sharp increase in patenting worldwide. The fast growth of patenting has been directly associated with the increase of patenting propensity following several pro-patent reforms in many developed and developing economies during the 1990s. Some these reforms include the introduction of the TRIPS agreements in the WTO; the extension of patenting to new subject areas such as biotechnology, software, and business methods; and the introduction of specialized courts and arbitrage offices for solving intellectual property controversies and others (Hall and Ziedonis 2001; Hall 2005).

The growth of Chinese patenting was initially propelled by the globalization of R&D activities, that is, multinational enterprises off-shoring R&D activities in China. Up to 1997, patenting by inward FDIs in China constituted two-thirds of all Chinese patents, although a decade later this share decreased to only one-third. In our dataset (SET 3), the MNEs with inward FDIs in China originate to a large extent in the Unites States (52.7%), the EU27 (24.0%), and less dramatically, in Taiwan (7.8%), Japan (6.25%), and Korea (2.35%).[10]

Since year 2000 patenting by MNEs has undergone a deceleration, and has been outperformed by the so-called indigenous R&D processes, that is, patenting by Chinese firms employing national inventors. In the

[10] Although I lack detailed data on the type of R&D investments done by MNEs in China, I do not think that this is a serious drawback for a preliminary study of this kind. We intend to fill the gap in future developments of this project.



Notes: SET 1 relies on the indigenous inventions when both the inventors and patenters originate from China. SET 2 is made up of outward R&D FDIs when Chinese firms employ foreign inventors. SET 3 is based on inward R&D FDIs when MNEs employ Chinese inventors.

FIGURE 1

CHINESE PATENTS AS PERCENTAGE OF ALL PATENTS

five years after 2002, indigenous patenting accelerated compared to patenting by foreign inventors, shifting from 1% to 3% of the overall patenting in the EPO and PCT systems. In particular, indigenous patenting reached 478.5 in 2007, considering 2002 as base year with value equal to 100. In terms of the compound annual growth rate, it means 97.3%, and this trend has well outperformed that of other BRICS and Central and East European countries (Goldberg *et al.* 2008; Crescenzi *et al.* 2012).

Quite interestingly, we can notice that a sharp decrease of indigenous patenting occurred in 2001. This can be explained by the collapse of the dotcom bubble of 2001, which further tightened financial constraints on innovative firms: put differently, the decrease of patenting during the financial crisis confirms the fact that patenting activities are highly pro-cyclical (Von Graevenitz 2009). Figure 2 reveals that the decrease of patenting in 2001 was essentially caused by business patenters and not by the other institutional sectors of the economy. Overall, patenting by non-business organizations in China has remained quite stable over the

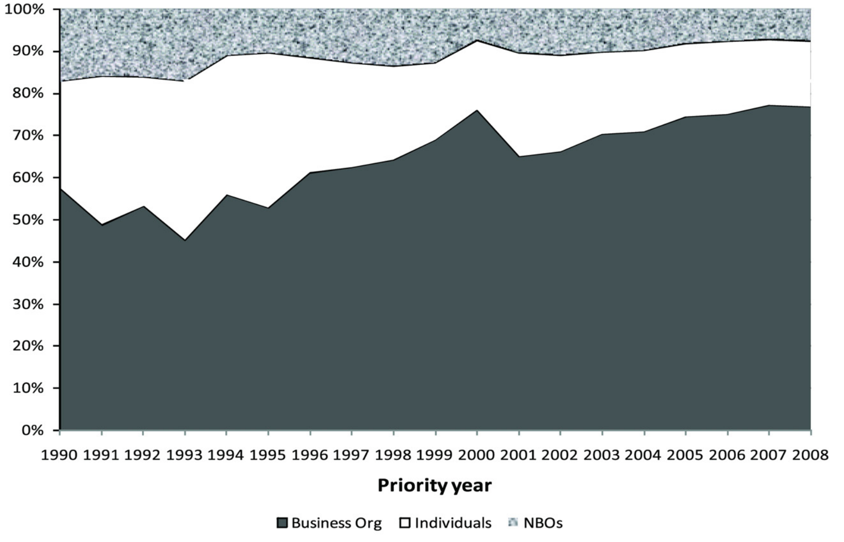


FIGURE 2
CHINESE PATENTS ACCORDING TO INSTITUTIONAL SECTOR

last two decades, whereas patenting by individual inventors has shrunken from 25.4% to 15.7% of Chinese patents, which nonetheless is still double the rate of patenting by individuals in developed economies (Thoma *et al.* 2010).

These trends are consistent with the model of technology catch-up by the Chinese economy discussed in Amighini *et al.* (2010).[11] They claim that Chinese firms benefit from technology acquisition from more advanced economies through imports of final goods and inward FDIs, which can then propel the production of market-oriented products with lower costs. In particular, inward FDIs have played a crucial role by allowing foreign MNEs to establish joint-ventures with domestic firms, which in turn can have access to more advanced technology suppliers.

Secondly, in some key high-technology fields — mainly telecommunication and electronics — Chinese firms have increasingly enlarged their knowledge assets *via* outward FDIs by establishing international technology alliances and merger and acquisitions (M&A) with firms in developed economies. Typically, the target of the outward FDIs by the Chinese MNEs has been the acquisition of strategic knowledge assets, such as

[11] I thank an anonymous referee for making out this comment.

technology and know-how. However, in some consumer industries, Chinese MNEs have extended to the acquisition of recognized brands and reputation in sophisticated markets to access unique managerial and marketing competences.

In our sample, the outward FDIs from China account for about 3.5% of all Chinese patents. From Figure 1 we can notice that while in the 1990s the outward FDIs from China were practically nonexistent, after year 2000 they have grown steadily. In particular, Chinese MNEs have invested relatively more in the European Union (26.8%), United States (16.5%), Australia (16.1%), Hong Kong (12.9%), and Japan (8.6%) than in other nations. It is noteworthy that the level of international openness of Chinese patenters — ratio SET2/SET1 is about 6.7% — lags well behind that of many developed economies, but it is similar to the case of Japan during the 1980s, when the level of international openness computed using a similar approach and dataset was about 9.4% (Harhoff and Thoma 2010).

