

Made in China: How Chinese Innovation is Changing the Patent Landscape

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Abstract

Although many developing economies are increasingly impacting the global economy, China's impact has been the greatest by far. Once hindered from competition by political and economic restrictions, China is now a major economic player. Curiously, China's increased impact has coincided with an increased demand for intellectual property protection for technologies originating from China, with rising application rates from the Chinese at SIPO and the USPTO. Indeed, more patents may be sought to protect the myriad range of technological innovations emerging from China.

This Article examines Chinese patenting trends in the United States over the last several decades, comparing those trends to those from other nations such as Japan, South Korea, Brazil, Russia and India. Additionally, we identify the technology mix of patent applications that the Chinese are submitting to the USPTO and how they are changing with time. The Article also compares China's patenting trends in the past decade to other patenting trends for other Asian countries from earlier decades and we find some rather striking similarities. Ultimately, we determine that patenting from China is not unique, as a historical matter, but rather an accelerated version of earlier Asian patenting trends.

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I. Introduction

The growth of the Chinese economy since the beginning of the new century has been impressive. Adjusting for changes in the value of the Yuan over this period, China's GDP has roughly tripled. This growth has coincided with a significantly increased demand for intellectual property protection on the Chinese mainland, particularly for the patenting of new inventions. According to data from the World Intellectual Property Organization, the number of patent applications from Chinese residents to China's State Intellectual Property Office (SIPO) increased at an average annual rate of 29 percent from 25,346 in 2000 to 415,829 in 2011.⁴ Even more impressive, the number of patent applications that large and medium enterprises in high-technology industries submitted to SIPO increased at an average annual rate of 38 percent over the same time period, from 2,245 in to 77,725.⁵ In fact, SIPO currently receives more patent application than any other patent granting authority, and 80 percent of all applications to SIPO come from Chinese residents. By way of comparison, slightly fewer than 50 percent of all applications to the U.S. Patent and Trademark Office (PTO) come from U.S.-based inventors.

Patent systems all over the world are no longer operating in isolation. Modern patent regimes are emphasizing international harmonization of substantive rules by reaching across borders for best practices and procedures. Peter K. Yu chronicles the changes in the American patent approach in light of the acceleration of globalization brought about by modern technology.⁶ As the global economy transforms, the United States has become necessarily more aggressive in protecting its intellectual property internationally.⁷ Because of the "world-flattening" phenomenon that we discuss below, the U.S. has a strong interest in adjusting its own intellectual property regime with an eye towards

⁴ *Statistical Country Profiles: China*, WIPO, http://www.wipo.int/ipstats/en/statistics/country_profile/countries/cn.html (last updated March 2014).

⁵ These numbers come from the *2012 China Statistics Yearbook on High Technology Industry*, which was compiled by China's National Bureau of Statistics, National Development and Reform Commission, and Ministry of Science and Technology. The high technology industries include the manufacture of medicines, aircrafts and spaceships, electronic and communication equipment, computers and office equipment, medical equipment, and measuring instruments.

⁶ See generally Peter K. Yu, *From Pirates to Partners: Protecting Intellectual Property in China in the Twenty-First Century*, 50 AM. U.L. REV. 131 (2000).

⁷ *Id.*

greater international conformity. It is also in America's best interests to have an intellectual property regime that is accessible to foreign inventors who are increasingly becoming more innovative themselves.⁸ Scholars like Graeme B. Dinwoodie recognize the need for an international (or internationally minded) patent regime in today's global economy.⁹

As an example, consider the United States' recent move from a first-to-invent patent system to a modified first-to-file patent system.¹⁰ With the passage of the America Invents Act (AIA), President Obama signed into law that crucial shift in the U.S. regime.¹¹ This change brings American patent law and patent procedures more in line with patent regimes in other countries, as America joins the vast majority of countries who employ the "first to file" system.¹²

Thomas Friedman's ground-breaking work, *The World is Flat*, described our society as being increasingly global due to advancements in technology. Technology has changed the way businesses compete on the global stage. Rather than simply relying on manufacturing, as economies have in the past, economies are growing and becoming more dominant through advancements in technology.

As technology "flattens the world," or allows new players to compete in the marketplace, 3 billion people who were once frozen out of global competition now find themselves able to enter the playing field.¹³ These individuals were

⁸ *Id.*

⁹ See generally Graeme B. Dinwoodie, *Developing a Private International Intellectual Property Law: The Demise of Territoriality?*, 51 William & Mary L. Rev. 771 (2009) (calling for an improved private international property regime).

¹⁰ John Villasenor, *March 16, 2013: The United States Transitions to a 'First-Inventor-To-File' Patent System*, FORBES (Mar. 11, 2013), <http://www.forbes.com/sites/johnvillasenor/2013/03/11/march-16-2013-america-transitions-to-a-first-inventor-to-file-patent-system/>.

¹¹ *Id.*

¹² Jessica C. Engler, *Chinese Patent Innovation and Competition Under the America Invents Act – A Whole New World of Prior Art*, ENERGY LAW CURRENTS (Mar. 28, 2013), <http://sites.law.lsu.edu/jelrblog/2013/03/28/chinese-patent-innovation-and-competition-under-the-america-invents-act-a-whole-new-world-of-prior-art/>. Organizations including the Intellectual Property Owners Association unsuccessfully urged the shift to a first-to-file jurisdiction on the basis of global harmonization for several years; the notion finally gained support and was included in the America Invents Act once justified on the basis of job creation. Wayne C. Jaeschke, et al., *Comparison of Chinese and U.S. Patent Reform Legislation: Which, If Either, Got it Right?* 11 J. MARSHALL REV. INTELL. PROP. L. 567, 573 (2012).

