Innovation in the emerging economy of China:
Transnational patenting and citation trajectories

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ABSTRACT

Intellectual property rights (IPR), specifically patents, have increasingly played a central role in empirical research on innovation. Patents provide rich, fine-grained details on innovation by precisely identifying the inventors, assignees, regions, times and innovative characteristics of every filed invention. Patent citations often serve as a proxy for approximating knowledge flow and spillovers. They also serve as a proxy for ascertaining the importance of knowledge being patented. One must remember that citations are a comparative measure and as such differences in policies regarding citation would not only affect the absolute numbers but also, its derived measures such as importance. In other words, citations received by a patent from patents filed in a low IPR protection region (like China) may not be more indicative of actual knowledge transfer than those from a patent filed in a high IPR protection region (say the U.S.). It may thus also be more indicative of the importance of the cited work.

In this thesis, we compare citation trajectories of matching patents granted for the same invention in both China and the U.S. and put forth four propositions related to patent citations. We find that patents filed in China are cited less than their counterparts in the U.S., and have a higher percentage of foreign citations. Within China, we find that patents from regions with high relative technological advantage receive more citations, though this does not hold true for regions with high specialization. These findings have implications for the measurement of the value of innovations as well as for intellectual property policy and firm strategy.

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This study would not have been possible without the continued support and guidance from professor Kenneth Huang.

The data for this study primarily comes from State Intellectual Property Office (SIPO) PRC and the U.S. Patent and Trademarks Office (USPTO). A constructed set of U.S.-China patent dyads is also used, adopted from Huang (2011).

DEDICATIONS

This thesis is dedicated to my brother, Arpit Guglani. Whose presence facilitated the process by making it more enjoyable.

CHAPTER 1

INTRODUCTION

Patents offer a means to stake claim over the ownership of intellectual property as an exclusionary measure. Patenting has become prevalent across a wide range of industries. Everything from genes to computer software can be, and is being patented. To ensure protection, the same patent is often applied for, in multiple jurisdictions. This is referred to as “transnational patenting” (Huang, 2011). The advent of the Patent Cooperation Treaty (PCT) failed to curb transnational patenting, as one still needs to apply for the patent through local agents in desired jurisdictions. There is no “international patent”. With business operations spread all across the world and unprecedented globalization, transnational patenting has become increasingly critical for innovating firms.

From a research perspective, transnational patenting offers a rich set of data-points for comparison of impact that intellectual property policy has on knowledge flow and accumulation (Huang, 2011). Since the same patent is being applied for in two or more jurisdictions the only difference in the treatment should be in response to the policies in place in the said jurisdictions. For example if citations were mandatory and required by law in one jurisdiction and voluntary in the other. Such a situation would lead us to expect vastly different citation trajectories, even for the “same” patents.

Citations specifically, are important as they are used as proxy measures for various attributes and as ingredients in the construction of many indices. The reach and impact of scientific and technological inventions, and in turn their importance, are often proxied via citations received. If policy was indeed responsible for a sizable difference in the number of citations received, this would need to be understood, for a meaningful continuation of use of citation counts as indicators for such measures.

The focus in the initial part of this study is thus directed towards patent citations and comparing citation trajectories of matching patents granted for the same invention in both China and the U.S. Thus comparing the impact that policy has, on otherwise the same patent.

Apart from citations, study of patenting activity in China is interesting for other reasons. Patenting activity in China is rising at exponential rates and yet, there is very little indication as to the value of patenting something in a low intellectual property protection jurisdiction.

The implications of this rapid patenting are still unfolding. There are differences in patenting patterns within China. There is concentration of high-technology patents and increase specialization of patenting in certain regions. As observed in other countries, one would expect to find certain relationships in the patenting patterns of certain regions and their relative patenting performance.

The latter part of the study is devoted to exploring regional differences in patenting within China. We construct novel data set and use econometric tools try to explore whether amassment of technological knowledge or high degree of specialization in knowledge in a certain region affects its patent output.

1.1 Citation Analysis

Few studies have sought to understand the differences in the treatment of citations by patent offices of different countries. For example, Michel and Bettels (2001) find a three-fold more citation in U.S. patents as compared to those filed in the EU just because of differences in policy. The authors argue that patents search reports may vary significantly in their completeness as a function of the patent office responsible for drawing up the report. The authors further stress that proper analysis based on citation data can only be performed by someone who is knowledgeable about the underlying reports and the general functional practices of the patent office responsible.

Citations have been used to chart the development of scientific inquiry (Small and Griffith, 1974); to evaluate the performance of academic departments (Wallmark, McQueen and Sedig, 1988) and of scientific research programs (Narin and Rozek, 1988; Vinkler, 1986); and have even been used in strategic planning (Van der Eerden and Saelens, 1991). They are still widely used to ascertain importance (Trajtenberg, 1990; Hall, B. H. and Ziedonis, R. H., 2001; K. Lim, 2004); to understand follow-on knowledge production and accumulation (Huang and Murray, 2009) and as indicators of spillovers (Jaffe, Trajtenberg and Henderson, 1993; Caballero and Jaffe, 1993). Given the explosive increase in patents in China (Hu and Jefferson, 2009; Huang 2010)[1] it becomes imperative to ascertain to what extent the relatively weaker patent enforcement and more liberal reporting policy of patent references of the State Intellectual Property Office (SIPO) of China influence citation patterns of patents filed in China.

Nevertheless, to our knowledge, there has been no study to date on patent citation for the Chinese patent data. Such a study would be important, as it would influence the interpretation of future citation related studies for Chinese patents. The primary efforts of this study are thus justly directed towards analyzing China patent citations and comparing the citation trajectories of matching patents granted for the same invention in both China and the U.S.

1.2 Geographical Technological Concentration

Over the past few decades, there have been a large amount of resources and foreign direct investments diverted towards China. This, among other things has led to a high growth rate of patents in China. Proponents of the "accumulation" view of growth (Krugman, 1994; Young, 1995; Collins and Bosworth, 1996) argue that this is merely the result of high savings and investments that have enabled China to better use technologies inherited from the world's technological leaders. In contrast, the proponents of the "assimilation" view (Dahlman, 1994; Hobday, 1995; Nelson and Pack, 1998;

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[1] Accompanying image from Hu and Jefferson (2009) showing patent growth, can be found in the Appendix

Kim, 1998) insist that the critical source of growth in China (and East Asia) has been productivity growth resulting from the learning, entrepreneurship and innovation that these economies have gone through, which has made not only adoption of foreign technologies but also development of indigenous technologies possible.

The high growth rate has led to rapid technology development in high-growth / key cities in China (e.g. Shanghai and Beijing) especially in recent years (Zhang and Song, 2001; Tseng and Zebregs, 2003). We will examine the patent data from China to understand China's regional innovative activities and gain in technical expertise. Specifically, we first focus on understanding China (SIPO) patent citations as compared to the United States Patent and Trademark Office (USPTO) patent citations and then on citations analyses as a proxy of knowledge flow and accumulation.

We look at patents filed in Chinese regions of high-technology patent concentration and those in regions with a high degree of specialization. These regional differences aid in the understanding of knowledge flows.

This research contributes to the literature on management of innovation and technology especially in intellectual property rights as most of previous studies using patent data has focused on patenting activity in developed countries (e.g. the U.S. and western European countries) because the extent of patenting from other countries was traditionally too small in comparison to be considered meaningful for analyses. However, over the past two decades, many other emerging economies such as China have started to patent heavily, opening up an opportunity for more research using patent data.

CHAPTER 2
LITERATURE REVIEW AND PROPOSITIONS

2.1. Citation Analysis

Citations have been used as an indicator of importance since the early 90's (Trajtenberg, 1990). They have since been employed to infer various related measures such as spillovers (Jaffe, Trajtenberg and Henderson, 1993, Caballero and Jaffe, 1993), and as ingredients in the construction of measures for other features of innovations, such as "originality" and "generality" (Trajtenberg, Jaffe and Henderson, 1997).

Citations, as a measure though, are imperfect and have their limitations. To alleviate some of these concerns, measures derived from patent citation counts should consider organization's self-citations, and citations added for strategic or other reasons, such as examiner-added citations due to directions from the patent office. Similarly, citations may be omitted for various reasons. Alcacer and Gittelman (2006), note that using citations as an indicator of knowledge flows assumes the claim that citations form the mechanism behind the knowledge flows. This may not always be the case as citations may be added for reasons such as avoiding litigation or clarifying claims, with a large fraction added by lawyers or patent examiners rather than the inventors themselves. It is still not clear how to interpret such citations. For example, to the extent that inventors have strategic motives for omitting citations, including examiner-added citations might actually be desirable (Lampe, 2011). While considering citations as a measure or indicator, one must consider these drawbacks, and where possible, correct for them.

If the study involves patents across industries, it must adjust for differences caused by the field / industry specific citation behavior. If the study encompasses patents from more than one legal jurisdiction, the measures must be further adjusted for differences in the patenting policies across the different legal systems. Finally, one must remember that citations are still only a relative measure and can be misleading devoid of proper application of such adjustments. Some of these issues have been described by Hall and Ziedonis (2001).

Citations form an integral part of understanding the complex innovative environment. There are patents, trade secrets, copyrights and many other devices employed to gain protection of intellectual property. Even with the many limitations , citations offer a means to infer importance of an intellectual work, by serving as a proxy for the importance of the knowledge. This makes patent citations useful even if only a fraction of all inventions is manifested in the form of patents.

There are some differences in the way the State Intellectual Property Office (SIPO) of China operates as compared to the other major patent examination and granting offices in other jurisdictions. In this study we compare the citation trajectories of matching patents granted for the same invention in both China and the U.S. (Huang, 2011) We choose the U.S., since citations provide a relative measure and most of the literature is around the patents from the U.S. Patents and Trademarks Office (USPTO).

Unlike in the U.S. – where citations are a legal requirement verified by the patent office – declaration of references in the patent documents (i.e, backward citations) is not mandatory in China. This would have implications on the citation count. Since a patent search requires additional effort on the part of the author, and could serve to weaken the originality of the patent if it were ever to be contested in court. This voluntary citation practice in China would reduce the incentive for the assignee to conduct a comprehensive search for prior claims. We expect omissions of citation (strategic or otherwise) to manifest in Chinese patents. So one would expect the Chinese patents to have less number of citations than their U.S. counterparts. This leads us to our first proposition:

P1: *The average citation count per patent should be lower for Chinese patents as compared to patents filed in the U.S.*

It would be important to investigate the difference in number of citations between patents filed under strong and weak intellectual property rights environments.

Citations are a useful proxy for studying knowledge flow. Prior literature suggests there is a substantial amount of technology transfer from and investments by neighboring countries such as Korea and Japan which help to shape the core technological capabilities of China and allow Chinese technologies to build on (e.g., Huang, 2010). This could be reflected in the patent citations. As such we would expect to see more Chinese patents building on patented knowledge from outside of China such as neighboring countries like Korea and Japan which invest heavily in China. This could be manifested in higher number of cited patents (i.e., backward citations) from outside China. On the other hand, the U.S. is the global leader in science, technology and intellectual property rights. Relative to SIPO patents, focal U.S. patents may build more on other U.S. technologies captured in other USPTO patents assigned to U.S. assignees. Accordingly, these focal U.S. patents should capture less backward citations to patents assigned to non-U.S. entities. This leads us to our next proposition:

P2: *The percentage of SIPO patents assigned to non-China entities cited by focal Chinese patents will be greater than the percentage of USPTO patents assigned to non-U.S. entities cited by focal U.S. patents.*

2.2. Geographical Technological Concentration

In the past two decades, China has witnessed exceptional GDP growth rates and growth rates per capita through investment levels that are enhanced through large flows of foreign direct investment (Hu and Mathews, 2008). The Chinese government and government related institutions have also played a key role in organizing and directing investment and technology development efforts in key regions in China such as Beijing, Shanghai and Guangdong, especially after the at least two serious reforms of the Patent Law.

The firms and organizations in these key regions have benefitted greatly from the inflow of investment and we believe, that over time they would have come to harness highly specialized knowledge.