To explore the technological specialization of Chinese patenting, I rely on the (Normalized) Revealed Technological Advantage Index (RTA). The RTA index was originally defined as:

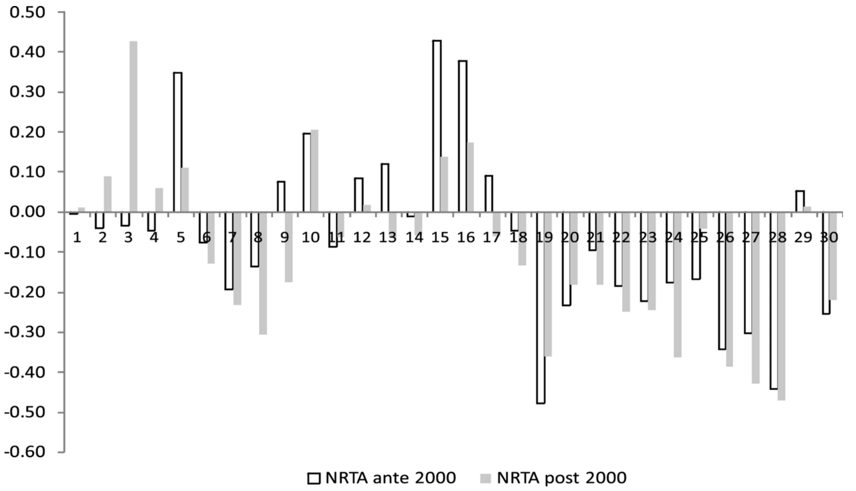
$$RTA_{ij}=(n_{ij}/\Sigma_i n_{ij})/(\Sigma_j n_{ij}/\Sigma_i\Sigma_j n_{ij}) \tag{1}$$

where n_{ij} is the count number of the patents of the country i in the technological field j. This definition generates an index that takes the values between zero and infinity with an average of 1. As has been shown, the scaling of the index (1) can be improved by taking the normalized formulation (Grupp 1994). In particular I have:

$$Normalised\ RTA=(RTA-1)/(RTA+1) \tag{2}$$

Formulation (2) makes the RTA change in the unitary interval and has the advantage of attributing to negative variations the same weight as the positive ones.

At the level of technological specialization, we can notice that China has a positive technological advantage in a small group of fields (Figure 3) — media, telecommunications and communications, and consumer goods, chemicals, pharmaceuticals and biotechnology — whereas it is following more distantly in a larger group of technologies such as environment, mechanics, transport, space technology, medical devices, instruments, materials, construction, *etc.* This finding should be interpreted



Notes: The technology aggregations are articulated in 30 categories: 1 Electrical devices — electrical engineering; 2 Audiovisual technology; 3 Telecommunications; 4 Information technology; 5 Semiconductors; 6 Optics; 7 Analysis, measurement, control; 8 Medical engineering; 9 Nuclear engineering; 10 Organic fine chemicals; 11 Macromolecular chemistry, polymers; 12 Basic chemical processing, petrol; 13 Surfaces, coatings; 14 Materials, metallurgy; 15 Biotechnology; 16 Pharmaceuticals, cosmetics; 17 Agriculture, food; 18 General processes; 19 Handling, printing; 20 Material processing; 21 Agriculture & food machinery; 22 Environment, pollution; 23 Mechanical tools; 24 Engines, pumps, turbines; 25 Thermal techniques; 26 Mechanical elements; 27 Transport; 28 Space technology, weapons; 29 Consumer goods & equipment; 30 Civil engineering, building, mining.

FIGURE 3

TECHNOLOGICAL SPECIALIZATION OF CHINESE PATENTING OVER TIME: NORMALIZED REVEALED TECHNOLOGICAL ADVANTAGE INDEX

attentively and at least two caveats are called for. First of all, in this study I am considering only international patenting and not domestic filings: patenting in some technological fields could be less internationalized because of the presence of a large internal market, such as in agriculture, food industry, and construction. On the other hand, in some fields internationalization could be limited because of government regulations, as in space and military technologies. Thus, it could be expected that an analysis based on domestic filings could reveal a different picture.

The dynamic perspective of Figure 3 suggests that in recent years, Chinese patenting has shifted from previous technological specializations and accelerated in an even narrower set of areas with very high patenting propensity, namely media, telecommunications and communications, and consumer goods. These technology fields are typically characterized by strategic patenting behavior of firms and are responsible for the lion's share of the growth of patenting recorded in major offices (Hall 2005). Previous studies have shown that patents in these fields are on average in the lower tail of the patent value distribution (Hall and Ziedonis 2001; Gambardella *et al.* 2008).

V. The Determinants of Patent Value and Quality

In order to test our hypotheses, I regressed a series of probit equations for the probability of a grant conditional on application (Table 3), a supplementary search report conditional on the PCT route (Table 4), and opposition conditional on grant (Table 5). For a renewal decision in the patent life cycle, measured by the scope year index weighted by the GDP of the country where protection is sought and renewed, I estimated an OLS regression (Table 6). Indeed, as previously mentioned, these outcome variables are a valid indicator of the quality and value of the patent filing and of the speed with which the patenter pursues the application. For example, after having checked for time and technology effects, a grant decision is a direct indicator telling us whether the patent application fulfills the criteria of subject matter and inventive steps. Secondly, if the examiners call for a supplementary search report, this indicates that they think the original search report of the PCT filing lacks relevant prior art. Third, opposition has been shown repeatedly to correlate with the economic value and importance of the patented invention (Harhoff *et al.* 2003; Harhoff and Reitzig 2004). Lastly, renewal decisions have been considered an objective and reliable measure of the lower tail of the patent value distribution (Bessen 2008).