¹³ Thomas L. Friedman, *THE WORLD IS FLAT* 181 (2005).

formerly blocked from competition by virtue of where they live: countries with closed economies and strict, hierarchical political and economic structures. Included among those people now free to compete are the people of China. Because of something Friedman calls the “triple convergence” (new players, on a new playing field, developing new technologies), China is increasingly becoming a major force. No longer forced to rely on “the ponderous deliberations of finance ministers,”¹⁴ Chinese patentees are free to make major impacts on the global economy with their individual tech-based inventions. Chinese influence will only increase as they continue to make headway in the American patent system.

Our results suggest that Chinese technology is evolving at a far faster rate than in other developing economies even those that Friedman says have the advantage of the “triple convergence.” Throughout this paper, we will explore theories about why China is experiencing patent growth at a rate much faster than other developing economic forces like Brazil and Russia.

Thus far, there has been limited empirical work studying how cross-national/international patenting trends have changed over time and what they can tell us.¹⁵ Previous work is generally limited to statistical data compilation geared towards use by government agencies or practitioners. We hope to remedy the dearth of academic research in this area, by providing the data itself, which may be helpful in aiding further study in the area. Additionally, this Article attempts add to the literature by studying Chinese patenting trends in the U.S. over the past two decades and determining what insights we can draw from these trends.

In Part II of this Article, we identify current theories explaining the changing patent trends in China and propose our own hypotheses to explain these changes and the implications thereof. In Part III, we explain how the data for this study was selected and explain the research methods used. In Part IV, we present the results of the study, including patent applications, allowance rates,

¹⁴ *Id.* at 183.

¹⁵ For other studies in this area, see World Intellectual Property Organization, *2013 World Intellectual Property Indicator*, available at http://www.wipo.int/export/sites/www/freepublications/en/intproperty/941/wipo_pub_941_2013.pdf, BAKER & MCKENZIE, *INTELLECTUAL PROPERTY: TRENDS AROUND THE WORLD, 2012*, available at <http://www.bakermckenzie.com/files/Uploads/Documents/North%20America/IntellectualProperty/Baker%20&%20McKenzie%20Doing%20Business%20Globally%2010.9.12%20Track%20V%20Final.pdf>.

and technology mix concentrations for Chinese patent applications to the USPTO. The definitions of technology mix and allowance rate are discussed in Part III below.

We compare current patenting trends in China to those in other Asian countries and the BRICS set of countries.¹⁶ The results indicate that, since 2000, the growth in applications from China has greatly outpaced the growth in applications from Japan, South Korea, and the other emerging economies. Over this time period, the technology mix of Chinese applications has become more heavily weighted toward communications and computing. We found a similar result for patent applications that originated from the other emerging economies. Finally, over the past 6 years, the allowance rate for Chinese applications has begun to converge with the allowance rate for Japanese and South Korean applications.

We also use historical data to compare the recent growth in Chinese applications to (1) the growth in South Korean applications of the 10-year period starting from the mid-1980s, and (2) the growth in Indian applications for the 10-year period starting in the late 1990s. This data is also used to consider the evolution of the technology mix and allowance rates in each case over these periods of intense growth in patenting activity. The rates of growth for the South Korean and Chinese cases are quite similar and both are much higher than the growth rate of Indian applications. The results illustrate the fact that the growth in applications from China is not unique historically, and that the Chinese appear to be following a strategy that has already been quite successful for other large East Asian economies.

We also analyze the geographic distribution of China's patent applications and how this compares to applications from other emerging and established economies in Part IV. Finally, we draw implications from these results and suggest how this data might augment further research in Parts V and VI.

II. Theory & Hypothesis

¹⁶ *Id.* BRIC began as an acronym used to refer to Brazil, Russia, India and China as similar emerging economies. About Us, forum BRICS, <http://www.bricsforum.org/sample-page/> (last visited June 15, 2014). Since that time, these countries have formed an international association in the same name, which was changed to BRICS when South Africa was included in 2010. *Id.*

As discussed, China's economy continues to grow at an incredible rate and is expected to surpass the United States as the world's biggest economy in 2014.¹⁷ This coincides with rapid growth in the number of Chinese patent applications received by the USPTO. In light of this knowledge, we wanted to know whether China was following some historical pattern of development when it came to innovation, or whether it was blazing a new trail. We hypothesized that the convergence of so many unique factors (population size, growth rate, political history) could make China's recent innovation boom exceptional. Other scholars have also looked at this increase and theorized as to the reason and implication of the trend.

A. Research & Development

Many scholars point to the surge in research and development (R&D) spending in China as a cause for the influx of patent applications. R&D funding has come from both the government and from multinational corporations working in China.