Mahmood and Singh (2003) have found an increasing technological capability over time in key countries and regions across East Asia such as Singapore, Taiwan, Hong Kong and Korea. Similar trend was observed in mainland China (as a whole) using a sample of USPTO patents assigned to Chinese entities (Hu and Mathews, 2008). Following this argument, we have the following propositions:

P3.a: *Citations to patents with assignees based in Chinese regions of high relative technological advantage (RTA) will be higher than those to patents with assignees outside these regions.*

This would be expected since these are the technological hubs and we expect to see a spillover effect. The firms in these regions would have more resources and access and draw more from other firms in the region leading to cumulating of knowledge reflected in the patents. Furthermore, over time we would expect to see an increasing trend of such knowledge accumulating at an increasing pace. Such a trend should be captured and observable in the citations. Thus we put forth the following propositions:

P3.b: *Citations to older patents with assignees based in Chinese regions of high relative technological advantage (RTA) will attract higher citation rates than those to older patents with assignees outside these regions.*

P3.c: *Citations to newer patents with assignees based in Chinese regions of high relative technological advantage (RTA) will attract higher citation rates than those to newer patents with assignees outside these regions.*

As these key regions slowly diversify from traditional sectors of production such as textiles, mining and food processing towards high-technology sectors like computing, semiconductor, pharmaceutical and chemicals, their high technological specialization should increase due to growth and acquisition of technological specialization over other regions (Bell and Pavitt, 1993; Amsden and Hikino, 1994). With time, their innovative activities (captured by patents) will intensify and increase across selected high-technology sectors of particular importance or strength to the region. This will lead to more even development of innovative activities across the selected high-technology sectors within these key regions of technology growth and more technological specialization. The impact on patent citations should capture such effects due to technological concentration. Thus we have the following propositions:

P4.a: *Citations to patents with assignees based in Chinese regions of high-technological specialization will be higher than those to patents with assignees outside these regions.*

P4.b: *Citations to older patents with assignees based in Chinese regions of high technological specialization (TSI) will attract higher citation rates than those to older patents with assignees outside these regions.*

P4.c: *Citations to newer patents with assignees based in Chinese regions of high technological specialization (TSI) will attract higher citation rates than those to newer patents with assignees outside these regions.*

In the following section, we will describe the data, methods and measures we used to test these propositions.

CHAPTER 3
DATA, METHODS AND MEASURES

3.1. The data

We analyzed a comprehensive data set from the State Intellectual Property Office (SIPO) of PRC, which consists of more than two million patent applications in China from 1985 to 2006 yielding 959,548 granted patents. For the purposes of this study, we considered only the subset of granted patents. As shown in Table 1, both the number of patents applied and patents granted in China across all sectors in all regions have increased significantly over each application year.

Table 1: Number of Patents Applied and Granted in China by Application Year

Patent Application Year	Number of Patents Applied	*Number of Patents Granted*
1985	12566	*4277*
1986	16018	*8069*
1987	22480	*12214*
1988	27350	*15145*
1989	27212	*13642*
1990	32178	*18719*
1991	38498	*23292*
1992	48653	*33384*
1993	54655	*35583*
1994	57038	*33578*
1995	60124	*33034*
1996	67617	*35055*
1997	72929	*36107*
1998	79275	*38821*
1999	90035	*46087*
2000	110394	*53578*
2001	129643	*62116*
2002	161789	*73840*
2003	199879	*83552*
2004	226418	*88998*
2005	267624	*106016*
2006	216644	*104441*
TOTAL	**2,019,019**	***959,548***

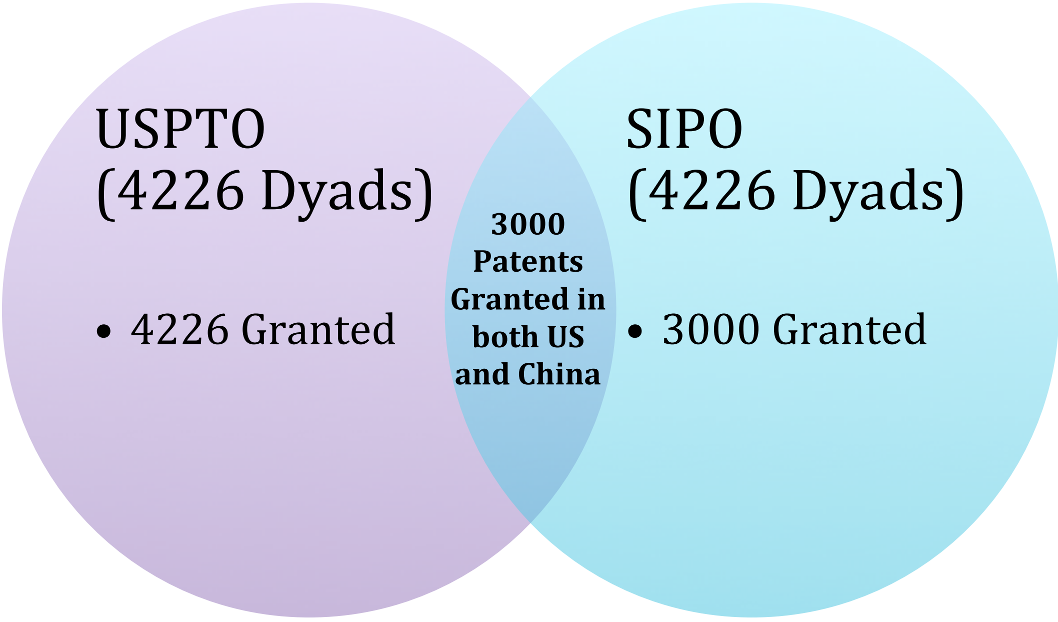
For the propositions relating to comparison between the citations for Chinese and U.S. patents (proposition 1 and 2) we used a subset of the above, identifying patent pairs filed in both the jurisdictions (China and the U.S.).

We used a data set of 4226 patents, taken from Huang (2011), which identified the set of patents first applied in China with the SIPO and subsequently in the U.S. with the USPTO. Since these patents were first applied for in China, all these patents have a Chinese priority. Thus, this represents technology originating from China and subsequently patented in the U.S. This set of 4226 U.S.-China patent dyads captures only USPTO invention (i.e., utility) patents which are precisely matched to both SIPO invention and utility model patents.

The matching 4226 U.S.-China patent dyads were generated based on priority in SIPO. A priority enables the subsequent application of the same patent in another jurisdiction to enjoy certain benefits, such as a retroactive grant date, same as the one in the jurisdiction where the patent has been granted with priority. Priorities enable us to match one-to-one the same invention being patented in both jurisdictions. Priorities also enable us to ensure where the origins of the knowledge lie. For the purposes of this study and dataset constructed contains patents whose priorities lie with SIPO PRC.

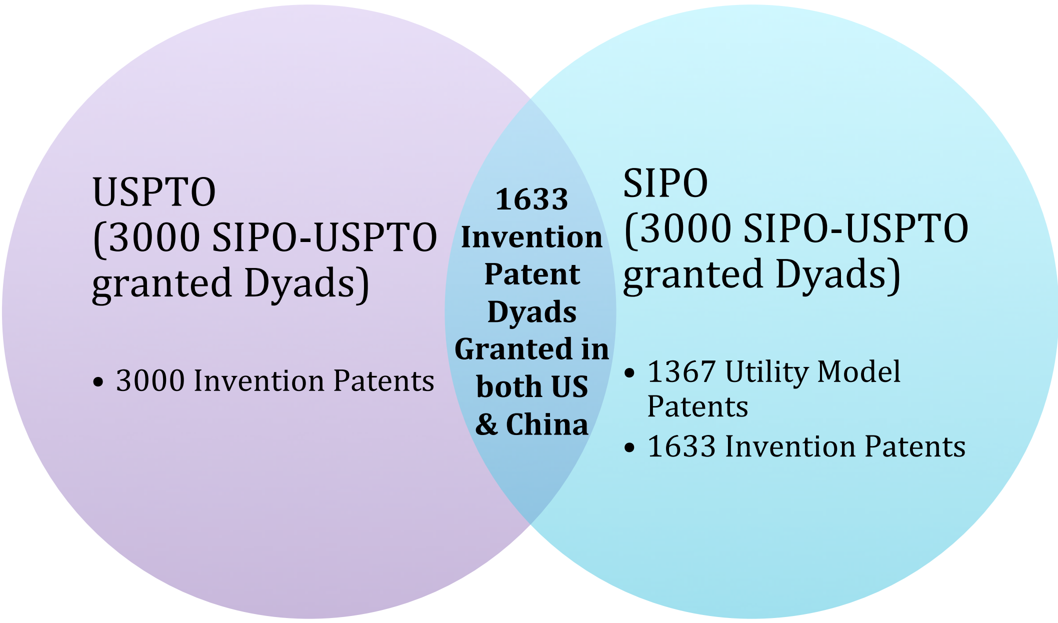
Specifically, using patent data from both the U.S. (USPTO) and China (SIPO), Huang (2011) constructed a subset of 4,226 U.S.-China patent dyads such that each patent had a priority in China and was subsequently applied for, and granted in the U.S. by the USPTO. Building upon this dataset by adding variables (such as citation data, inventor type, patent classification and others) we arrived at the initial data for this study (figure 1)

Figure 1: Patent dyads – granted in both jurisdictions.



Out of the 4226 U.S.-China patent dyads (all granted by USPTO), 3000 patents were found to have been also granted by the SIPO (figure 2).

Figure 2: Patent dyads – Invention patents (with citations).



Since SIPO utility model patents go through a slightly different examination process from the SIPO invention patents which does not require or capture patent citations, we were left with 1633 invention patent dyads (that were granted in both jurisdictions. This is part of the granted sub-set of the SIPO database.

Further for propositions 3.a, 3.b and 3.c we used the Relative Technological Advantage (RTA) – explained below in section 3.2 – which is computed by considering patents belonging to 12 high-technology sectors.

While for propositions 4.a, 4.b and 4.c we used the Technical Specialization Index (TSI) to identify regions with highly specialized knowledge. This similarly is elaborated upon in the below, in section 3.3.

3.2. Measuring the Relative Technological Advantage

To understand the technological advantage across key high-technology sectors of different regions, we adopt from previous research (Soete, 1987; Archibugi and Pianta, 1992; Mahmood and Singh, 2003; Huang, 2010) and construct a "relative technological advantage" (RTA) index that measures the relative distribution of a region's innovative activity in each technology sector, taking into account the variation in propensity to patent across different sectors and regions (Scherer, 1983).

Formally, the RTA index for region i in sector j is defined as the ratio of region i's share of total China granted patents in sector j to region i's share of total China granted patents, i.e.

$$\mathrm{RTA}_{ij} \equiv \frac{n_{ij}/\sum_i n_{ij}}{\sum_j n_{ij}/\sum_i \sum_j n_{ij}}$$

where n_{ij} is the number of patents of region i in sector j.

A region i, is defined as Chinese special district, provinces or other countries with a patent granted in China (each as defined by SIPO). A sector j is defined as one of the technological area of inventions and utility models based on the international patent classification (IPC).

We also considered taking only the Chinese special districts and provinces as regions (and exclude patent assignees of foreign entities). This effectively makes the population of granted patents in China the total. Both calculations yielded similar RTA results since the contribution by the other countries is generally low.

The calculation of the RTA relies on our ability to identify the technology related patent. In order to calculate this index, we need to identify the technology patents in different sectors. Using the international patent classification (IPC) provided by World Intellectual Property Organization (WIPO), we can identify the key classifications for the high-tech sectors which are central to our analyses of technological innovation.

Table 2 below (adopted from Huang, 2010) highlights the sections from the IPC we have considered as the key technology sectors. These classifications were used for the calculation of the RTA as they were identified to be the key high-technology sectors based on previous literature (e.g. Mansfield, 1986). They range from medical technologies, pharmaceutical, life sciences - organic chemistry and genetics, to computing, electronics, semiconductors and nano-technology. The entire table of IPC is provided in the appendix for reference.