The explanatory variables for these equations are shown in Table 2 A and B, plus three dummies for Chinese patenting for each of the definitions adopted: indigenous inventions (SET 1), outward FDIs (SET 2), and inward FDIs (SET 3). We included two binary variables to identify whether the patenter is an individual or non-business organization, considering business patenters as the excluded category. All the other variables including divisional and PCT dummies have been detrended by their geometric mean computed over priority year and the technology fields and then the resulting logarithms have been taken to facilitate

TABLE 3
PROBABILITY OF GRANTING DECISION: CHINESE PATENTS VS. ALL SAMPLE

Dependent variable	1978-1999		2000-2007	
	Model 1	Model 2	Model 3	Model 4
D (Indigenous R&D)	-0.107 *** (0.02)	-0.344 * (0.167)	0.005 (0.006)	-0.017 (0.031)
D (Inward FDI)	-0.306 *** (0.007)	-0.306 *** (0.007)	-0.081 *** (0.004)	-0.081 *** (0.004)
D (Outward FDI)	-0.039 (0.036)	-0.039 (0.036)	-0.010 (0.016)	-0.010 (0.016)
D (Individual patenter)	-0.051 *** (0.002)	-0.051 *** (0.002)	-0.053 *** (0.002)	-0.053 *** (0.002)
D (Individual patenter) * D (Indigenous R&D)		0.018 (0.042)		0.040 * (0.021)
D (NBO Patenter)	0.002 (0.002)	0.002 (0.002)	-0.014 *** (0.003)	-0.014 *** (0.003)
D (NBO Patenter) * D(Indigenous R&D)		0.001 (0.059)		0.045 (0.031)
Patenter's portfolio size	0.012 *** (0.000)	0.012 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)
Patenter's portfolio size * D(Indigenous R&D)		0.023 (0.016)		0.030 *** (0.002)
Patenter's portfolio age	-0.023 *** (0.002)	-0.023 *** (0.002)	0.038 *** (0.001)	0.040 *** (0.001)
Patenter's portfolio age * D(Indigenous R&D)		0.070 (0.062)		-0.054 *** (0.015)
Family size weighted by GDP (log)	1.410 *** (0.004)	1.410 *** (0.004)	0.389 *** (0.004)	0.390 *** (0.004)
Family size (log)	-0.083 *** (0.002)	-0.083 *** (0.002)	0.087 *** (0.002)	0.086 *** (0.002)
Forward citations after 5 years (log)	0.012 *** (0.001)	0.012 *** (0.001)	-0.026 *** (0.001)	-0.026 *** (0.001)
Technological classes (log)	-0.012 *** (0.002)	-0.012 *** (0.002)	-0.007 *** (0.002)	-0.007 *** (0.002)
Non-patent literature references (log)	-0.033 *** (0.001)	-0.033 *** (0.001)	-0.043 *** (0.001)	-0.043 *** (0.001)

(Continued)

TABLE 3
(CONTINUED)

Dependent variable	1978-1999		2000-2007	
	Model 1	Model 2	Model 3	Model 4
Number of Claims (log)	-0.233 ***	-0.233 ***	0.056 ***	0.055 ***
	(0.002)	(0.002)	(0.001)	(0.001)
Inventors (log)	0.040 ***	0.040 ***	-0.035 ***	-0.035 ***
	(0.002)	(0.002)	(0.002)	(0.002)
XY Type backward citations (log)	-0.068 ***	-0.068 ***	-0.002 ***	-0.002 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Backward citations (log)	-0.105 ***	-0.105 ***	0.002 ***	0.002 ***
	(0.001)	(0.001)	(0.001)	(0.001)
PCT (dummy)	-0.017 ***	-0.017 ***	-0.095 ***	-0.096 **
	(0.001)	(0.001)	(0.001)	(0.001)
Divisional (dummy)	-0.122 ***	-0.122 ***	-0.123 ***	-0.123 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Chi-squared (3) geographic origin	1760.7 ***	1734.9 ***	445.8 ***	441.0 ***
Chi-squared (2) institutional type	689.2 ***	688.0 ***	487.6 ***	467.7 ***
Chi-squared (2) size and age	2458.5 ***	2456.4 ***	2222.6 ***	2195.0 ***
Chi-squared all patenter characteristics	6083.6 ***	6089.0 ***	4025.6 ***	4229.3 ***
Pseudo R-squared	0.138	0.138	0.107	0.107
Number of observations (number=1)	1,215,987 (775,888)		976,806 (325,684)	

Notes: 1) Marginal effects and their robust standard errors are shown. Significance at 1% ***, 5% **, and 10% *. All equations include a complete set of priority year and technology dummies.
2) The variables definitions are reported in Tables 1, 2A, and 2B.

interpretation.[12] We also included a complete set of year and technology

[12] I have applied the following transformation to obtain the detrended log indicator:

$$I^{D}_{pct} = Log\left(1 + \frac{I_{pct}}{e^{\frac{\sum_{i=1}^{n}\log(1+I_{ict})}{n}}}\right)$$

Where I_{pct} is the patent indicator of the focal patent p in technology class c and year t, I_{ict} is the indicator of a given patent i in c and t, and n is the number of all patents in same class and year.

TABLE 4
PROBABILITY OF SUPPLEMENTARY SEARCH REPORT (NON EURO PCTS)
CHINESE PATENTS VS. ALL SAMPLE

Dependent variable	Model 1	Model 2
D (Indigenous R&D)	0.411 ***	0.222 ***
	(0.005)	(0.045)
D (Inward FDI)	-0.040 ***	-0.040 ***
	(0.005)	(0.005)
D (Outward FDI)	0.030	0.031
	(0.031)	(0.031)
D (Individual patenter)	-0.021 ***	-0.018 ***
	(0.004)	(0.004)
D (Individual patenter) * D (Indigenous R&D)		0.045
		(0.028)
D (NBO Patenter)	0.091 ***	0.092 ***
	(0.003)	(0.003)
D (NBO Patenter) * D (Indigenous R&D)		-0.027
		(0.045)
Patenter's portfolio size	-0.044 ***	-0.046 ***
	(0.000)	(0.000)
Patenter's portfolio size * D (Indigenous R&D)		0.092 ***
		(0.004)
Patenter's portfolio age	0.037 ***	0.041 ***
	(0.002)	(0.002)
Patenter's portfolio age * D(Indigenous R&D)		-0.053 **
		(0.023)
Family size weighted by GDP (log)	0.252 ***	0.258 ***
	(0.008)	(0.008)
Family size (log)	-0.229 ***	-0.232 ***
	(0.003)	(0.003)
Forward citations after 5 years (log)	-0.016 ***	-0.015 ***
	(0.002)	(0.002)
Technological classes (log)	0.118 ***	0.119 ***
	(0.003)	(0.003)
Non-patent literature references (log)	0.002	0.001
	(0.001)	(0.001)

(Continued)

TABLE 4
(CONTINUED)

Dependent variable	Model 1	Model 2
Number of Claims (log)	0.060 ***	0.058 ***
	(0.002)	(0.002)
Inventors (log)	0.056 ***	0.057 ***
	(0.003)	(0.003)
XY Type backward citations (log)	0.240 ***	0.239 ***
	(0.002)	(0.002)
Backward citations (log)	0.046 ***	0.046 ***
	(0.002)	(0.002)
Divisional (dummy)	0.028	0.027
	(0.034)	(0.034)
Chi-squared (3) geographic origin	2464.1 ***	74.3 ***
Chi-squared (2) institutional type	800.8 ***	798.6 ***
Chi-squared (2) size and age	1549.4 ***	1598.3 ***
Chi-squared all patenter characteristics	1947.7 ***	2001.9 ***
Pseudo R-squared	0.107	0.109
Number of observations (number= 1)	485,436	485,436
	(229,005)	(229,005)

Notes: 1) Marginal effects and their robust standard errors are shown. Significance at 1% ***, 5% **, and 10% *. All equations include a complete set of priority year and technology dummies.
2) The variables definitions are reported in Tables 1, 2A, and 2B.

dummies in all the regressions.