The most pervasive theory for this explosion in PTO applications from China seems to be China's emphasis on research and development. Huawei Corporation, China's telecom giant, increased R&D spending by more than 25% in 2012.¹⁸ Huawei holds more than 50,000 patents worldwide.¹⁹ Another Chinese company, ZTE Corp, spent \$1.4 billion on R&D in 2012.²⁰ ZTE led the world in number of Patent Cooperation Treaty (PCT) filings for the second year, with more than 3,900 applications.²¹ In total, China spends around \$300 billion on R&D, a number that is only exceeded by the United States.²²

The efficiency of China's R&D spending provides further explanation for their exponential growth in patent applications. According to WIPO, for every million

¹⁷ *China Set to Overtake U.S. as Biggest Economy in PPP Measure*, BLOOMBERG NEWS (Apr. 30, 2014, 3:32 PM), <http://www.bloomberg.com/news/2014-04-30/china-set-to-overtake-u-s-as-biggest-economy-using-ppp-measure.html>.

¹⁸ Chris Neumeyer, *China's Great Leap Forward in Patents*, IP WATCHDOG (Apr. 4, 2013, 10:30 AM), <http://www.ipwatchdog.com/2013/04/04/chinas-great-leap-forward-in-patents/id=38625>.

¹⁹ *Id.*

²⁰ *Id.*

²¹ *Id.*

²² *Id.*

dollars spent on R&D, China applies for 3.5 patents.²³ Americans, by contrast, apply for only 0.9 patents per every million dollars spent on R&D.²⁴ This efficiency may be linked to the Chinese practice of turning out innovative products much quicker and cheaper, though at the cost of quality, than its foreign counterparts.²⁵ By “reengineering research and development and innovative processes” Chinese firms are able to scale up novel technology and bring a product to market much more quickly.²⁶

One scholar believes that China will increasingly become a presence in the intellectual property market because of multinational firms’ investment in China’s R&D facilities.²⁷ It follows that if multinational firms with a presence in the U.S. keep investing in China, we will see a continued increase in Chinese patent applications at the PTO. Other studies, however, have focused on patents-R&D elasticity estimates and concluded that, “R&D intensification is unlikely to be the primary driving force of China’s patenting boom.”²⁸ Instead, accelerated restructuring of state-owned enterprises and increased privatization may be more important factors explaining the upsurge of patenting.²⁹

Multinational enterprises and foreign investors deserve at least partial credit for the Chinese patent boom. The growth of foreign direct investment (FDIs) is prompting Chinese companies to file for more patent applications than before.³⁰ These same foreign firms are teaching Chinese companies the importance of protecting their intellectual property.³¹

B. Government Agenda & Foreign Policy

²³ *Id.*

²⁴ *Id.*

²⁵ Peter J. Williamson & Eden Yin, *Accelerated Innovation: The New Challenge from China*, MIT SLOAN MGMT. REVIEW (forthcoming 2014), available at <http://sloanreview.mit.edu/article/accelerated-innovation-the-new-challenge-from-china/>; Yue Zhang, Institution, Debate at DRUID Conference 24: Let It Be Resolved That This Conference Believes That China Will Become the Leading Innovative Power In the World in 2040, min. 07:05-10:00, available at <http://vimeo.com/98925171>.

²⁶ *Id.*

²⁷ Yu, *Rise and Decline*, *supra* note 40, at 552.

²⁸ Hu & Jefferson, *supra* note 29, at 64.

²⁹ *Id.* at 64–65.

³⁰ Hu & Jefferson, *supra* note 29, at 64.

³¹ *Id.*

Another crucial part of China's success is their government's intellectual property agenda. The State Council adopted their National Intellectual Property Strategy in June 2008, which emphasizes actively developing intellectual property in China.³² Government initiatives, like financial remuneration and tax breaks, reward Chinese inventors for filing patents both domestically and abroad.³³ Scholar Ram Mudambi goes so far as to cite the Chinese government's clear plan and vision as to innovation as a factor that will set China apart as the world's leading innovative power by the year 2040.³⁴

China's aggressive patent law reform may also have contributed to Chinese success in applying to the PTO. In 2008, China enacted regulations and published guidelines for their patent office that look remarkably like the regulations the United States has for the PTO.³⁵ China implemented regulations, which include "how-to" instructions, in 2010. These regulations are equivalent to the U.S. rules of practice, found in Chapter 37 of the U.S. Code of Federal Regulations.³⁶ Even more telling, China enacted guidelines for patent examination in February 2010 that are equivalent to the U.S. Manual of Patent Examination Procedure (MPEP).³⁷ Perhaps by making the SIPO application process more similar to the USPTO application process, China made its inventors more equipped to apply for patents in the United States.

Several scholars attribute the Chinese government's prioritization of intellectual property rights to the influence of Western foreign policy, primarily that of the United States. After decades of battling with the U.S. and other trade partners over lax enforcement of IP rights, it appears, at least in patenting, that outsiders have helped push Chinese policy towards alignment with western IP systems.³⁸ It follows that when the Chinese government was forced to enforce outsider's

³² Peter K. Yu, *The Rise and Decline of the Intellectual Property Powers*, 34 CAMPBELL L. REV. 525, 530 (2012).

³³ Neumeyer, *supra* note 33.

³⁴ Ram Mudambi, Temple University Fox School of Business, Debate at the DRUID 2014 Conference: Let it be Resolved That This Conferences Believes that China Will Become The Leading Innovative Power in the World in 2040, min. 28:47-41:07 (June 16, 2014), *available at* <http://vimeo.com/98925171>. For other arguments for and against the proposition that China will take over as the world's leading innovative power by 2040, watch the full debate.