Table 2: High-technology Sectors Identified for Empirical Analysis (Adopted from Huang, 2010)

A61	MEDICAL OR VETERINARY SCIENCE; HYGIENE
B81	MICRO-STRUCTURAL TECHNOLOGY
B82	NANO-TECHNOLOGY
C07	ORGANIC CHEMISTRY (such compounds as the oxides, sulfides, or oxysulfides of carbon, cyanogen, phosgene, hydrocyanic acid or salts thereof C25B7/00) [2]
C08	ORGANIC MACROMOLECULAR COMPOUNDS; THEIR PREPARATION OR CHEMICAL WORKING-UP; COMPOSITIONS BASED THEREON (manufacture or treatment of artificial threads, fibres, bristles or ribbons D01)
C12	BIOCHEMISTRY; BEER; SPIRITS; WINE; VINEGAR; MICROBIOLOGY; ENZYMOLOGY; MUTATION OR GENETIC ENGINEERING
G02	OPTICS (making optical elements or apparatus C03C)
G06	COMPUTING; CALCULATING; COUNTING (score computers for games B43K29/08)
G11	INFORMATION STORAGE
H01	BASIC ELECTRIC ELEMENTS (includes semiconductor and devices)
H03	BASIC ELECTRONIC CIRCUITRY
H04	ELECTRIC COMMUNICATION TECHNIQUE

Table 3 shows the number of patents granted by patent grant year in these 12 high-technology sectors, which will be the focus of our empirical analyses. Again, the number is increasing by the year and these 12 sectors forms more than 18% of the total granted patents in China.

Table 3: Number of Patents Granted by Grant Year in the 12 High-tech Sectors (Adopted from Huang 2010, Table S3)

Patent Grant Year	Total for 12 Classes	Percent of SIPO Patents across all classes
1986	219	12.03
1987	676	13.09
1988	1182	12.97
1989	2326	14.74
1990	2892	13.88
1991	2774	14.3
1992	3538	14.03
1993	7429	14.29
1994	5825	14.86
1995	4325	13.27
1996	3974	13.22
1997	4987	15.9
1998	5188	14.64
1999	8745	14.52
2000	11839	17.41
2001	12665	17.39
2002	15043	18.71
2003	23228	22.24
2004	29388	24.38
2005	30392	22.87
2006	32836	20.3
TOTAL	**209471**	**18.72**

We now turn to the specifics of the RTA calculations. Since we are identifying the technology patents based on the international patent classification, it is entirely possible that a patent may fall under more than one classification. In such cases we calculate the fraction of each sector (based on IPC) over all the sectors this patent is classified under. For example, if a patent were filed under A61, B81, B82 and C07, each of the 4 sectors for this patent would be weighted as 0.25. In addition, we also calculated a combined RTA for the chosen 12 sectors by summing up the RTA in each region in each patent grant year across all 12 high-technology sectors.

3.3. Measuring overall degree of technological specialization

In order to measure how evenly or unevenly the patenting activities of a given country are distributed across all the sectors, we modified and constructed a technological specialization index (χ2 –index) defined as:

$$\chi_i^2 = \sum_j \left[\frac{(p_{ij} - p_{wj})^2}{p_{wj}} \right]$$

where j is the sector, P_{wj} the percentage of total patents in sector j and P_{ij} the percentage of patents held by region i in sector j. The more diverse a region is in its relative sectoral strengths and weaknesses, the greater the value of χ2. Since the χ2 -indices are calculated on the region's percentage distribution and not levels of activities across sectors, they make cross-regional comparisons in technological specialization meaningful. This is consistent with the approach used in previous studies such as Mahmood and Singh (2003).

3.4. Key variables and descriptors

Table 4: List of key variables

Variable Name	Definition
ID	Numeric ID, unique for each location
Location	Text location where the patent originates
Region	Numeric region code, to which the location belongs
Year	Numeric field ranging 1986 through 2007
RTA	The Relative Technology Advantage (as per section 3.2)
TSI	The Technology Specialization Index (as per section 3.3)
BKRef_GrantYr	Number of backward references for a particular location (grouped by the grant year)
BKRef_AppYr	Number of backward references for a particular location (grouped by the application year)
FWRef_GrantYr	Number of forward references for a particular location (grouped by the grant year)
FWRef_AppYr	Number of forward references for a particular location (grouped by the application year)

Table 5: Pairwise correlation of key variables

PWCORR	RTA	TSI	BKRef_ GrantYr	BKRef_ AppYr	FWRef_ GrantYr	FWRef_ AppYr
RTA	1					
TSI	0.7111	1				
BKRef_GrantYr	0.0531	-0.0065	1			
BKRef_AppYr	0.0698	-0.0076	0.2854	1		
FWRef_GrantYr	0.0446	-0.0063	0.5673	0.1327	1	
FWRef_AppYr	0.0635	-0.0064	0.2309	0.5911	0.2401	1

As seen in table 5, there is a high correlation between the RTA and TSI. This can be expected, as a high RTA would eventually manifest in the form of specialization. There is also appears to be a relation between the forward and backward citation counts.

CHAPTER 4

ANALYSIS AND RESULTS

4.1. Liberal Intellectual Property Protection and Citations

China, with its liberal patent enforcement and optional citation policy is expected to have a much lower rate of citations just due to the lack of incentive if not for other strategic reasons. The question then becomes, how much less is the citation rate when compared to a high intellectual property protection jurisdiction with mandatory citations, such as the U.S.

To answer this question we constructed a dataset of patent pairs (or dyads) for the same invention granted in both the U.S. and China. We then compared the foreign and domestic citations that each patent received. We grouped the counts by application years and grant years of the focal patents (filed in China).

Firgure 3:
Citation counts for patents filed at the USPTO by Patent Application Year

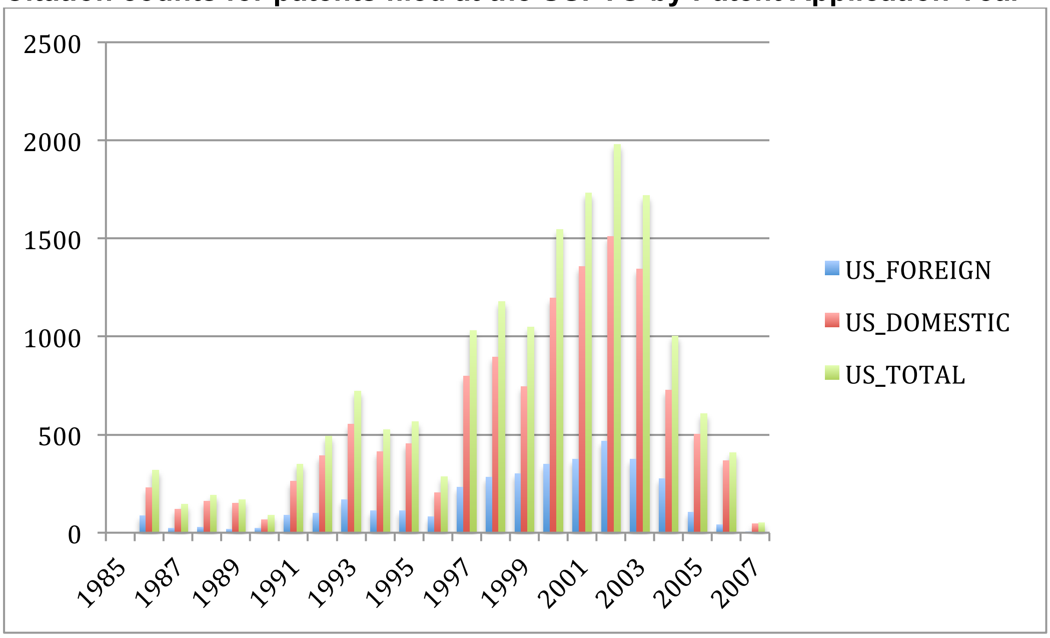
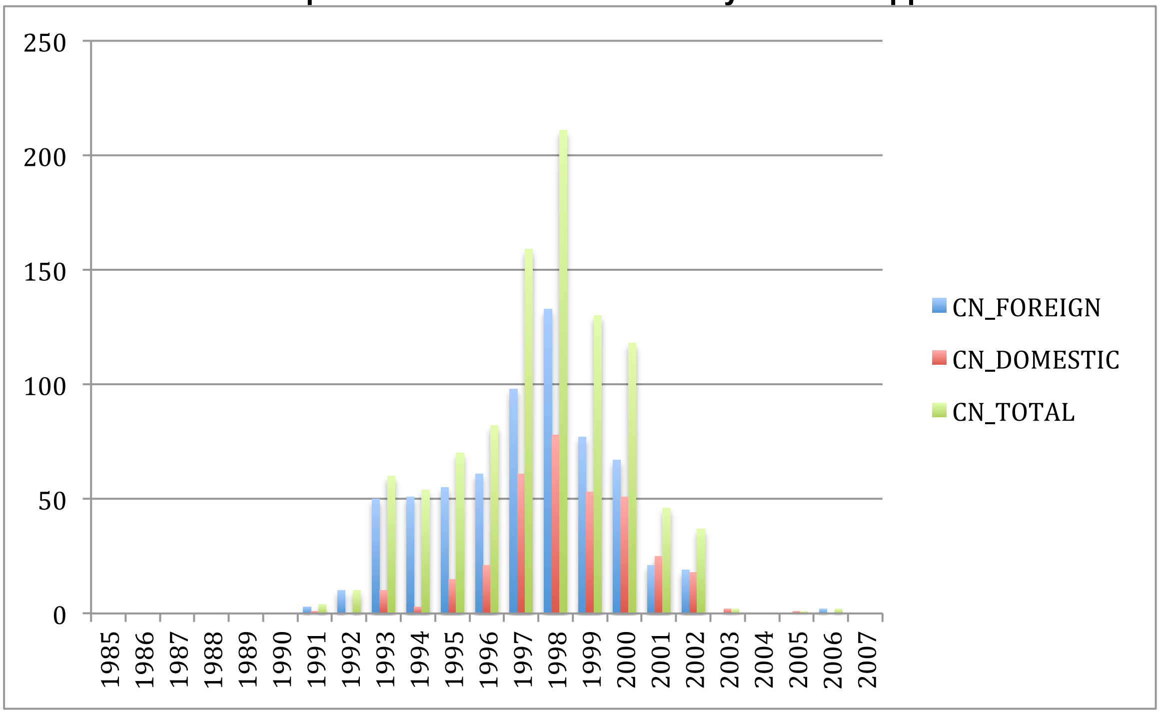


Figure 3 depicts the citation counts for patents filed under the USPTO. The counts are grouped by the patent application year. The U.S. Domestic citations (red) represent citations to publications of U.S. origin. U.S. Foreign citations (blue) are citations to publications whose origins lie outside of the U.S. The sum of the two is represented by U.S. Total (green). As is evident majority of the U.S. citations are domestic in nature.

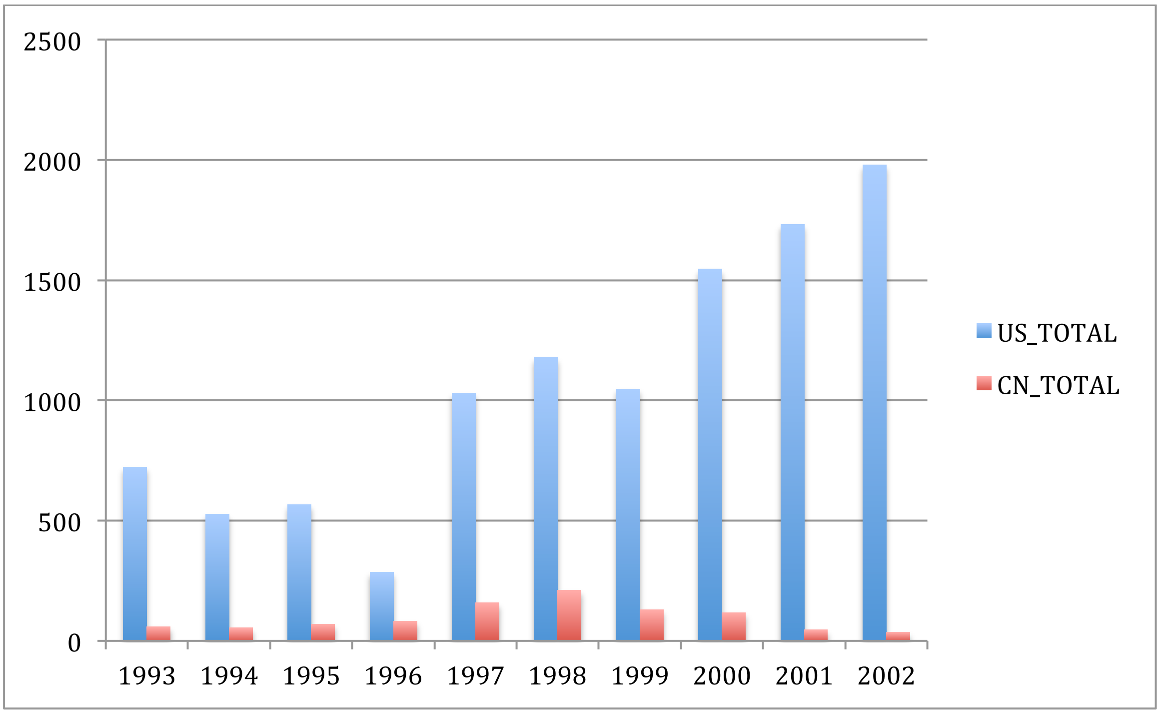
Figure 4:

Citation counts for patents filed at the SIPO by Patent Application Year



Similar to figure 3, figure 4 depicts the citation counts for patents, but filed under the SIPO. The counts are grouped again, by the patent application year. The China Domestic citations (red) represent citations to publications of Chinese origin. China Foreign citations (blue) are citations to publications whose origins lie outside of the China. The sum of the two is represented by China Total (green). As is evident majority of the Chinese citations are foreign in nature.