In general, the results of the prior art and patent scope variables agree with those in the literature. The XY citations, normalized by the number of claims, have a positive probability for getting an supplementary search report and an opposition, and a negative one for the granting decision. The effect on renewal decisions is more controversial: it is positive for patents before 1995 and negative after that year. This finding could be interpreted in terms of a survival selection bias: once a patent with many XY citations has overcome the granting and post-grant reviewing stage (opposition), it means that the patent has been doubly scrutinized and hence has a higher value.[13] The other prior art indicators (inventors and non-patent references) have a positive probability for getting an supple-

TABLE 5
PROBABILITY OF OPPOSITION CONDITIONAL ON
GRANT CHINESE PATENTS VS. ALL SAMPLE

Dependent variable	1978-1999		2000-2007	
	Model 1	Model 2	Model 3	Model 4
D (Indigenous R&D)	-0.029 **	-0.050	0.041 ***	0.046
	(0.01)	(0.016)	(0.008)	(0.07)
D (Inward FDI)	-0.036 ***	-0.036 ***	-0.007 ***	-0.006 **
	(0.002)	(0.003)	(0.002)	(0.002)
D (Outward FDI)	-0.036	-0.036	-0.015	-0.015
	(0.014)	(0.014)	(0.007)	(0.007)
D (Individual patenter)	-0.022 ***	-0.022 ***	-0.014 ***	-0.014 ***
	(0.001)	(0.001)	(0.001)	(0.001)
D (NBO Patenter)	-0.002 ***	-0.002 ***	-0.001 ***	-0.001 ***
	(0.000)	(0.000)	(0.000)	(0.000)
Patenter's portfolio size		0.010		0.014 ***
		(0.007)		(0.002)
Patenter's portfolio size * D (Indigenous R&D)	0.003 ***	0.004 ***	0.004 ***	0.005 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Patenter's portfolio age		0.020		-0.036 **
		(0.043)		(0.016)
Patenter's portfolio age * D (Indigenous R&D)	-0.086 ***	-0.086 ***	-0.010 ***	-0.011 ***
	(0.003)	(0.003)	(0.003)	(0.003)
Family size weighted by GDP (log)	-0.086 ***	-0.086 ***	-0.011	-0.011 ***
	(0.003)	(0.003)	(0.003)	(0.003)
Family size (log)	0.037 **	0.036 ***	0.024 ***	0.023 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Forward citations after 5 years (log)	0.032 ***	0.032 ***	0.014 ***	0.014 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Technological classes (log)	-0.003 ***	-0.003 ***	-0.010 ***	-0.010 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Non-patent literature references (log)	0.011 ***	0.010 ***	0.002 ***	0.002 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Number of Claims (log)	0.000	-0.001	0.009 ***	0.009 ***
	(0.001)	(0.001)	(0.001)	(0.001)

(Continued)

TABLE 5
(CONTINUED)

Dependent variable	1978-1999		2000-2007	
	Model 1	Model 2	Model 3	Model 4
Inventors (log)	0.002	0.002	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
XY Type backward citations (log)	0.007 ***	0.007 ***	0.001 ***	0.001 **
	(0.000)	(0.000)	(0.001)	(0.001)
Backward citations (log)	-0.002 **	-0.002 **	-0.005 ***	-0.005 ***
	(0.001)	(0.001)	(0.001)	(0.001)
PCT dummy	-0.006 ***	-0.004 ***	-0.005 ***	-0.005 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Divisional dummy	-0.009 ***	-0.005 ***	-0.012 ***	-0.006 ***
	(0.001)	(0.001)	(0.002)	(0.001)
Chi-squared (3) geographic origin	111.6 ***	81.4 ***	60.4 **	9.3 **
Chi-squared (2) institutional type	762.8 ***	758.6 ***	139.5 ***	133.0 ***
Chi-squared (2) size and age	257.3 ***	257.9 ***	39.3 ***	55.2 ***
Chi-squared all patenter characteristics	985.1 ***	963.9 ***	230.0 ***	383.1 ***
Pseudo R-squared	0.056	0.098	0.068	0.069
Number of observations (number=1)	775,888	775,888	325,684	325,684
	(50,078)	(50,078)	(11,935)	(11,935)

Notes: 1) Marginal effects and their robust standard errors are shown. Significance at 1% ***, 5% **, and 10% *. All equations include a complete set of priority year and technology dummies.
2) The variables definitions are reported in Tables 1, 2A, and 2B.

mentary search report and a negative one for renewal decisions: in fact, these variables are also a proxy of the complexity of the R&D process, and in terms of quality and value, a more complex inventive process could have a negative first order statistical dominance, though a positive second order one (Fleming 2004).

Patent family increases the probability of grant and renewals, whereas it reduces that of opposition. We find that patent family also positively

[13] In addition to the opposition system, a patent can be invalidated through a legal action in the courts, but this process is far more expensive than a post-grant review action, that has been estimated on average around €25,000 (Graham and Harhoff 2006).