³⁵ Jaeschke, et al., *supra* note 12, at 570.

³⁶ *Id.*

³⁷ *Id.*

³⁸ Yu, *From Pirates to Partners*, *supra* note 6, at 136-54.

patent rights domestic inventors would seek the same rights, contributing to greater rates of patenting by Chinese nationals both home and abroad.

C. Increase in Chinese Advanced Technology Products Exports

A final explanation for the rapid increase in the number of patent applications from mainland China is the fact that an increasing share of Chinese exports to the U.S. can be thought of as advanced technology products (ATPs).³⁹ The share of ATP exports from China has more than doubled from 16 percent in 2002 to 33 percent in 2012.⁴⁰ Meanwhile, the ATP share of total exports to the U.S. fell for the other BRICS, although this can be attributed entirely to the ATP shares from Brazil and Russia. Some point out that a large number of these exports are merely processed in China, but even in non-processing exports, China's share of high and medium-high technology exports grew by over 20% from 1997 to 2007.⁴¹

The shift away from discrete product industries to more complex product industries is to be expected as any economy develops, but has occurred much more rapidly in China.⁴² Operating in these complex industries brings far greater incentive to patent, both for product protection and to equip one's firm with a

³⁹ About 500 of some 22,000 commodity classification codes used in reporting U.S. merchandise trade are identified as "advanced technology" codes and they meet the following criteria:

- The code contains products whose technology is from a recognized high technology field (e.g.), biotechnology).
- These products represent leading edge technology in that field.
- Such products constitute a significant part of all items covered in the selected classification code.

This product and commodity-based measure of advanced technology differs from broader North American Industry Classification System (NAICS) industry-based measures, which include all goods produced by a particular industry group, regardless of the level of technology embodied in the goods. ATP classifications are assigned by the Foreign Trade Division of the U.S. Census Bureau. For the full list of classification codes, see *Foreign Trade*, UNITED STATES CENSUS BUREAU, <http://www.census.gov/foreign-trade/reference/codes/#atp> (last visited June 21, 2014). See also Hammer, *supra* note 29, at 7–8 (describing the increase in Chinese exports of APTs to the U.S.).

⁴⁰ The data used to generate the graph in Figure 3 can be found at *Foreign Trade: ATP Data-Imports and Exports-Country by ATP Group*, UNITED STATES CENSUS BUREAU, <http://www.census.gov/foreign-trade/statistics/product/atp/2013/12/ctryatp/index.html> (last accessed on Feb. 19, 2014).

⁴¹ Mudambi, *supra* note 34, at min. 39:00-40:00.

⁴² Javade Chaudhri, *Chinese Industrial Policies: Indigenous Innovation, Intellectual Property Rights, and the Trade Issues of the Next Decade*, 34 T. Jefferson L. Rev. 1, 4–5 (2011).

complex portfolio for negotiation purposes.⁴³ The development of more complex industries is no doubt fueled by the influx of FDI and government supported R&D fund. Additionally, scholars point to an increasingly educated work force.⁴⁴ Others have also suggested that the shift is attributable, at least in part, to domestic demand side drivers, namely climate change and population growth.⁴⁵

II. Data and Methods

In order to test these theories and hypotheses, we examined the number of patent applications originating from China, allowance rates for such applications, and the mix of technology covered by these applications. We also compared Chinese patenting activity with the patenting activity of inventors in other countries. Because examination standards differ across patent offices, comparing domestic filings in China with domestic filings in other countries may lead to spurious findings. By focusing on PTO filings, we are able to control for examination standards.

Data on the number of applications received may help distinguish whether China's current patenting trends are unprecedented or following an established development pattern. By comparing the applications to those from other countries, we can see how China's patent activity is different from that of other emerging economies as well as from established economies. This may also be

⁴³ Hu & Jefferson, *supra* note 29, at 58. Complex product industry actors tend to produce three times as many patent applications as discrete product industries. *Id.*

⁴⁴ Riccardo Crescenzi et al., *The Territorial Dynamics of Innovation in China and India*, 12 J. ECON. GEOGRAPHY 1055, 1058 (2012) ("Both India and, in particular, China have invested heavily in innovation 'inputs.' Both countries have witnessed rapidly rising literacy rates and education enrollment...Moreover, the rise in university placement in the two countries has been absolutely phenomenal."); see e.g. Anil K. Gupta & Haiyan Wang, *China as Innovator, Not Just an Imitator*, BUSINESS WEEK (March 9, 2009, 7:41 AM), <http://www.businessweek.com/stories/2009-03-09/china-as-an-innovator-not-just-an-imitatorbusinessweek-business-news-stock-market-and-financial-advice> ("Many of the scientific leaders who are overseeing the utilization of [government R&D] funds are highly qualified Western-educated researchers returning to China in growing numbers.").

⁴⁵ Gupta & Wang, *supra* note 44 ("The social and economic challenges that are either unique or particularly acute in China are likely to serve as the demand-side drivers of innovation."). As an example Gupta & Wang offer BYD, a Chinese based company that became the world's first company to start selling a plug-in electric hybrid car. *Id.*

helpful in understanding whether the influx of R&D in China has been effective and efficient and may be used to project future patenting behavior.