Figure 5: Totals of Domestic citation counts for the U.S. and China by Patent Application Year.



We take the U.S. totals (green bars from figure 3) and China totals (green bars from figure 4) as blue and red bars respectively in figure 5 for a side-by-side comparison. It is evident that not only is citation for the same invention lesser in China than it is in the U.S., as predicted in proposition 1, it is an order of a magnitude less.

The U.S. seems to procure about 3 to 50 times more citations per application year than the same patents filed in China in that year. On an average, U.S. patents exhibit 15 times more citations per year for the same patents being filed in China.

Out of the 1633 invention patents granted in both the U.S. and China, the patents filed under the USPTO had 15,975 citations with an average of 9.782 citations per patent. On the other hand the same patents filed in China had only 992 citations with an average of 0.607 citations per patent. By this measure, patents filed under the U.S. show 16.1 times more citations than the same patents filed under China.

Although it is now evident that there exists a big difference between the number of the citations cited by patents filed in the U.S. and China, there are differences beyond just the numbers. There are fundamental differences in the composition of the citations.

Figure 6: Percentage of Domestic citation counts for the U.S. and China by Patent Application Year

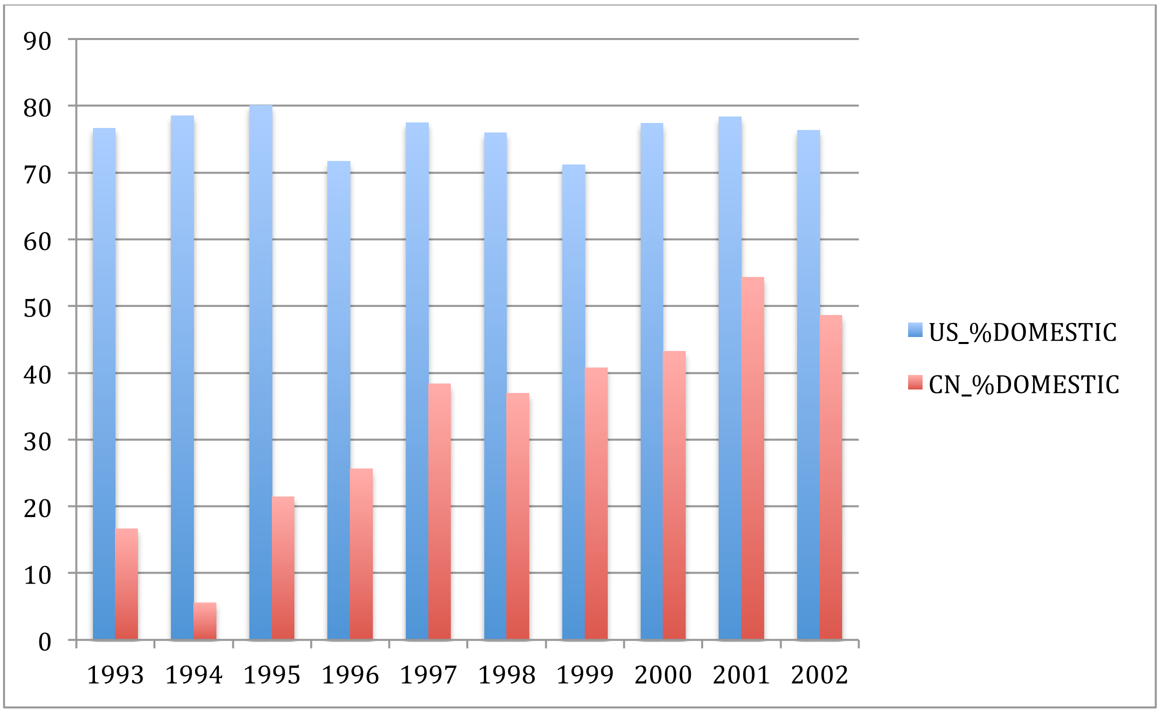


Table 6: Percentage of Domestic citation counts for the U.S. and China by Patent Application Year

	1993	1994	1995	1996	1997
US_%DOMESTIC	76.62517289	78.55787476	80.07054674	71.67832168	77.49757517
CN_%DOMESTIC	16.66666667	5.555555556	21.42857143	25.6097561	38.36477987
	1998	1999	2000	2001	2002
US_%DOMESTIC	75.99660729	71.18320611	77.42561449	78.34872979	76.35169277
CN_%DOMESTIC	36.96682464	40.76923077	43.22033898	54.34782609	48.64864865

Figure 6 and the accompanying table depict a side-by-side comparison of the percentage of domestic citations compared to the total citations for patents filed in both jurisdictions for application years 1993 through 2002.

At the patent level, out of the 1663 invention patents granted in both jurisdictions, the patents filed in China, under the SIPO expressed 320 domestic citations and just over twice as many foreign citations, at 652.

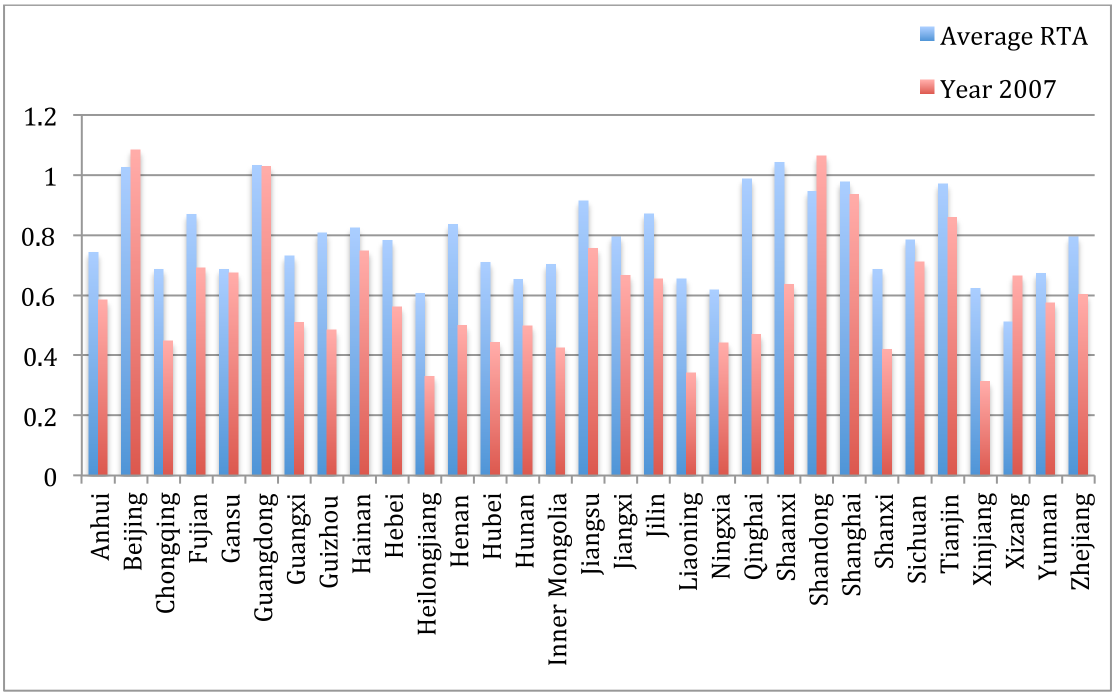
The case was very different for the same patents when filed in the U.S., under the USPTO. There were 12359 domestic citations. That is an average of 7.4317 domestic citations per patent. Comparatively, there was only a fraction of mentions of foreign citations; with 3616 foreign citations.

As predicted in proposition 2, the U.S. attains a much higher percentage of domestic citations than its Chinese counterparts. Therefore, proposition 2 is supported.

4.2. Relative Technology Advantage

We now turn to our results on the Relative Technology Advantage index (RTA) to look at the regional differences in patenting within China. We adapted the Relative Technology Index from Mahmood and Singh, 2003 wherein we consider each of the 31 provinces in China as a region. The figure below shows the cumulative RTA for all the regions (provinces) through 1986 to 2007.

Figure 7: Relative Technology Advantage (RTA) of the 31 Chinese Provinces for patent grant year 2007 and Average across the years (1986 through 2007).



The RTA was calculated for each of the chosen 12 category classes previously mentioned, across each of the 31 Chinese provinces through years 1986 to 2007. In addition a cumulative RTA was also calculated for each province for each year.

Figure 7 exhibits the cumulative RTA for the year 2007 across the 31 provinces (in red) and the average of the cumulative RTA across all the years (1986 – 2007) for the 31 provinces (in blue). This figure clearly shows deviation from the mean in many cases.

Figure 8: Average Combined Relative Technology Advantage (RTA) of the 31 Chinese Provinces

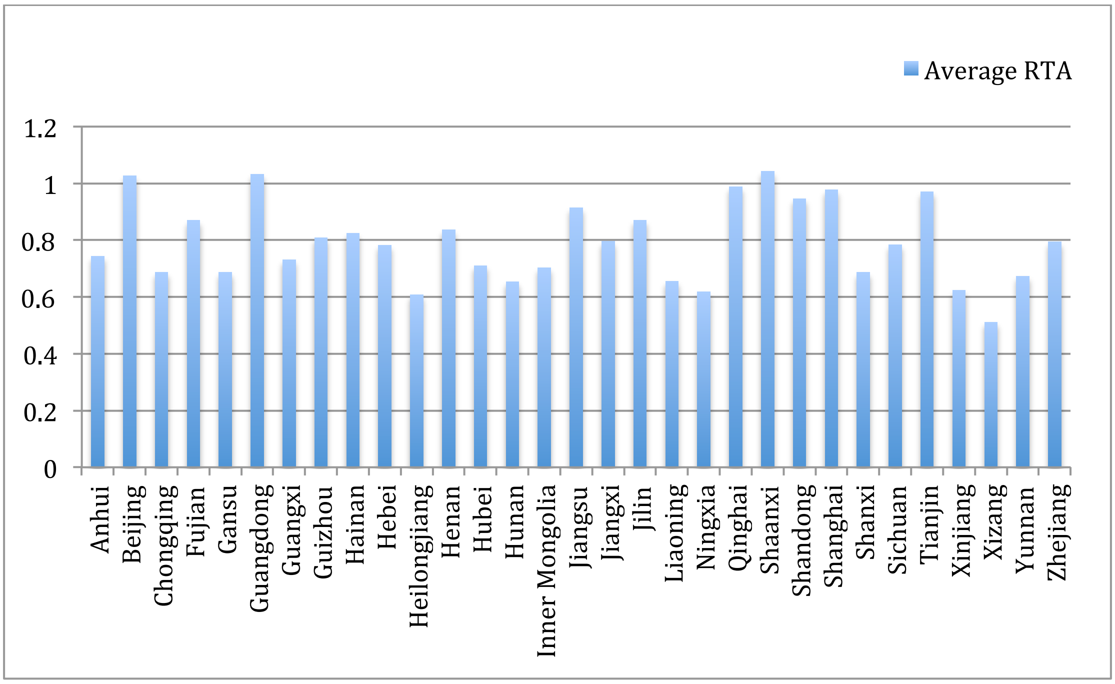


Figure 8, not unlike figure 7 depicts the average cumulative RTA. Glancing at this figure one can quickly identify the provinces with high-cumulative RTA.