TABLE 6
PROBABILITY OF RENEWAL CONDITIONAL ON
GRANT CHINESE PATENTS VS. ALL SAMPLE

Dependent variable	1980-1990		1991-1995		1996-2000	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
D (Indigenous R&D)	-0.036 *** (0.011)	-0.033 (0.298)	-0.020 ** (0.009)	-0.047 (0.229)	-0.023 *** (0.005)	-0.131 *** (0.044)
D (Inward FDI)	-0.057 *** (0.004)	-0.057 *** (0.004)	-0.050 *** (0.003)	-0.050 *** (0.003)	-0.013 *** (0.002)	-0.013 *** (0.002)
D (Outward FDI)	0.045 (0.035)	0.045 (0.035)	0.044 ** (0.022)	0.044 * (0.022)	0.014 (0.008)	0.014 (0.008)
D (Individual patenter)	-0.010 *** (0.001)	-0.010 *** (0.001)	-0.006 *** (0.001)	-0.007 *** (0.001)	-0.008 *** (0.001)	-0.008 *** (0.001)
D (Individual patenter) * D (Indigenous R&D)		-0.026 (0.029)		0.055 *** (0.021)		0.026 ** (0.013)
D (NBO Patenter)	-0.002 ** (0.001)	-0.002 ** (0.001)	-0.002 ** (0.001)	-0.002 ** (0.001)	0.000 (0.001)	0.000 (0.001)
D (NBO Patenter) * D (Indigenous R&D)		0.002 (0.035)		0.075 *** (0.029)		-0.007 (0.016)
Patenter's portfolio size	0.000 ** (0.000)	0.000 ** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.000 *** (0.000)	0.000 *** (0.000)
Patenter's portfolio size * D (Indigenous R&D)		-0.001 (0.01)		0.007 (0.014)		-0.005 ** (0.002)
Patenter's portfolio age	0.003 ** (0.001)	0.003 *** (0.001)	0.001 (0.001)	0.001 (0.001)	0.005 *** (0.001)	0.005 *** (0.001)
Patenter's portfolio age * D (Indigenous R&D)		0.003 (0.095)		-0.006 (0.081)		0.042 ** (0.016)
Family size weighted by GDP (log)	0.088 *** (0.002)	0.088 *** (0.002)	0.100 *** (0.002)	0.100 *** (0.002)	0.110 *** (0.002)	0.110 *** (0.002)
Family size (log)	0.067 *** (0.001)	0.067 *** (0.001)	0.054 *** (0.001)	0.054 *** (0.001)	0.052 *** (0.001)	0.052 *** (0.001)
Forward citations after 5 years (log)	0.004 *** (0.000)	0.004 *** (0.000)	-0.004 *** (0.000)	-0.004 *** (0.000)	-0.009 *** (0.000)	-0.009 *** (0.000)
Technological classes (log)	0.002 *** (0.001)	0.002 *** (0.001)	0.001 ** (0.001)	0.001 ** (0.001)	-0.002 *** (0.001)	-0.002 *** (0.001)

(Continued)

TABLE 6
(CONTINUED)

Dependent variable	1980-1990		1991-1995		1996-2000	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Non-patent literature references (log)	-0.005 *** (0.000)	-0.005 *** (0.000)	-0.005 *** (0.000)	-0.005 *** (0.000)	-0.004 *** (0.000)	-0.004 *** (0.000)
Number of Claims (log)	0.006 *** (0.001)	0.006 *** (0.001)	0.002 *** (0.001)	0.002 *** (0.001)	0.000 (0.001)	0.000 (0.001)
Inventors (log)	-0.002 ** (0.001)	-0.002 ** (0.001)	-0.004 *** (0.001)	-0.004 *** (0.001)	-0.003 *** (0.001)	-0.003 *** (0.001)
XY Type backward citations (log)	0.002 *** (0.000)	0.002 *** (0.000)	0.003 *** (0.000)	0.003 *** (0.000)	-0.001 *** (0.000)	-0.001 *** (0.000)
Backward citations (log)	-0.028 *** (0.001)	-0.028 *** (0.001)	-0.025 *** (0.001)	-0.025 *** (0.001)	-0.020 *** (0.000)	-0.020 *** (0.000)
PCT (dummy)	-0.011 *** (0.001)	-0.011 *** (0.001)	-0.004 *** (0.000)	-0.004 *** (0.000)	-0.004 *** (0.000)	-0.004 *** (0.000)
Divisional (dummy)	-0.004 *** (0.001)	-0.004 *** (0.001)	-0.011 *** (0.001)	-0.011 *** (0.001)	-0.018 *** (0.001)	-0.018 *** (0.001)
Chi-squared (3) geographic origin	5.0 ***	29.4 ***	47.3 ***	45.1 ***	16.6 ***	12.9 ***
Chi-squared (2) institutional type	72.6 ***	72.0 ***	32.3 ***	33.0 ***	40.7 ***	41.8 ***
Chi-squared (2) size and age	16.9 ***	17.0 ***	97.9 ***	97.6 ***	40.1 ***	39.1 ***
Chi-squared all patenter characteristics	50.7 ***	33.2 ***	71.1 ***	49.0 ***	35.8 ***	26.5 ***
Pseudo R-squared	0.133	0.133	0.126	0.127	0.135	0.135
Number of observations	175,591	175,591	204,529	204,529	244,868	244,868

Notes: 1) Marginal effects and their robust standard errors are shown. Significance at 1% ***, 5% **, and 10% *. All equations include a complete set of priority year and technology dummies.
2) The variables definitions are reported in Tables 1, 2A, and 2B.

affects the probability of getting a supplementary search report: this result does not contradict the claim that because there are differences in subject matter across the ISAs, the EPO examiners give more attention to the PCT filings originating from other ISAs which presumably have a broader geographical scope.[14] Overall, the remaining patent value indicators reduce the probability of grant, whereas they increase that of opposition. The impact on renewals is positive for the cohorts before year 1995, and negative for those after that year, which is plausible because in the latter case patent life cycle decisions suffers from an end-of-sample censoring.

For individuals or NBO's there is a negative probability of grant, opposition and renewal decision. We interpret this evidence with the assumption that these kind of patenters lack complementary assets in the market and hence their inventions are more abstract and general compared to the business patents (Henderson *et al.* 1998). Put differently, these inventions require further adaptations to become commercially viable and compared to business patents their time-to-market is much longer. Typically, the economic exploitation of these inventions take place through technology licensing programs and/or technology acquisitions by business firms.

Experience and size of the patenter's portfolio have a positive impact on granting and a negative one on supplementary search report. In this case, I think that the experience of these patenters makes them better at selection and drafting than inexperienced patenters, and enables them to recognize which inventions can be successfully patented and which cannot. For renewals, patenter experience and patent portfolio size have a positive impact, a finding consistent with the claim that large and established firms are less financially constrained than smaller sized innovators (Hall and Lerner 2010). In terms of oppositions, size and experience produce an interesting twist, because the size of the patenter's portfolio has a negative impact, while its experience has a positive one. This is seen in the skewness of the patent value distribution: large patenters who file many patents have higher patent propensity — *i.e.,* ratio of patents to R&D — and hence the average value of a given patent is lower (Hall and Ziedonis 2001). On the other hand, patents with higher commercial potential are those filed by serial innovators who also have more experience with the patent system (Hicks and Hedge 2005).