Data on allowance rates and the change in allowance rates is helpful in determining whether the increase in applications is merely the result of a push for more applications or whether there is a true increase in the development of patentable technology in China. This data may also be helpful in establishing what impact MNCs and foreign policy have had on the quality of applications. Comparing allowance rates over time and by country may again demonstrate whether China's current patenting behavior is unique.

Data on the technology mix of applications may add to the assertion that the Chinese innovation market is becoming more advanced, which would in turn explain the increase in applications. Examination of the technology mix concentration may have implications for whether China's patent trends are sustainable in the future or the incidental result of a boom in one industry.

In order to understand whether China is exhibiting unique trends or following some historical pattern, we first compare Chinese patent trends from 2000 to the present with those trends from the other BRICS countries and with Japan and South Korea during the same period.

We then make a historical comparison using South Korea and India as comparisons. Here we seek to compare China's highest 10-year growth in patent applications period, 1997-2007, with similar high-growth rate periods ("high growth periods") experienced by the comparison groups. We chose the South Korean comparison group because the growth in the numbers of South Korea applications between 1986 and 1996 was very similar to the growth in Chinese applications from 1997-2007. We chose the Indian comparison group because the growth in applications from that country has greatly exceeded the growth in applications from the other major emerging economies outside of China. These two sets of data (China, BRICS, Japan/South Korea for 2000-Present and China, South Korea, India for their respective high growth periods) are examined for each trend observed.

A. Measuring the Increase in Patent Applications

The data used in this study are from PTO's internal Patent Application Location and Monitoring (PALM) system. Patent examiners use the PALM system to monitor the progress of prosecution of each patent application. The PALM data include the following information: (1) the date that each application was received by the PTO; (2) the identities of the inventors; (3) the addresses of the inventors; (4) the art unit to which the application is assigned; and (5) the ultimate disposal state (allowed, abandoned, or pending) of the application. All patent applications received by the PTO, including those that have never been published, are present in PALM.⁴⁶ The analyses that follow consider only regular utility patent applications, not design patent applications or provisional patent applications.

We define an application's country of origin as the country of residence of the application's first-named inventor. For example, we consider an application to be from China if the first-named inventor's residence is listed as mainland China. The Chinese applications included in the study do not include applications where the first-named inventor was from Hong Kong, Macau, or Taiwan. The applications can, however, include cases where a foreign national, who is living in China, is the first-named inventor. Also, the Chinese applications include many cases in which Chinese nationals, living in China but working for multinational enterprises, are first-named inventors.⁴⁷ A similar approach is used to determine which applications originated from each of the comparison countries.

B. Measuring Allowance Rates

The allowance rates reported in this Article were calculated for the set of all applications that had either been abandoned or allowed as of August 2013. The allowance rates are reported for the year of application rather than the year of disposal. As an example, consider a case where the USPTO received 10,000 applications from inventors in a given country in 2006. Suppose that by August 2013, 4,500 of the applications had been issued as a patent, 4,500 had been

⁴⁶ In this way, PALM differs from the public version of the Patent Application Information Retrieval (PAIR) system. Public PAIR only includes applications that have been made public due to the issuing of a patent, the publication of the application, or for other reasons. The PALM data can only be accessed by USPTO personnel who can show reason for needing to access it.

⁴⁷ In both India and China, the majority of U.S. patents are owned by multinational corporations. About half of them are co-invented.

abandoned, and 1,000 were still pending. The allowance rate for 2006 would be 50 percent (*i.e.*, 4,500 total issued patents divided by 9,000 total disposals).

We also addressed a couple of issues regarding the allowance rate results. The first issue relates to the fact that we are calculating the allowance rates only for applications that have been disposed; many of the applications filed in the later years are still pending. It is unclear what the final allowance rate will be for applications filed in these years. However, for applications filed in the earliest years (2000 through 2002), we found no evidence that the final allowance rate (after almost all applications had been disposed) differed from the allowance rates for, say, the first 20 or 50 percent of applications disposed from each of those years. In essence, the allowance rate for disposed applications when only 20 or 30 percent of the applications have been disposed appears to be a good estimate of what the final allowance rate will be after all applications have been disposed. Thus, we feel confident that the convergence of allowance rates in the later years is not due to biased measures of the final allowance rates.

The second issue relates to the different technology mixes of the applications from different countries. Certain technology areas, such as biotechnology, exhibit lower allowance rates. Thus, overall allowance rates may change simply due to changes in the technology mix. We used multivariate statistical models to control for the differences in technology mix and the result regarding the convergence of the Chinese allowance rate to the Japanese/South Korean allowance rate did not change. After controlling for technology mix, we found that the allowance rate for the other major emerging economies also converges toward that of Japan and South Korea. However, the rate of convergence is still greater for the Chinese patent applications.

C. Measuring the Technology Mix

To examine the technology mix of incoming applications, we consider the technology centers (TCs) at the PTO to which they are assigned. We decided on the following six technology categories:

- Biotechnology and organic chemistry (BIO) – TC 1600⁴⁸
- Chemical and materials engineering (CHEM) – TC 1700⁴⁹
- Computers and communications (COMP)⁵⁰ – TCs 2100, 2400, and 2600⁵¹

⁴⁸ In prior years, TCs 1200 and 1800 (no longer in use) mapped to the BIO area.