Through the combined RTA calculation, we have been able to identify the six key growth regions – Beijing, Guangdong, Jiangsu, Shandong, Shanghai and Tianjin. All of them have combined RTA and individual RTAs across each of the 12 high-technology sectors consistently increasing at a faster rate compared to the other regions. Table 7 below summarizes the combined RTA for these 6 regions. (The complete RTA table for the 6 identified regions is included in the appendix.)

Table 7: Combined RTA for Six High Growth Regions

Region	Combined RTA
Beijing	1.026001472
Guangdong	1.031698747
Jiangsu	0.914256182
Shandong	0.945967122
Shanghai	0.97677161
Tianjin	0.971066292

The six identified regions form the top 20% in terms of combined RTA. All six identified regions have a combined RTA greater than 0.9, again demonstrating that they have superior technological advantages in these twelve high-technology sectors, compared to other regions.

Figure 9: Relative Technology Advantage (RTA) of the 6 high-RTA regions for patent grant years 1987 through 2007.

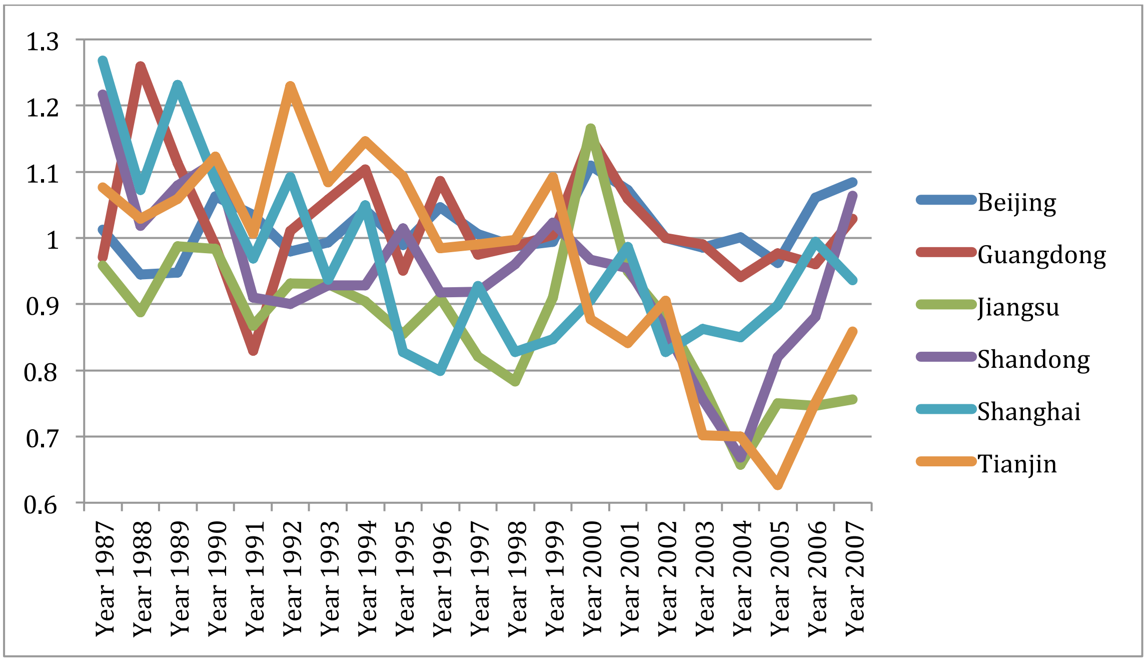


Figure 9 tracks the RTA of the 6 high-RTA provinces through the years. The RTA for these provinces seems to stay relatively high.

We ran the following negative binomial regression to ascertain the impact RTA has on cumulative forward citations. The dependent variable is number of forward citations (by application year). The independent variable is RTA. We also control for the years (from 1986 to 2007) in our regression models.

Table 8: Negative Binomial Regression Results: RTA and Forward References (by Patent Application Year)

	Coef.	z
RTA	4.378905 *	2.08
year1986	14.40316 ***	17.55
year1987	14.02299 ***	8.13
year1988	13.24025 ***	11.68
year1989	-3.023463 ***	-8.12
year1990	15.40389 ***	17.74
year1991	14.78761 ***	17.84
year1992	14.8627 ***	22.05
year1993	15.29435 ***	17.27
year1994	15.90103 ***	24.48
year1995	14.66804 ***	14.79
year1996	15.83256 ***	19.23
year1997	16.4439 ***	21.14
year1998	16.51072 ***	22.55
year1999	17.43566 ***	18.68
year2000	15.48071 ***	19.65
year2001	14.86831 ***	18.9
year2002	15.78213 ***	20.8
year2003	14.80816 ***	13.86
year2004	-1.791578 ***	-4.9
year2005	-1.859029 ***	-5.82
year2006	-1.901981 ***	10.66
year2007	0	
log alpha	2.419209	
alpha	11.23697	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table 8 above shows that the coefficient of 4.3 is statistically significant at the 5% level. Robustness analyses using Possion regression yield qualitatively similar results (see Table 9 below).

Similar to the previous regression, the dependent variable is number of forward citations (by application year). The independent variable is RTA. We also control for the years (from 1986 to 2007) in our regression models.

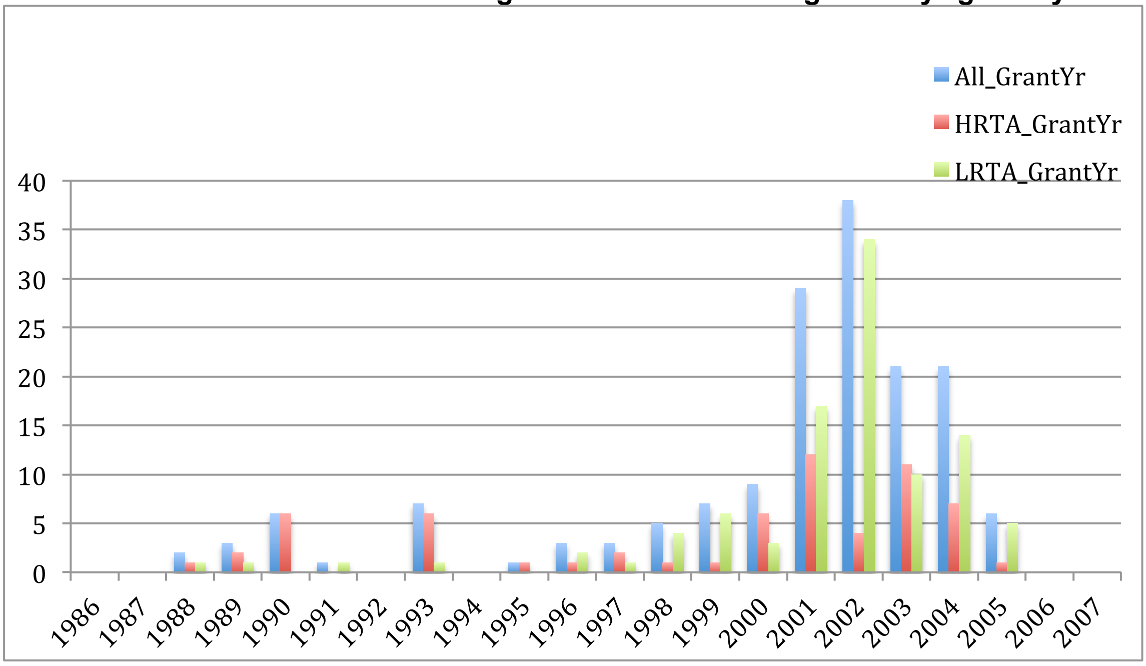
Table 9: Poisson Regression Results: RTA and Forward References (by Patent Application Year)

Variable	Coef.	z
RTA	0.43726 ***	3.34
year1986	15.1642	.
year1987	14.64239 ***	3.72
year1988	14.5979	.
year1989	0.1167673 ***	0.05
year1990	16.44298	.
year1991	15.36317	.
year1992	15.73835	.
year1993	15.75883	.
year1994	16.7188	.
year1995	15.3583 ***	4.63
year1996	16.44134	.
year1997	17.29998	.
year1998	17.06591	.
year1999	17.8128	.
year2000	16.62174 ***	4.08
year2001	15.38199 ***	2.17
year2002	16.12161	.
year2003	14.75537	.
year2004	-0.0015374	.
year2005	-0.0061921	.
year2006	-0.0109971	.
year2007	0	.

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Now let us look at temporal effects to determine whether the overall trend is actually maintained throughout the years.

Figure 10:
Forward reference counts for high and low RTA regions by grant year



Clearly, correlation between a high RTA and increased forward citation is not evident for the high-RTA provinces in figure 10. Congruous to our findings in the pairwise correlation (table 5)

Figure 11: Forward reference counts for High and Low RTA regions by application year.

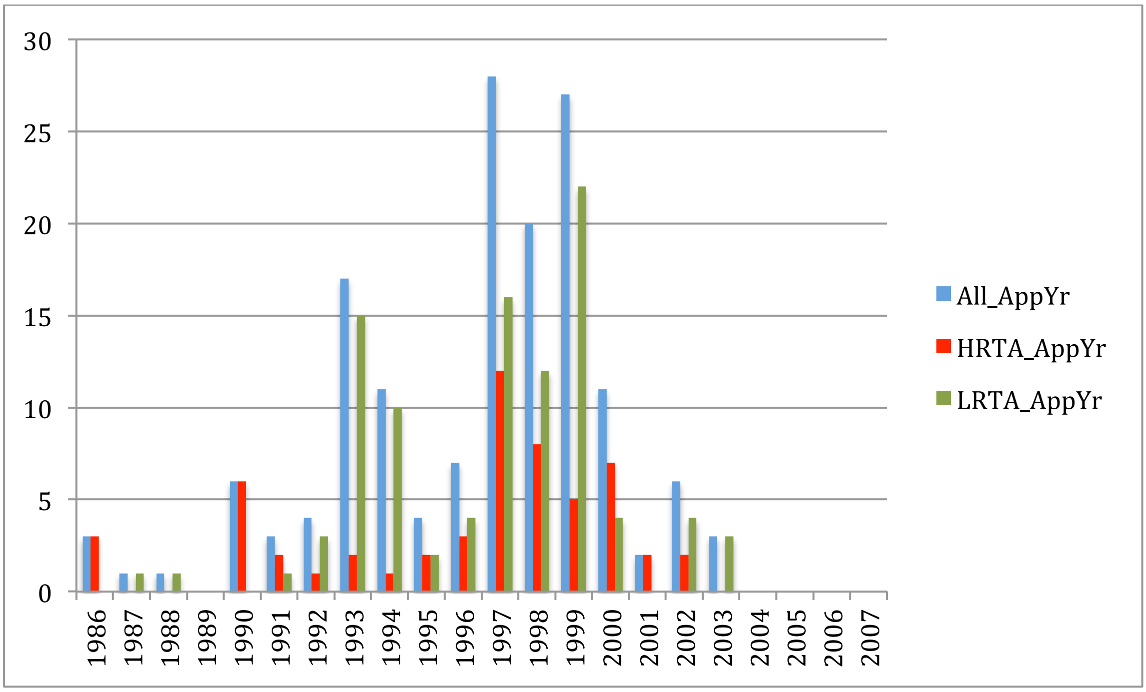
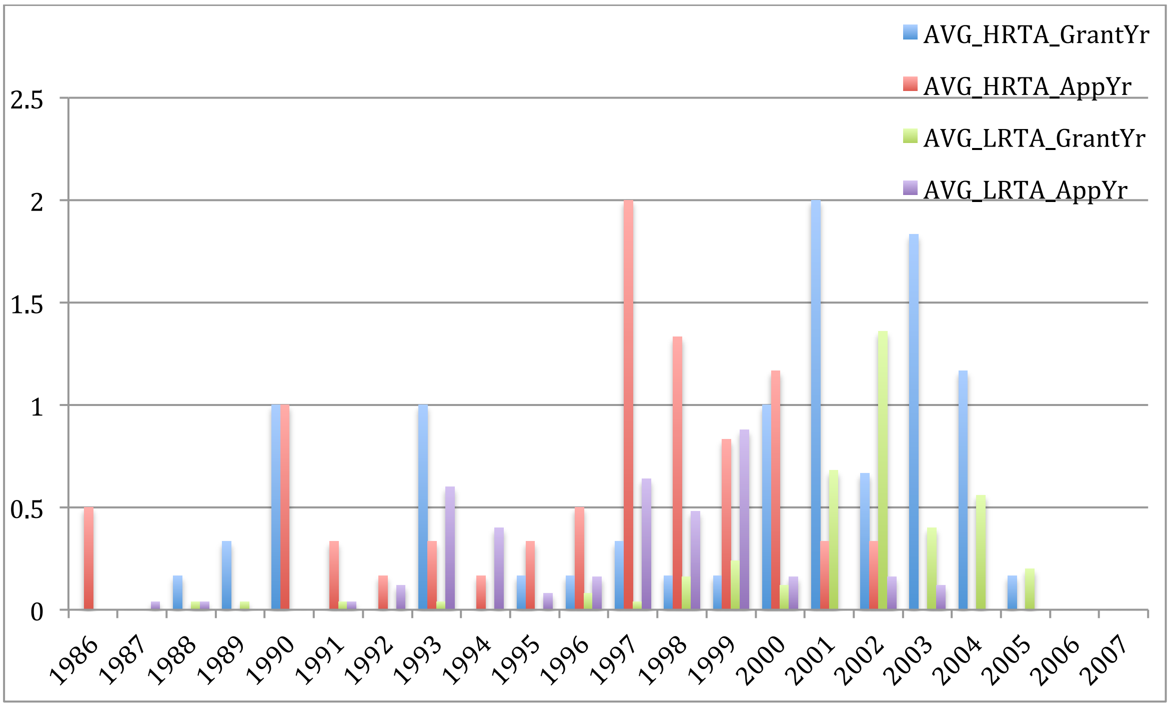