The findings on Chinese patenting depict a broader picture of the "strategic patenting" hypothesis, and it would be well to take into con-

[14] The European Patent Office serves as an International Search Authority for about two-thirds of the PCT filings, whereas the EPC contractual countries and the EPO are responsible for only 34.4% of the PCT first filings. Assuming there is no reason to believe that the decision to choose a given ISA is determined by the extent of the patent family, conditioned on the probability of filing a PCT, then we can conclude that on average a PCT filing with an ISA different from the EPO has a broader patent family.

sideration a few caveats. Firstly, when foreign MNEs employ Chinese inventors (Inward FDIs), we see a negative impact on granting decisions. Before the year 2000, this category of patent applications had 30.6 percent less probability of being granted the patent than other categories whereas the granting probability dropped to about minus 8.1 percent after that year. Being a foreign MNE in China has a positive impact on the opposition decision and a negative one on renewals — though the effects are quite small (on the order of one percent): the impact on renewal decisions before the year 2000 was about five percent. These finding are consistent with previous studies that claimed that foreign firms in China perform lower potential R&D, which can yield on average more incremental innovations (Hu and Jefferson 2009) and thus less valuable patenting. However, this conclusion needs to be interpreted with caution. First, the patents by MNEs in China are relatively strong regarding the prior art, which counters the statement of hypothesis 2: in fact, on average, they receive fewer supplementary search reports from examiners. Second, the effects are relatively small (except for a grant decision), which might underline not only lower value of the underlying invention but also less valuable patent premium for foreign MNEs in China, particularly before year 2000. Lastly, it is possible that some applicants deliberately seek a delay in processing their patent application because in this way they postpone payment of the associated fees and gain more time to understand the commercial potential of the technology they seek to patent. In some technological fields, it could be beneficial to delay the granting decision by several months in order to assess the commercial viability of their invention and monitor the evolution of the market and competition. In summary, keeping in mind these caveats, hypothesis 1 on “strategic patenting” for foreign MNEs employing Chinese inventors cannot be rejected.

For Chinese indigenous inventions, two different scenarios are in act regarding granting decisions before and after the year 2000. In the first period, there is a negative impact which is mediated neither by the institutional sector of the patenter nor by its size and patenting experience. After year 2000, there was negative probability of grant for indigenous Chinese patent applications by individuals and NBOs. Put differently, the probability of grant is positive for business patenters, the excluded category; this observation is also corroborated by the positive impact of experience and size of the patenter. Thus, hypothesis 1 with respect to the granting decision is rejected for business patenters, whereas accepted for individuals and NBOs.

Regarding hypothesis 2 about the examiner's prior art search, indigenous Chinese have 41.1 percent probability of getting a supplementary search report. We think this is not related to subject matter, but is fueled by the lack of suitable research into prior art. Indeed, the Chinese SIPO has been quite conservative on the patentability of software and business methods, and even chemical, pharmaceutical and food and beverage inventions only became patentable in 1992 (Liang and Xue 2010). The lack of relevant prior art research is associated with individuals and business patenters, but not with NBOs. Also, the size and younger age of the patenter positively mediate the probability of getting an supplementary search report. Thus, hypothesis 2 is substantially confirmed.

There is also support for hypothesis 1 regarding opposition, in particular there was about 4.1 percent higher probability during the period 2001-2007 that a third party would request a post-grant review in the case of a Chinese indigenous patent. This is not a small percentage considering that an opposition action is costly for a third party [about €25,000 (Graham and Harhoff 2006)]. We cannot trace the effect of the patenter's institutional sector because no oppositions were received by NBOs and only one by individuals. However, the mediating effects of patenter size and patenting experience can be estimated, revealing that large and young patenters are targets for a higher number of oppositions. This is in line with the claim by Eberhardt *et al.* (2010) that the bulk of Chinese patenting is filed by recently founded firms in a few industries with very high patent propensity.

We think that the higher opposition rates for Chinese indigenous patenting is not related to higher patent value but to the opposite: lower patent quality. Third parties consider them more controversial because they lack suitable prior art research (that is, they receive more supplementary search reports by examiners). This claim is also corroborated by the renewal rates decisions. During priority years 1996-2000, Chinese indigenous patents had a shorter life cycle compared to other Chinese patents and patenting in general. Being a large and less experienced patenter has a negative impact on patent renewal decisions. Quite surprisingly, individuals and the non-business sector renew for a longer time period, a result that prompts the desire for further investigation into how these patents are exploited economically. To sum up, there is confirming evidence for hypothesis 1 with respect to renewal decisions for larger and younger patenters, but not for individuals and NBOs. In conclusion, regarding our two testable hypotheses, there seems to be no differential effect for the outward FDIs of Chinese MNEs inventing abroad.

VI. Conclusions

This paper has offered one of the first analyses in the literature of the determinants of the quality and value of Chinese patenting at the international level. It has discussed the implications of the "strategic patenting" hypothesis, according to which companies file patents not to protect real products in the market but also for strategic reasons (Hall and Ziedonis 2001), and has drawn upon the literature to develop two testable implications and then examined them using econometric analysis.

A novel dataset has been developed based on the population of EPO and PCT filings, in such a way as to avoid potential selection issues, and a new taxonomy has been proposed to account for the geographical location where the R&D invention process takes place and where R&D innovators come from. Two main groups of owners have been defined regarding Chinese inventions: indigenous patenting by Chinese patenters relying on domestic inventors, and foreign MNEs off-shoring R&D in China, and thus employing local inventors.

The econometric model has been used to attempt to trace how patenter geographic origin, institutional sector, and characteristics such as size and experience impact patent quality and value. The results obtained are generally consistent the "strategic patenting" hypothesis for the two groups of patenters, with some caveats. On the one hand, except in granting decisions the effects for foreign MNEs are relatively small, particularly after the year 2000, and thus it would be wise to examine more carefully not only the estimation of the patent value of the invention, but also of the patent premium related to its IPR protection. These patents are also robust from the prior art point of view (less probability of getting a supplementary search report). Conversely, ample evidence confirms that Chinese indigenous patents are considered more controversial, and are targets of more oppositions, probably because of the lack of prior art research (obtaining an supplementary search report) rather than because it has a higher value. Indeed, a shorter renewal life cycle characterizes Chinese indigenous patents compared to other Chinese patents and patenting in general (the finding is particularly remarkable for the cohort 1996-2000). These effects are positively mediated by the patenter's size and experience, in this case, larger and younger patenters that are concentrated in a few industries with high patent propensity, which adds further evidence in favor of the "strategic patenting" hypothesis.