⁴⁹ In prior years, TCs 1100, 1300, and 1500 (all no longer in use) mapped to the CHEM area.

- Semiconductors, electrical and optical systems and components (SEMI) – TC 2800⁵²
- Transportation, construction, electronic commerce, agriculture, national security and license & review (TRANS) – TC 3600⁵³
- Mechanical engineering, manufacturing, products (MECH) – TC 3700⁵⁴

While examining the changes in the technology mix, this Article also considers changes in the relative concentration of the technology mix over time for each country (or group of countries) of interest. To do so, we use the Herfindahl-Hirschman index (HHI), a measure commonly used by economists when examining market concentration. To calculate the index, we first calculate the share of all applications in each of the six technology areas. We then square each of these shares and sum them up. Higher values of the index indicate higher levels of concentration. Given that we have six technology areas, the smallest value the index can take on is 0.167, which would indicate a uniform distribution of applications across the six technology areas. The largest value that the index can take on is 1, which would indicate that all of the applications were assigned to just one of the six technology areas.

D. Calculating Geographic Concentration

Lastly, we looked at where in China patent applications originated. We identify several regions that are particularly productive in patent applications. Again we employ the Herfindahl-Hirschman index, explained above, to calculate the relative geographic concentration of patent applications.

⁵⁰ In the areas of computers and telecommunications, the TCs have not been stable since 2000. Currently, these types of patent applications are assigned to one of the following three TCs:

- 2100 – Computer Architecture, Software, and Information Security
- 2400 – Computer Networks, Multiplex Communication, Video Distribution and Security
- 2600 – Communications

TC 2400 is relatively new; applications that would commonly be assigned to that TC would have been assigned to either 2100 or 2600 earlier in the decade. Thus, we decided to combine these three TCs into one category called “computers and communications.”

⁵¹ In prior years, TCs 2300 and 2700 (both no longer in use) mapped to the COMP area.

⁵² In prior years, TCs 2200 and 2500 (both no longer in use) mapped to the SEMI area. Prior to 1998, TC 2100 mapped to the SEMI area instead of the COMP area.

⁵³ In prior years, TCs 3100 and 3500 (both no longer in use) mapped to the TRANS area.

⁵⁴ In prior years, TCs 3200, 3300, and 3400 (all no longer in use) mapped to the MECH area.

IV. Results & Analysis

In the following subsections, we explain the results of our study organized by the three four patent trend measures focused on: patent applications, allowance rates, technology mix concentration, and geographic concentration. For each trend, the results from the first data set, that focused on the current time period and on applications from China, the BRICS, and Japan or South Korea, are discussed first, and the data from the second set, that focused on the 10-year high growth periods for China, South Korea, and India, is discussed second.

A. Patent Applications to the USPTO

1. Applications: 2000-Present

Figure 1 compares the growth in the number of PTO applications from mainland China to applications from the other BRICS economies since the year 2000. The PTO received 422 patent applications from mainland China in 2000, as compared to 1,200 applications from the other four BRICS countries.⁵⁵ By 2006, the USPTO was annually receiving 40 percent more applications from China than from the other four emerging economies combined. In 2012, the number of applications from China was more than 90 percent higher than the number of applications from the other emerging economies. This is in part due to the tax incentives given to American companies in China, leading to an intensification of research and development in China and prompting Chinese firms to file for more patent applications at home and abroad.⁵⁶

Figure 1

At the same time, the number of applications coming from China over this time period was still quite small compared to the number of applications coming from Japan and South Korea.⁵⁷ Japanese and South Korean inventors accounted for roughly 50,000 applications in the year 2000, with applications from those countries peaking at a little over 80,000 in 2007. After the financial crisis, the

⁵⁵ If current trends continue, the number of Chinese patents granted by the USPTO will exceed the number of patents from Germany, Britain, Italy, and France combined by the year 2020.

Gupta & Wang, *supra* note 44.

⁵⁶ Hu & Jefferson, *supra* note 29, at 64.

⁵⁷ This explains why the numbers for this comparison group are not included in Figure 1.

number of applications from Japan and Korea fell slightly, but was back above 79,000 by 2012. This growth in the number of applications since 2000 is comparable to the growth in the number of applications from U.S.-based inventors during the same time period – roughly 55 percent over 12 years for an average annual growth rate of 3.7 percent. At the same time, this growth pales in comparison to the growth in the number of foreign applications to PTO, which roughly doubled over the same 12-year period reflecting an average annual growth rate of 6 percent.

However, even the rate of growth in foreign applications pales in comparison to the rate of growth in the number of applications from China. In Figure 2, we compare China's growth rate with those of the two comparison groups (Japan/South Korea and the other BRICS). The number of applications from the other BRICS grew at an average annual rate of roughly 11 percent, so that by 2012, the PTO received more than three times as many applications from these countries than it had received from them in 2000. Thus, the number of applications from these countries grew at a rate far greater than the number of all foreign applications. However, over this same time period, the number of applications from mainland China grew at an average annual rate of 31 percent. By 2012, the PTO was receiving 25 times as many applications from Chinese inventors than it had received in 2000.⁵⁸