Figure 11 further highlights the apparent disassociation between the high RTA regions and forward citations. There reason for this disconnect is that we are looking at the absolute number of forward citations to patents from 6 Chinese provinces and comparing them to the same for 25 Chinese provinces.

Figure 12: Forward reference counts for High and Low RTA regions by application year; Averaged by number of high and low RTA regions respectively.



The red and blue bars reaching for the top seem to support the hypotheses 3.b and 3.c. Yet, to be thoroughly conclusive, we should use a yearly average by patent and not by province.

4.3. Technological Specialization Index

The Technological Specialization Index, or TSI is calculated using the same 12 category classes as the RTA. TSI provides us with a measure of technological specialization. This means that a province with most of its patents falling under one of the category classes will have a higher TSI indicating a high degree of specialization in that category class. Similar to the RTA we constructed a combined score for each province, across the years, which we use for our tests.

Similar to RTA, we use a negative binomial regression to confirm the relation between TSI and forward references as shown in Table 10 below:

The dependent variable is number of forward citations (by grant year). The independent variable is TSI. We also control for the years (from 1986 to 2007) and location fixed effects through the "ID" (from 2 to 32) variables.

Table 10: Negative Binomial Regression Results: TSI and Forward References (by Patent Grant Year)

	Coef.	z
TSI	1.509634	0.25
year1986	-6.080343	0
year1987	-4.964145	0
year1988	14.53713	0.01
year1989	15.80745	0.01
year1990	16.06299	0.01
year1991	14.83987	0.01
year1992	-4.963017	0
year1993	16.4349	0.01
year1994	-4.95679	0
year1995	14.96532	0.01
year1996	14.95797	0.01
year1997	15.15523	0.01

year1998	14.54138	0.01
year1999	16.78314	0.01
year2000	16.59032	0.01
year2001	16.71693	0.01
year2002	18.16652	0.01
year2003	17.08184	0.01
year2004	16.78096	0.01
year2005	14.46078	0.01
year2006	-5.067235	0
year2007	0	0.01
id2	18.66649	0.01
id3	15.28079	0
id4	-6.518997	0
id5	-6.536424	0
id6	-6.548472	0.01
id7	14.50706	0.01
id8	14.49331	0
id9	-6.552753	0
id10	-6.530414	0.01
id11	15.52887	0.01
id12	14.98625	0
id13	-6.528139	0
id14	-6.625996	0
id15	-6.535092	0
id16	-6.591645	0
id17	-6.59367	0.01
id18	14.54703	0.01
id19	15.51331	0.01
id20	15.53177	0
id21	-6.530204	0
id22	-6.815333	0.01
id23	14.45386	0.01
id24	17.05256	0
id25	-6.565572	0
id26	-6.562715	0
id27	-6.925464	0
id28	-6.572084	-0.02
id29	0	0
id30	-581.3533	-0.02
id31	-6.612301	
id32	0	
log alpha	- 0.4120157	
alpha	0.6623139	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

There is a negative correlation, but it is not significant. As a robustness analysis, we also ran a Poisson regression with the same variables as shown in Table 11 below:

The dependent variable is number of forward citations (by application year). The independent variable is TSI. We also control for the years (from 1986 to 2007) in our regression.

Table 11: Poisson Regression Results: TSI and Forward References (by Patent Application Year)

	Coef.	z
TSI	-10.15901**	-2.64
year1986	15.65463 ***	10.8
year1987	14.30848 ***	10.75
year1988	14.16487	10.94
year1989	-0.0233933 ***	-0.02
year1990	15.78267 ***	11.19
year1991	14.69181 ***	13.98
year1992	15.03773 ***	13.49
year1993	14.97023 ***	12.42
year1994	15.94354	.
year1995	14.57808 ***	14.77
year1996	15.74268 ***	11.79
year1997	16.61777 ***	10.96
year1998	16.35512 ***	10.53
year1999	17.0477 ***	11.28
year2000	15.91954 ***	9.69
year2001	14.68335 ***	11.04
year2002	15.40862 ***	13.41
year2003	14.09892 ***	9.12
year2004	-0.0287672	-0.03
year2005	-0.0719551	.
year2006	-0.098393	-0.12
year2007	0	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

A higher TSI will significantly reduce cumulative forward citations. This is significant at the 1% level.

Proposition 4 is not supported by these results. This may in part be attributed to the high variability in TSI over the years. It is difficult to identify regions with high TSI throughout. For example:

Table 12: Combined TSI for Xizang (1989 – 1991)

Location	Year	TSI
Xizang(54)	1989	0.139031064
Xizang(54)	1990	5.415191601
Xizang(54)	1991	0.122041823

This high variability stems from a small sample size, since very few patents have forward citations, further compounded by the fact that we are only looking at forward citations within China. This when calculated for each of the category classes can lead to extremely high TSI which influences the combined TSI.

Table 13: TSI for Intl. class G02 and the Combined TSI for Xizang (1989 – 1991)

Location	Year	TSI_G02	TSI
Xizang(54)	1989	0.008075921	0.139031064
Xizang(54)	1990	5.293374	5.415191601
Xizang(54)	1991	0.006108477	0.122041823

In the above case, a single TSI value for the category class G02 drastically changed the combined TSI adding high variability.

These results may also be directly influenced the fact that very few entries with forward citations exist.

4.4. Results Summary

Table 14: Summary of statistical results

The dependent variable being forward references.

	Model 1	Model 2	Model 3	Model 4
RTA	4.378905 * [2.103305]	0.43726 *** [0.1307848]		
TSI			1.509634 [6.025411]	-10.15901 ** [3.852604]
Year fixed Effects (1986 –2007)	Yes	Yes	Yes	Yes
Location fixed Effects (2 – 32)			Yes	
log alpha	2.419209 [.377987]		-.4120157 [.530598]	
alpha	11.23697 [4.247429]		.6623139 [.3514224]	

$^{*}\ p < 0.05$ $^{**}\ p < 0.01$ $^{***}\ p < 0.001$

Standard errors are in parentheses.

Model 1 and 2 show significant results in support for proposition 3. Patents filed in high RTA regions receive more citations than their counterparts outside these regions. Model 3 did not yield any significant results, while model 4 yielded results contrary to expectations in proposition 4. We shall discuss these results in more detail, in the following chapter.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

This study offers a look into the comparison of U.S. and Chinese patent data at a level never before studied. Constructing a data set by compiling information and building upon the U.S. China patent dyads adopted from Huang (2011) we were able to compare the impact of policy on patents filed across jurisdictions. We were also able to ascertain the impact of regional differences within China in terms of technology concentration and specialization.

We found the citation rates in the U.S. to be over 15 times that in China and the percentage of U.S. patent citations in U.S. patents to be much higher than the percentage of Chinese patent citations in Chinese patents. We also found a significant correlation between the Relative Technology Advantage (RTA) and forward citations. The findings with regards to the Technology Specialization Index (TSI) were inconclusive.

The lower backward citation rates in China mean that each citation in a Chinese patent is equivalent to about 15 in a U.S. patent. So when considering the impact of an intellectual work or any other measure that includes citations, one must take this fact in consideration and compensate for it.

The difference in the amount of citations is apparent; we did not however delve into causes other than differences in policy that may be responsible for these variations. There may be other strategic reasons for abstaining from making citations specifically in China.

The low percentage of domestic backward citation suggests that most of the innovation in China still derives from other jurisdictions. We would expect the percentage of domestic backward citation to rise over a period of time, as China becomes more of a creator of intellectual property rights, specifically patents.

The forward citations to patents filed in provinces with high technology concentration are higher than other provinces. This means that technology concentration leads to generation of knowledge that has a higher impact. We can be certain of this because all the citations are by patents filed in the same jurisdiction, China. This analysis could be improved by considering the year of patent grant and factoring for the time a patent has had to be cited, but due to the low number of observations under such restrictions, these calculations were not performed.

Unfortunately, propositions 3 and 4 which deal with forward citations are limited by data availability. Our current data can only account for forward citations by patents filed in China. This may be one of the reasons for the inconclusive results for proposition 4.

These results have strategy implication for inventors in firms and organizations. Inventors who do not wish to attribute their works to prior knowledge could strategically avoid citations while filing the patents in China. Because of this, inventors that have their patents cited in China should realize that their inventions are valued, perhaps greater than an invention with citations from patents filed in the U.S. under that USPTO. One reason for this could be that the cited China patent is of high potential importance to follow-on inventions such that they are cited despite the voluntary citation regulation in China. Such “signal” could be useful in interpreting the value of the inventions for firms and organizations that are looking for investments. .

Similarly there are policy implications for regions and countries. Different countries make different choices on the degree of their IPR protection While China is enhancing its IPR regime, it currently has a relatively weak protection over the inventions in China. For example, the voluntary citation regulation reduces the precision in measuring the value of inventions covered by SIPO patents. A strengthened IPR policy and implementation is important for the dissemination of innovation and knowledge.

China has made significant progress in terms of enhancing its IPR protection, application and examination process. Continued reform in its IPR regime and regulations would go a long way to enhance the innovative capability of China as well as our understanding of the financial and strategic importance of its innovations captured by patents.