Future research could advance in several directions. First of all, it is of high interest to understand how patents are used by firms, individual inventors and NBOs. For firms, analysis of the impact on performance, in terms of total factor productivity, the firm's growth and profitability, and other factors, could shed light on the returns of investing in R&D in China compared to other countries. On the other hand, the large share of patenting (and renewals) by individuals and NBOs demands further investigation into how these patents are exploited in licensing, commercialization, launching a new technology venture, *etc.* One of the main drawbacks of this research agenda is the paucity of data, and scholars need not only to identify novel data sources, but also to carefully assess them in terms of coverage and selection bias.

A second direction of research regards the impact of geographical dimension on patent value and quality. As discussed above, patenting is highly concentrated in a few Chinese regions. On the one hand, this depends on the pre-existent industrial specialization of regions, which has given rise to industries with high R&D intensity and high patent propensity. On the other hand, local governments have implemented active policies to promote patenting at various levels, including financial and non-financial incentives. In this regard, it would be interesting to evaluate the impact of policy changes in patent fee compensation programs on patent quality and value.

Third, the finding that Chinese patents owned by businesses have shorter renewal life cycle calls for a careful analysis to distinguish the patent's invention value from the patent premium: in this direction, one could study how the different patterns of renewals of the same invention change in the different patenting systems — including China's SIPO — as a base for devising an indicator for patent premium in China.

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Appendix: Descriptive Statistics

	Overall dataset excluding Chinese patents		Chinese patents					
			Set 1		Set 2		Set 3	
			Indigenous R&D		Outward FDI		Inward FDI	
Observations	2,162,055		7,573		1,089		22,076	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Granted (dummy)	0.506	0.500	0.264	0.441	0.352	0.478	0.274	0.446
Supplementary Search Report (dummy)	0.114	0.318	0.565	0.496	0.174	0.380	0.189	0.392
Opposed (dummy)	0.029	0.166	0.010	0.100	0.006	0.074	0.011	0.104
Scope Year Index	0.184	0.078	0.153	0.076	0.193	0.074	0.200	0.085
Applicant being Individual (dummy)	0.061	0.240	0.169	0.375	0.028	0.166	0.027	0.162
Applicant being NBO (dummy)	0.039	0.193	0.059	0.236	0.037	0.188	0.049	0.216
Size (log)	4.720	2.831	4.141	3.538	3.404	2.793	5.481	2.722
Experience (log)	3.192	0.508	2.238	0.523	2.616	0.727	3.129	0.576
Family size weighted by GDP (log)	0.525	0.152	0.585	0.123	0.553	0.144	0.705	0.245
Family size (log)	0.696	0.312	0.771	0.240	0.761	0.300	1.142	0.885
Forward citations after 5 years (log)	0.600	0.559	0.420	0.439	0.518	0.517	1.141	1.033
Technological classes (log)	0.554	0.282	0.570	0.256	0.527	0.244	0.675	0.381
Non-patent literature references (log)	0.476	0.588	0.548	0.471	0.418	0.536	1.096	1.024
Number of Claims (log)	0.692	0.388	0.942	0.548	0.756	0.479	0.734	0.533
Inventors (log)	0.531	0.255	0.524	0.287	0.469	0.237	0.720	0.324
XY Type backward citations (log)	0.500	0.546	0.469	0.466	0.497	0.495	0.427	0.493
Backward citations (log)	0.703	0.483	0.671	0.382	0.708	0.446	1.234	1.090
PCT (dummy)	0.418	0.493	0.740	0.439	0.464	0.499	0.630	0.483
Divisional (dummy)	1.081	0.395	1.049	0.310	1.108	0.453	1.204	0.606

Notes: 1) SET 1 relies on the indigenous inventions when both the inventors and patenters originate from China. SET 2 is made up of outward R&D FDIs when Chinese firms employ foreign inventors. SET 3 is based on inward R&D FDIs when MNEs employ Chinese inventors.

2) The dataset is made up of INPADOC patent families with at least an EPO equivalent. Patent indicators have been aggregated at the patent family level. Citation and family links are consolidated both on the citing and cited side. The other indicators - with the exception of the binary variables - are at the median value levels. For size and experience variables I included the patenter with the largest value.

References

Amighini, A., Rabellotti, R., and Sanfilippo, M. "Outward FDI from Developing Country MNEs as a Channel for Technological Catch-up." *Seoul Journal of Economics* 23 (No. 2 2010): 239-61.

Arora, A., Ceccagnoli, M., and Cohen, W. "R&D and the Patent Premium." *International Journal of Industrial Organization* 26 (No. 5 2008): 1153-79.

Bessen, J. "The Value of U.S. Patents by Owner and Patent Characteristics." *Research Policy* 37 (No. 5 2008): 932-45.

China IP. Who Is Making Junk Patents? China Intellectual Property, by Jody Lu, Appeared on March 6th, 2011.

Crescenzi, R. A., Rodríguez-Pose, A., and Storper, M. The Territorial Dynamics of Innovation in China and India. IMDEA Working Papers Series 2012/09, 2012.

Eberhardt, M., Helmers, C., and Yu, Z. Is the Dragon Learning to Fly? An Analysis of the Chinese Patent Explosion. University of Oxford, CSAE Working Paper 2011/15, 2011.

Eun, J.-H., Lee, K., and Wu, G. "Explaining the 'University-run Enterprises' in China: A Theoretical Framework for University-industry Relationship in Developing Countries and Its Application to China." *Research Policy* 35 (No. 9 2006): 1329-46.

Fraser. The Fraser Institute — Measuring Global Patent Protection. The Economic Freedom Network, http://oldfraser.lexi.net/publications/forum/1999/03/patent_protection.html, 1999.

Gambardella, A., Harhoff, D., and Verspagen, B. "The Value of European Patents." *European Management Review* 5 (No. 2 2008): 69-84.

Ginarte, J. C., and Park, W. G. "Determinants of Patent Rights: A Cross-national Study." *Research Policy* 26 (No. 3 1997): 283-301.