Figure 2

2. Applications: High Growth Periods

In all three cases in the second data set, the number of applications in the base year is quite small, ranging from 131 applications from China in 1996 to 158 applications from South Korea in 1986 to 164 applications from India in 1998. Figure 11 illustrates how quickly the number of applications from each of these countries grew over the following ten years. The growth in Chinese applications from 1996 to 2006 was quite similar to the growth in South Korean applications over the previous decade, especially through the first 8 years (through 2005 in the case of China). In each case, the number of applications at the end of the period was roughly 30 times higher, which reflected a roughly 40-percent

⁵⁸ Interestingly, this growth rate is very similar to the rate of growth in patent applications to SIPO from Chinese residents.

average annual growth rate over 10 years. Even India, with its 30-percent average annual growth rate in applications from 1998 to 2008, is left lagging.⁵⁹ This comparison shows that there is at least one precedent for the recent explosive growth in applications from China.⁶⁰

B. Allowance Rates for Applications to the USPTO

Given the enormous increase in the number of patent applications from China, it makes sense to ask whether this increased activity has been at a cost of decreased application quality.

1. Allowance Rates: 2000-Present

Figure 8 illustrates how the allowance rates have changed for Chinese applications as well as for the two comparison groups, Japan/South Korea and the other BRICS economies. Among the three groups discussed here, allowance rates have been highest for applications from Japan and South Korea. For applications that were received from these two countries in 2000, the allowance rate was slightly over 80 percent (as compared to roughly 66 percent for applications from China and the other major emerging economies). Allowance rates generally fell, regardless of origin, through 2007, but have been increasing since that time. The most important insight in Figure 8 is the fact that the allowance rate for Chinese applications has been steadily converging with the allowance rate for Japanese and South Korean applications, while diverging from the relatively lower allowance rate for the other BRICS countries. This may indicate that Chinese applicants are learning how the system works at PTO. It may also indicate that the mix of inventors has changed and that more applications are coming from Chinese inventors who are working for multinational enterprises.

⁵⁹ Why else might India be left lagging? One critic argues that the geography of innovation in China and India is different. In China, innovation is driven by agglomeration forces, linked to population, industrial specialization, and infrastructure endowment. In India, innovation is more dependent on a combination of good local socioeconomic structures and investment in science and technology. *See generally* Crescenzi et al., *supra* note 52.

⁶⁰ Both India and China are predicted to be very successful in securing patents. One critic predicts that by 2015 or 2020, the share of USPTO patents is likely to have grown significantly due to the emphasis both countries have on R&D. Gupta & Wang, *supra* note 44.

Figure 8

2. Allowance Rates: High Growth Periods

When adjusted by technology-area,⁶¹ the allowance rate for South Korean applications generally increased while the allowance rates for Chinese and Indian applications generally decreased over the time periods of interest.⁶² However, it appears that these trends were driven by general trends in the overall allowance rate. If anything, the evolution of South Korean and Chinese allowance rates followed the evolution of the allowance rates for all applications to the PTO. The decrease in the allowance rate for Indian applications was more dramatic than the underlying decrease in the allowance rate for all applications to the PTO. Additionally, the technology area-adjusted allowance rate for South Korean applications from 1988 through 1996 was generally on par with the overall allowance rate at the PTO, while the allowance rate for Chinese applications from 1997 through 2007 was generally lower than the overall allowance rate. The allowance rate for Indian applications went from being much higher than average from 1998 to 2002 to being average by 2005.

C. Evolution of the Technology Mix Represented by Patents Submitted to the USPTO

1. Technology Mix: 2000-Present

Figure 4 illustrates that the rate of growth in the number of applications from China has not been uniform across technology areas. The highest rates of growth have come in computers and communications (COMP) and in electrical engineering and optics (SEMI). In each of these areas, the numbers of applications have grown at average annual rates of 37 percent and 33 percent, respectively. The biotechnology area has experienced the least growth. Still, the number of patent applications in this technology area increased at an average annual rate of 19 percent between 2000 and 2012.

⁶¹ See explanation of this adjustment *supra* Part II.B.

⁶² See Appendix, Figure 16.

Figure 4

Panel (a) in Figure 5 illustrates the change in the technology mix of Chinese patent applications between the 2000-02 and the 2010-12 time periods. Given the results presented in Figure 4, it is not surprising that we see a shift away from the technology areas that have been growing least quickly (BIO, CHEM, and MECH) to the two fastest growing technology areas, COMP and SEMI. The change in the share of all applications assigned to COMP has grown much larger, from 24 percent at the beginning of the period to 40 percent at the end of the period. Panels (b) through (d) in Figure 5 show the changes in the technology mixes for three different comparison groups. Panel (b) shows the changes for the other BRICS economies, Panel (c) shows the changes for Japan and South Korea, and Panel (d) shows the changes for all applications to the PTO for the same time period.

Figure 5

As was the case for China, the technology mix for the other BRICS economies has skewed more heavily toward COMP and away from the BIO, CHEM, and MECH areas. The share of all applications from these countries assigned to COMP has more than doubled over the past decade.