APPENDIX

A.) International Classification
[The 12 categories chosen for the calculation of the RTA are highlighted]

A 01	AGRICULTURE; FORESTRY; ANIMAL HUSBANDRY; HUNTING; TRAPPING; FISHING
A 21	BAKING; EDIBLE DOUGHS
A 22	BUTCHERING; MEAT TREATMENT; PROCESSING POULTRY OR FISH
A 23	FOODS OR FOODSTUFFS; THEIR TREATMENT, NOT COVERED BY OTHER CLASSES
A 24	TOBACCO; CIGARS; CIGARETTES; SMOKERS' REQUISITES
A 41	WEARING APPAREL
A 42	HEADWEAR
A 43	FOOTWEAR
A 44	HABERDASHERY; JEWELLERY
A 45	HAND OR TRAVELLING ARTICLES
A 46	BRUSHWARE
A 47	FURNITURE (arrangements of seats for, or adaptation of seats to, vehicles E06C)
A 61	MEDICAL OR VETERINARY SCIENCE; HYGIENE
A 62	LIFE-SAVING; FIRE-FIGHTING (ladders E06C)
A 63	SPORTS; GAMES; AMUSEMENTS
B 01	PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL (furnaces, kilns, ovens, retorts, in general F27)
B 02	CRUSHING, PULVERISING, OR DISINTEGRATING; PREPARATORY TREATMENT OF GRAIN FOR MILLING
B 03	SEPARATION OF SOLID MATERIALS USING LIQUIDS OR USING PNEUMATIC TABLES OR JIGS; MAGNETIC OR ELECTROSTATIC SEPARATION OF SOLID MATERIALS FROM SOLID MATERIALS OR FLUIDS; SEPARATION BY HIGH-VOLTAGE ELECTRIC FIELDS (separating isotopes B04) [5]
B 04	CENTRIFUGAL APPARATUS OR MACHINES FOR CARRYING-OUT PHYSICAL OR CHEMICAL PROCESSES
B 05	SPRAYING OR ATOMISING IN GENERAL; APPLYING LIQUIDS OR OTHER FLUENT MATERIALS TO SURFACES, IN GENERAL (domestic cleaning G03; apparatus or processes, restricted to a purpose fully provided for in a single other class, see the relevant class covering the purpose) [2]
B 06	GENERATING OR TRANSMITTING MECHANICAL VIBRATIONS IN GENERAL
B 07	SEPARATING SOLIDS FROM SOLIDS; SORTING (separation in general B04; sorting peculiar to particular materials or articles and provided for in other classes, see the relevant classes)
B 08	CLEANING
B 09	DISPOSAL OF SOLID WASTE; RECLAMATION OF CONTAMINATED SOIL (treatment of waste water, sewage or sludge G21F9/28) [3,6]
B 21	MECHANICAL METAL-WORKING WITHOUT ESSENTIALLY REMOVING MATERIAL; PUNCHING METAL (casting, powder metallurgy C25D1/00)
B 22	CASTING; POWDER METALLURGY
B 23	MACHINE TOOLS; METAL-WORKING NOT OTHERWISE PROVIDED FOR (punching, perforating, making articles by processing sheet metal, tubes, or profiles B24)
B 24	GRINDING; POLISHING
B 25	HAND TOOLS; PORTABLE POWER-DRIVEN TOOLS; HANDLES FOR HAND IMPLEMENTS; WORKSHOP EQUIPMENT; MANIPULATORS
B 26	HAND CUTTING TOOLS; CUTTING; SEVERING
B 27	WORKING OR PRESERVING WOOD OR SIMILAR MATERIAL; NAILING OR STAPLING MACHINES IN GENERAL
B 28	WORKING CEMENT, CLAY, OR STONE
B 29	WORKING OF PLASTICS; WORKING OF SUBSTANCES IN A PLASTIC STATE IN GENERAL (processing doughs D21J)
B 30	PRESSES
B 31	MAKING PAPER ARTICLES; WORKING PAPER (making layered products not composed wholly of paper or cardboard B65H)
B 32	LAYERED PRODUCTS
B 41	PRINTING; LINING MACHINES; TYPEWRITERS; STAMPS (reproduction or duplication of pictures or patterns by scanning and converting into electrical signals H04N) [4]
B 42	BOOKBINDING; ALBUMS; FILES; SPECIAL PRINTED MATTER

B 43	WRITING OR DRAWING IMPLEMENTS; BUREAU ACCESSORIES
B 44	DECORATIVE ARTS
B 60	VEHICLES IN GENERAL
B 61	RAILWAYS
B 62	LAND VEHICLES FOR TRAVELLING OTHERWISE THAN ON RAILS
B 63	SHIPS OR OTHER WATERBORNE VESSELS; RELATED EQUIPMENT
B 64	AIRCRAFT; AVIATION; COSMONAUTICS
B 65	CONVEYING; PACKING; STORING; HANDLING THIN OR FILAMENTARY MATERIAL
B 66	HOISTING; LIFTING; HAULING
B 67	OPENING OR CLOSING BOTTLES, JARS OR SIMILAR CONTAINERS; LIQUID HANDLING (nozzles in general F17C)
B 68	SADDLERY; UPHOLSTERY
B 81	**MICRO-STRUCTURAL TECHNOLOGY**
B 82	**NANO-TECHNOLOGY**
C 01	INORGANIC CHEMISTRY (processing powders of inorganic compounds preparatory to the manufacturing of ceramic products C25B)
C 02	TREATMENT OF WATER, WASTE WATER, SEWAGE, OR SLUDGE (settling tanks, filtering, e.g. sand filters or screening devices, B01D)
C 03	GLASS; MINERAL OR SLAG WOOL
C 04	CEMENTS; CONCRETE; ARTIFICIAL STONE; CERAMICS; REFRACTORIES (alloys based on refractory metals C22C) [4]
C 05	FERTILISERS; MANUFACTURE THEREOF (processes or devices for granulating materials, in general C09K17/00) [4]
C 06	EXPLOSIVES; MATCHES
C 07	ORGANIC CHEMISTRY (such compounds as the oxides, sulfides, or oxysulfides of carbon, cyanogen, phosgene, hydrocyanic acid or salts thereof C25B7/00) [2]
C 08	ORGANIC MACROMOLECULAR COMPOUNDS; THEIR PREPARATION OR CHEMICAL WORKING-UP; COMPOSITIONS BASED THEREON (manufacture or treatment of artificial threads, fibres, bristles or ribbons D01)
C 09	DYES; PAINTS; POLISHES; NATURAL RESINS; ADHESIVES; MISCELLANEOUS COMPOSITIONS; MISCELLANEOUS APPLICATIONS OF MATERIALS
C 10	PETROLEUM, GAS OR COKE INDUSTRIES; TECHNICAL GASES CONTAINING CARBON MONOXIDE; FUELS; LUBRICANTS; PEAT
C 11	ANIMAL OR VEGETABLE OILS, FATS, FATTY SUBSTANCES OR WAXES; FATTY ACIDS THEREFROM; DETERGENTS; CANDLES (edible oil or fat compositions A23)
C 12	BIOCHEMISTRY; BEER; SPIRITS; WINE; VINEGAR; MICROBIOLOGY; ENZYMOLOGY; MUTATION OR GENETIC ENGINEERING
C 13	SUGAR INDUSTRY (polysaccharides, e.g. starch, derivatives thereof C12C) [4]
C 14	SKINS; HIDES; PELTS; LEATHER
C 21	METALLURGY OF IRON
C 22	METALLURGY (of iron C25)
C 23	COATING METALLIC MATERIAL; COATING MATERIAL WITH METALLIC MATERIAL (by metallising textiles C25F) [2]
C 25	ELECTROLYTIC OR ELECTROPHORETIC PROCESSES; APPARATUS THEREFOR (electrodialysis, electro-osmosis, separation of liquids by electricity H01M) [4]
C 30	CRYSTAL GROWTH (separation by crystallisation in general B01D9/00) [3]
D 01	NATURAL OR ARTIFICIAL THREADS OR FIBRES; SPINNING (metal threads D02)
D 02	YARNS; MECHANICAL FINISHING OF YARNS OR ROPES; WARPING OR BEAMING
D 03	WEAVING
D 04	BRAIDING; LACE-MAKING; KNITTING; TRIMMINGS; NON-WOVEN FABRICS
D 05	SEWING; EMBROIDERING; TUFTING
D 06	TREATMENT OF TEXTILES OR THE LIKE; LAUNDERING; FLEXIBLE MATERIALS NOT OTHERWISE PROVIDED FOR
D 07	ROPES; CABLES OTHER THAN ELECTRIC
D 21	PAPER-MAKING; PRODUCTION OF CELLULOSE
E 01	CONSTRUCTION OF ROADS, RAILWAYS, OR BRIDGES (of tunnels E21D)
E 02	HYDRAULIC ENGINEERING; FOUNDATIONS; SOIL-SHIFTING
E 03	WATER SUPPLY; SEWERAGE
E 04	BUILDING (layered materials, layered products in general B32B)
E 05	LOCKS; KEYS; WINDOW OR DOOR FITTINGS; SAFES
E 06	DOORS, WINDOWS, SHUTTERS, OR ROLLER BLINDS, IN GENERAL; LADDERS
E 21	EARTH OR ROCK DRILLING; MINING

F 01	MACHINES OR ENGINES IN GENERAL (combustion engines F04); ENGINE PLANTS IN GENERAL; STEAM ENGINES
F 02	COMBUSTION ENGINES (cyclically operating valves therefor, lubricating, exhausting, or silencing engines F01); HOT-GAS OR COMBUSTION-PRODUCT ENGINE PLANTS
F 03	MACHINES OR ENGINES FOR LIQUIDS (for liquids and elastic fluids F04); WIND, SPRING, WEIGHT, OR MISCELLANEOUS MOTORS; PRODUCING MECHANICAL POWER OR A REACTIVE PROPULSIVE THRUST, NOT OTHERWISE PROVIDED FOR
F 04	POSITIVE-DISPLACEMENT MACHINES FOR LIQUIDS; PUMPS FOR LIQUIDS OR ELASTIC FLUIDS (portable fire extinguishers with manually-operated pumps H02K44/02)
F 15	FLUID-PRESSURE ACTUATORS; HYDRAULICS OR PNEUMATICS IN GENERAL
F 16	ENGINEERING ELEMENTS OR UNITS; GENERAL MEASURES FOR PRODUCING AND MAINTAINING EFFECTIVE FUNCTIONING OF MACHINES OR INSTALLATIONS; THERMAL INSULATION IN GENERAL
F 17	STORING OR DISTRIBUTING GASES OR LIQUIDS (water supply E03B)
F 21	LIGHTING (electric aspects or elements, see section H, e.g. electric light sources H05B)
F 22	STEAM GENERATION (chemical or physical apparatus for generating gases F28G)
F 23	COMBUSTION APPARATUS; COMBUSTION PROCESSES
F 24	HEATING; RANGES; VENTILATING (protecting plants by heating in gardens, orchards, or forests H05B)
F 25	REFRIGERATION OR COOLING; COMBINED HEATING AND REFRIGERATION SYSTEMS; HEAT PUMP SYSTEMS; MANUFACTURE OR STORAGE OF ICE; LIQUEFACTION OR SOLIDIFICATION OF GASES
F 26	DRYING
F 27	FURNACES; KILNS; OVENS; RETORTS (specially adapted for a purpose covered by a single other class and specifically mentioned in that class, see the class in question, e.g. bakery ovens H05B) [4]
F 28	HEAT EXCHANGE IN GENERAL (heat-transfer, heat-exchange or heat-storage materials F24F13/30)
F 41	WEAPONS
F 42	AMMUNITION; BLASTING
G 01	MEASURING (counting G06M); TESTING
G 02	OPTICS (making optical elements or apparatus C03C)
G 03	PHOTOGRAPHY; CINEMATOGRAPHY; ANALOGOUS TECHNIQUES USING WAVES OTHER THAN OPTICAL WAVES; ELECTROGRAPHY; HOLOGRAPHY (reproduction of pictures or patterns by scanning and converting into electrical signals H04N) [4]
G 04	HOROLOGY
G 05	CONTROLLING; REGULATING
G 06	COMPUTING; CALCULATING; COUNTING (score computers for games B43K29/08)
G 07	CHECKING-DEVICES
G 08	SIGNALLING (indicating or display devices per se H04N)
G 09	EDUCATING; CRYPTOGRAPHY; DISPLAY; ADVERTISING; SEALS
G 10	MUSICAL INSTRUMENTS; ACOUSTICS
G 11	INFORMATION STORAGE
G 12	INSTRUMENT DETAILS
G 21	NUCLEAR PHYSICS; NUCLEAR ENGINEERING
H 01	BASIC ELECTRIC ELEMENTS (includes semiconductor and devices)
H 02	GENERATION, CONVERSION, OR DISTRIBUTION OF ELECTRIC POWER
H 03	BASIC ELECTRONIC CIRCUITRY
H 04	ELECTRIC COMMUNICATION TECHNIQUE
H 05	ELECTRIC TECHNIQUES NOT OTHERWISE PROVIDED FOR

B.) Growth in Chinese Patenting Activity from 1986 to 2007.