Goldberg, I., Branstetter, L., Goddard, J. G., and Kuriakos, S. Globalization and Technology Absorption in Europe and Central Asia: The Role of Trade, FDI, and Cross-border Knowledge Flows. World Bank Working Paper No. 150, 2008.

Graham, S. J. H., and Harhoff, D. Can Post-Grant Reviews Improve Patent System Design? A Twin Study of US and European Patents. CEPR Discussion Papers No. 5680, 2006.

Grupp, H. "The Measurement of Technical Performance of Innovations by Technometrics and Its Impact on Established Technology

Indicators." *Research Policy* 23 (No. 2 1994): 175-93.

Guellec, D., and Van Pottelsberghe de la Potterie, B. "Applications, Grants, and the Value of Patent." *Economic Letters* 69 (No. 1 2000): 109-14.

Fleming, L. "Perfecting Cross-Pollination." *Harvard Business Review* 82 (September 2004): 22-4.

Hall, B. H. "Exploring the Patent Explosion." *Journal of Technology Transfer* 30 (No. 1 2005): 35-48.

Hall, B. H., and Lerner, J. "The Financing of R&D and Innovation." B. H. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation.* Vol. 1, Amsterdam: Elsevier, pp. 609-639, April 2010.

Hall, B. H., Thoma, G., and Torrisi, S. The Market Value of Patents and R&D: Evidence from European Firms. NBER Working Paper No. 13426, 2007.

________. "Financial Patenting in Europe." *European Management Review* 6 (No. 1 2009): 45-63.

Hall, B. H., and Ziedonis, R. "The Patent Paradox Revisited: an Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995" *The Rand Journal of Economics* 32 (No. 1 2001): 101-28.

Harhoff, D., Scherer, F. M., and Vopel, K. "Citations, Family Size, Opposition, and the Value of Patent Rights." *Research Policy* 32 (No. 8 2003): 1343-63.

Harhoff, D., and Reitzig, M. "Determinants of Oppositions against EPO Patent Grants: The Case of Biotechnology and Pharmaceuticals." *International Journal of Industrial Organization* 22 (No. 4 2004): 443-80.

Harhoff, D., and Thoma, G. Inventor Location and the Globalization of R&D. Paper Presented at the Conference on Patent Statistics on Decision Makers, Vienna, Austria, November 17-18th, 2010.

Harhoff, D., and Wagner, S. "Modelling the Duration of Patent Examination at the European Patent Office." *Management Science* 55 (No. 12 2009): 1969-84.

Henderson, R., Jaffe, A., and Trajtenberg, M. "Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting 1965-1988." *Review of Economics and Statistics* 80 (No. 1 1998): 119-27.

Hicks, D. M., and Hegde, D. "Highly Innovative Small Firms in the Markets for Technology." *Research Policy* 34 (No. 5 2005): 703-16.

Hu, G. A. "Propensity to Patent, Competition and China's Foreign Patenting Surge." *Research Policy* 39 (No. 7 2010): 985-93.

Hu, G. A., and Jefferson, G. "A Great Wall of Patents: What Is Behind China's Recent Patent Explosion?" *Journal of Development Economics* 90 (No. 1 2009): 57-68.

Hu, M. C., and Mathews, J. A. "China's National Innovative Capacity." *Research Policy* 37 (No. 9 2008): 1465-79.

JEGPE. Comparative Study Report on Inventive Step. Published by the Joint Experts Group for Patent Examination between JPO, KIPO, and SIPO, Available at http://www.jpo.go.jp/torikumi/kokusai/kokusai3/pdf/nicyukan_hikakuken/jegpe_comparative_study.pdf, 2010.

Lanjouw, J. O., and Schankerman, M. "Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators." *The Economic Journal* 114 (No. 495 2004): 441-65.

Lerner, J. "The Importance of Patent Scope: An Empirical Analysis." *The Rand Journal of Economics* 25 (No. 2 1994): 319-33.

Liang, Z., and Xue, L. "The Evolution of China's IPR System and Its Impact on the Patenting Behaviours and Strategies of Multinationals in China." *International Journal of Technology Management* 51 (Nos. 2-4 2010): 469-96.

Martinez, C. Insight into Different Types of Patent Families. OECD Science, Technology and Industry Working Paper 2010/2, OECD Publishing, Paris, 2010.

Meyer, M. "Does Science Push Technology? Patents Citing Scientific Literature." *Research Policy* 29 (No. 3 2000): 409-34.

OECD. OECD Patent Statistics Manual. OECD, Paris, 2009.

________. Territorial Reviews: Guangdong, China 2010. OECD, Paris, 2010.

Papageorgiadis, N. P., and Cross, A. R. Measuring the Institutional System of Patent Protection and Enforcement: a New Index of 46 Countries. Uppsala University, University of Leeds, Working Paper, 2011.

Park, W. G. "International Patent Protection: 1960-2005." *Research Policy* 37 (No. 4 2008): 761-66.

PatStat. EPO Worldwide Patent Statistical Database. Available under License from OECD-EPO Task Force on Patent Statistics, April 2012.

Putnam, J. The Value of International Patent Rights. Ph. D Thesis, Yale University, 1996.

The Economist. *Patents, Yes; Ideas, Maybe Chinese Firms Are Filing*

Lots of Patents. How Many Represent Good Ideas? October 14th, 2010.

Thoma G., Torrisi, S., Gambardella, A., Guellec, D., Hall, B. H., and Harhoff, D. Harmonizing and Combining Large Datasets – An Application to Firm-Level Patent and Accounting Data. NBER Working Paper No. 15851, 2010.

Van Pottelsberghe, B., and Van Zeebroeck, N. "A Brief History of Space and Time: The Scope-year Index as a Patent Value Indicator Based on Families and Renewals." *Scientometrics* 75 (No. 2 2008): 319-38.

Von Graevenitz, G. The Impact of Recessions on the Utilization of Intellectual Property. Paper Presented at the OECD Workshop on Trademarks and Trademark Data, OECD, Paris, July 17th, 2009.

Wright, B., Cao, S., and Lei, Z. Utility Models vs. Invention Patents: Why File Utility Models for Good Inventions in China? University of Berkeley Working Paper, 2011.

Wright B., and Lei, Z. Patenting Subsidy and Patent Filing's in China. University of Berkeley Working Paper, 2011.