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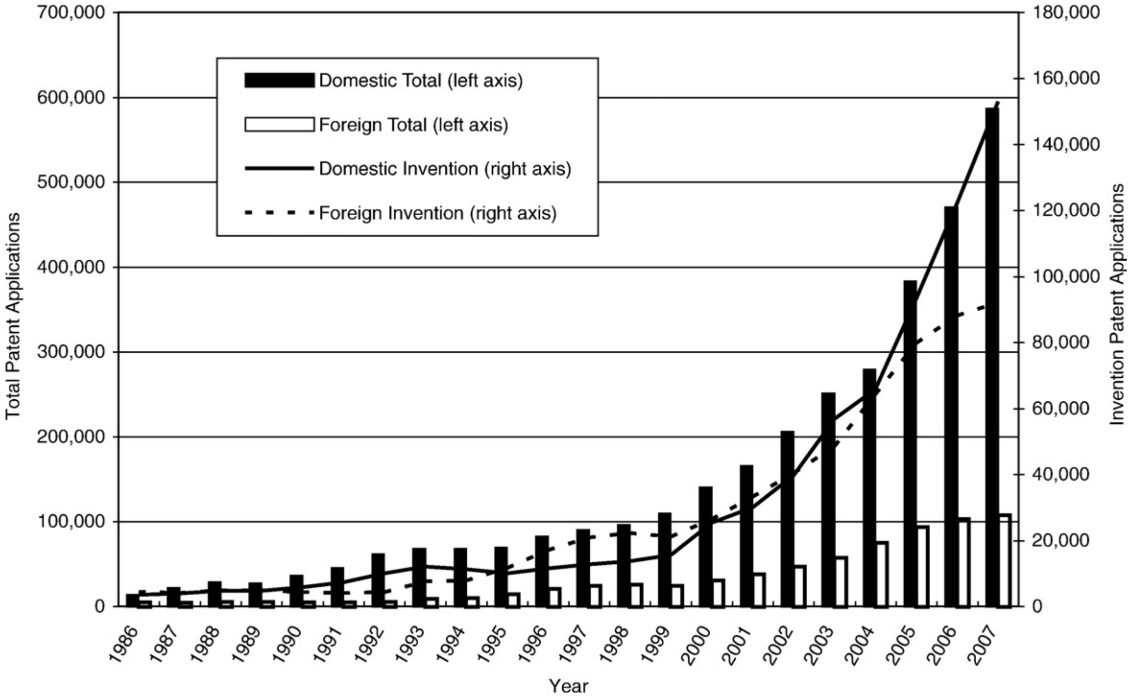

Fig. 1. Chinese patent applications, 1986–2007. Source: web site of China's National Bureau of Statistics — www.stats.gov.cn.

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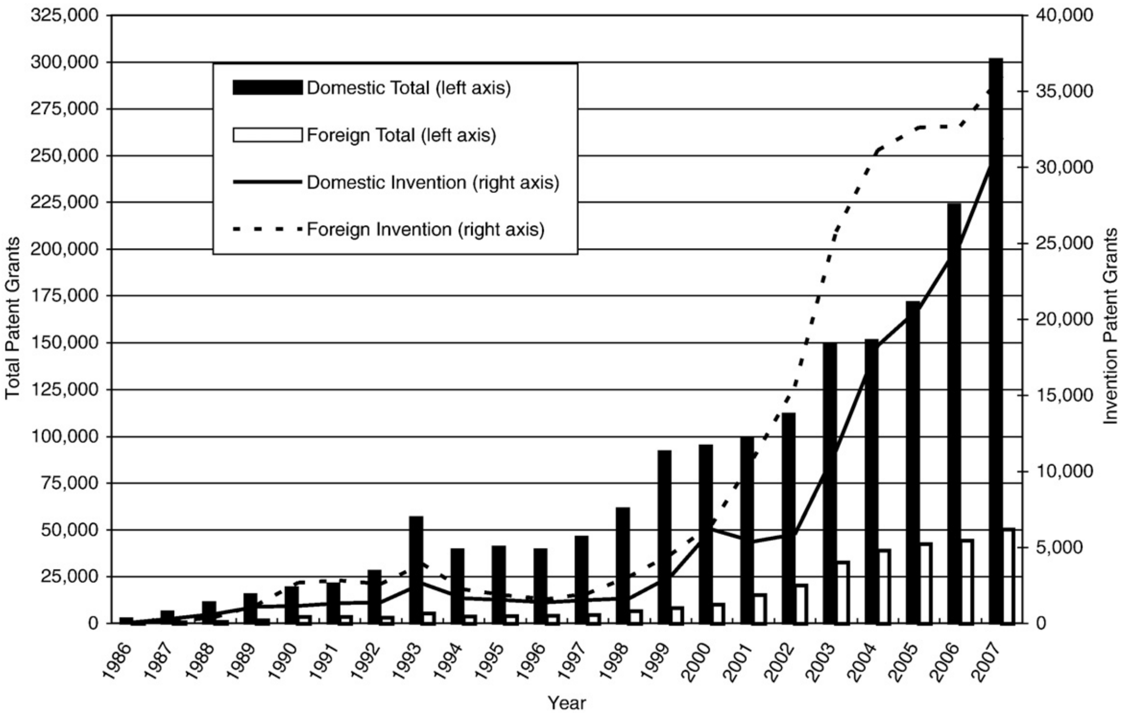

Fig. 2. Chinese patent grants, 1986–2007. Source: web site of China's National Bureau of Statistics — www.stats.gov.cn.

C.) Combined RTA for the seven key-growth regions

Location	Year	Combined RTA
"Beijing(11)"	1986	1.258560982
"Beijing(11)"	1987	0.984450871
"Beijing(11)"	1988	0.945114741
"Beijing(11)"	1989	0.997293082
"Beijing(11)"	1990	1.134622605
"Beijing(11)"	1991	1.167665235
"Beijing(11)"	1992	1.010044275
"Beijing(11)"	1993	1.051649777
"Beijing(11)"	1994	1.079632761
"Beijing(11)"	1995	1.047662331
"Beijing(11)"	1996	1.165839892
"Beijing(11)"	1997	1.079368657
"Beijing(11)"	1998	1.061990836
"Beijing(11)"	1999	0.990860734
"Beijing(11)"	2000	1.111448516
"Beijing(11)"	2001	1.078782464
"Beijing(11)"	2002	1.109164119
"Beijing(11)"	2003	1.208774237
"Beijing(11)"	2004	1.249944245
"Beijing(11)"	2005	1.163596548
"Beijing(11)"	2006	1.142447725
"Beijing(11)"	2007	1.088124886
"Guangdong(44)"	1986	1.284286286
"Guangdong(44)"	1987	0.940891099
"Guangdong(44)"	1988	1.321258233
"Guangdong(44)"	1989	1.197150857

"Guangdong(44)"	1990	1.042812043
"Guangdong(44)"	1991	0.959220416
"Guangdong(44)"	1992	1.083119459
"Guangdong(44)"	1993	1.182479126
"Guangdong(44)"	1994	1.197858003
"Guangdong(44)"	1995	1.037021762
"Guangdong(44)"	1996	1.156871019
"Guangdong(44)"	1997	1.057752233
"Guangdong(44)"	1998	1.116886835
"Guangdong(44)"	1999	1.101451414
"Guangdong(44)"	2000	1.284001349
"Guangdong(44)"	2001	1.207958301
"Guangdong(44)"	2002	1.177968395
"Guangdong(44)"	2003	1.281619419
"Guangdong(44)"	2004	1.252810252
"Guangdong(44)"	2005	1.27031477
"Guangdong(44)"	2006	1.21659836
"Guangdong(44)"	2007	1.21100126
"Jiangsu(32)"	1986	1.723017625
"Jiangsu(32)"	1987	0.983819003
"Jiangsu(32)"	1988	0.897513421
"Jiangsu(32)"	1989	1.048323413
"Jiangsu(32)"	1990	1.0515555
"Jiangsu(32)"	1991	1.029237406
"Jiangsu(32)"	1992	1.022762451
"Jiangsu(32)"	1993	1.043521759
"Jiangsu(32)"	1994	0.992581366
"Jiangsu(32)"	1995	0.914180097
"Jiangsu(32)"	1996	0.999366873
"Jiangsu(32)"	1997	0.860305181
"Jiangsu(32)"	1998	0.8783225

"Jiangsu(32)"	1999	0.98781379
"Jiangsu(32)"	2000	1.305257893
"Jiangsu(32)"	2001	1.110511585
"Jiangsu(32)"	2002	1.045151002
"Jiangsu(32)"	2003	1.025826898
"Jiangsu(32)"	2004	0.913060236
"Jiangsu(32)"	2005	1.006014382
"Jiangsu(32)"	2006	0.949579976
"Jiangsu(32)"	2007	0.955343258
"Shandong(37)"	1986	0.909765964
"Shandong(37)"	1987	1.226126774
"Shandong(37)"	1988	1.039713183
"Shandong(37)"	1989	1.171733407
"Shandong(37)"	1990	1.242540167
"Shandong(37)"	1991	0.997937248
"Shandong(37)"	1992	0.989146433
"Shandong(37)"	1993	1.056021335
"Shandong(37)"	1994	1.007705725
"Shandong(37)"	1995	1.103981329
"Shandong(37)"	1996	1.001736693
"Shandong(37)"	1997	0.993348826
"Shandong(37)"	1998	1.10041962
"Shandong(37)"	1999	1.109038288
"Shandong(37)"	2000	1.07633511
"Shandong(37)"	2001	1.086477175
"Shandong(37)"	2002	1.014872958
"Shandong(37)"	2003	1.061800147
"Shandong(37)"	2004	1.027829326
"Shandong(37)"	2005	1.165903465
"Shandong(37)"	2006	1.269339323
"Shandong(37)"	2007	1.491566128

"Shanghai(31)"	1986	1.204199311
"Shanghai(31)"	1987	1.242569087
"Shanghai(31)"	1988	1.082226489
"Shanghai(31)"	1989	1.248664077
"Shanghai(31)"	1990	1.163151923
"Shanghai(31)"	1991	0.967525354
"Shanghai(31)"	1992	1.155660341
"Shanghai(31)"	1993	0.965365744
"Shanghai(31)"	1994	1.092188612
"Shanghai(31)"	1995	0.837181012
"Shanghai(31)"	1996	0.778192452
"Shanghai(31)"	1997	0.95439256
"Shanghai(31)"	1998	0.896914164
"Shanghai(31)"	1999	0.871041891
"Shanghai(31)"	2000	0.901544615
"Shanghai(31)"	2001	1.022279257
"Shanghai(31)"	2002	0.935376906
"Shanghai(31)"	2003	1.022531644
"Shanghai(31)"	2004	0.982721152
"Shanghai(31)"	2005	1.047320867
"Shanghai(31)"	2006	1.128359981
"Shanghai(31)"	2007	1.035887187
"Zhejiang(33)"	1986	1.128615221
"Zhejiang(33)"	1987	0.932983822
"Zhejiang(33)"	1988	1.076248155
"Zhejiang(33)"	1989	1.166381398
"Zhejiang(33)"	1990	0.969942286
"Zhejiang(33)"	1991	0.807411864
"Zhejiang(33)"	1992	0.981619265
"Zhejiang(33)"	1993	0.989475062
"Zhejiang(33)"	1994	1.001440645

"Zhejiang(33)"	1995	1.024094942
"Zhejiang(33)"	1996	0.920415357
"Zhejiang(33)"	1997	0.897764194
"Zhejiang(33)"	1998	0.951707987
"Zhejiang(33)"	1999	0.823454697
"Zhejiang(33)"	2000	0.720699779
"Zhejiang(33)"	2001	0.792676262
"Zhejiang(33)"	2002	0.768080279
"Zhejiang(33)"	2003	0.788268429
"Zhejiang(33)"	2004	0.785794483
"Zhejiang(33)"	2005	0.78921529
"Zhejiang(33)"	2006	0.843702427
"Zhejiang(33)"	2007	0.736110403

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