For Japan and South Korea, the share of applications assigned to COMP has grown, but less so than for either China or the other BRICS. From 2000 to 2002, 24 percent of the applications were in COMP. By the later time-period, this share had grown to 29 percent. Also, SEMI continues to receive the greatest share of applications, with a 34 percent share at the beginning of the period and a 35 percent share at the end of the period. The growth in the shares of the COMP and SEMI areas was offset by small decreases in the shares of the other technology areas. The relative stability of the technology mix for Japan and South Korea is likely a result of a greater level of maturity in those countries' economies. As a final comparison, Panel (d) of Figure 5 presents the change in the technology mix of all patent applications received by the USPTO. Again, there is a small increase in the shares of applications in COMP and SEMI, but the result is not nearly as pronounced as the results are for China and the other major emerging economies. The rush to attempt patenting innovations in the COMP area by inventors in these emerging economies, including China, does not appear to be a broader trend. For China and the other BRICS economies, there

has been a much greater shift into the COMP and SEMI technology areas and away from the other areas.⁶³

Figure 7 shows that the technology mix of Chinese applications has not only changed significantly over the past decade, but that it has become more concentrated. In 2000, China's technology mix was not terribly concentrated in any one or two areas, with an HHI of 0.18. The same could be said for the technology mix for the other BRICS (HHI=0.17). By 2006, however, the technology mix of Chinese applications had become much more concentrated (skewed toward the COMP and SEMI areas). This is illustrated by the increase of the HHI to 0.27 by 2006. The technology mix of Chinese applications has maintained a comparable level of concentration ever since. The involvement of multinational corporations in the electrical and electronics industry helps explain why the SEMI area has become so concentrated. Since 2006, a sudden increase in new Class 361 (the PTO's designation for electrical system and device patents) patents from China can be traced to R&D that is heavily focused on China's electrical and electronics industry.⁶⁴ For example, Foxconn Technology Co. is responsible for 90% of China's newly issued American patents in the USPC 361 sector.⁶⁵ Foxconn is a Taiwanese multinational company with major American clients, including Amazon, Apple, Microsoft, and Dell.⁶⁶ Foxconn is also planning on expanding its American manufacturing power with new factories in the U.S.⁶⁷ It stands to reason that a multinational corporation with significant American involvement would be more adept at patent filings at the PTO.

Figure 7

There has also been an increase in the technology concentration of applications from the other BRICS, although this increase had not been as pronounced until 2012. The HHI for these countries had increased to 0.25 by 2008, and stayed in the 0.23 to 0.25 range until increasing sharply to roughly 0.28 in 2012. The technology mix concentration of Japanese and South Korean applications was high relative to those of the other comparison groups for the first part of the

⁶³ See Appendix, Figure 6.

⁶⁴ Jia Zheng et al., *Industry Evolution and Key Technologies in China Based on Patent Analysis*, 87 SCIENTOMETRICS 175, 183 (2010).

⁶⁵ *Id.* at 182.

⁶⁶ Charlie Osborne, *Foxconn in Talks to Boost Manufacturing in United States*, ZDNet (Jan. 24, 2014), <http://www.zdnet.com/foxconn-in-talks-to-boost-manufacturing-in-united-states-7000025724/>.

⁶⁷ *Id.*

time period, but has also remained fairly consistent, rising only slightly from 0.235 to 0.25 over the time period. Since 2006, the technology concentration for Japan and South Korea has been lower than China's and similar to that of the other BRICS countries.

2. Technology Mix: High Growth Periods

For each case in the second data set, we consider the evolution of the technology mix for applications received from the country over the 10-year period. Figure 12 illustrates how the technology mix changed for Chinese applications. At the beginning of the period, the CHEM and SEMI technology areas were most important accounting for 25 percent and 22 percent of all applications, respectively. By the end of the period, the CHEM area accounted for only 9 percent of all applications, while the COMP area had grown from a 10-percent share to a 35-percent share. The BIO area had also become a smaller share of applications falling from 15 percent to 7 percent over the time period.

Figure 12

By comparison, applications from India in the late 1990s were heavily concentrated in the BIO area.⁶⁸ Roughly 45 percent of the applications were in that area. By the end of the time period, the Indian applications were still heavily concentrated in one area, but that area had switched from BIO to COMP. For the 2006 to 2008 period, the COMP technology area accounted for roughly half of all applications. During South Korea's 10-year high growth period, the share of all applications in the SEMI area grew from 20 percent to 35 percent.⁶⁹ During this same period, the shares of applications in the TRANS and MECH areas each fell by at least 30 percent.

Figure 15 illustrates what happened to the technology-mix concentrations in each country as compared to changes in the technology mix concentration for all regular utility applications to PTO.⁷⁰ The first result to consider is that in each case, after an initial drop the technology mix concentration rose steadily. For China, the HHI initially fell from 0.2 to 0.175 between 1997 and 1999, but then rose to 0.275 by 2006. For South Korea, the HHI initially fell from 0.24 to 0.19

⁶⁸ See Appendix, Figure 13.

⁶⁹ For data on the change in technology mix for South Korean Applications, 1986-1996, see Appendix, Figure 14.

⁷⁰ We again use the HHI, discussed in Section 2, to measure the technology mix concentration.

between 1986 and 1988, but then rose to 0.25 by 1992 and fluctuated between 0.22 and 0.25 through 1996. The technology mix concentration was generally much higher for India. The HHI initially fell from 0.33 in 1998 to 0.26 in 2003, only to rise again to 0.34 by 2008. It is also worth noting that the technology mix of applications from China was generally the least concentrated of the technology mixes during the country's periods of fast growth, except toward the end of the ten-year period where China's technology mix concentration for 2006 and 2007 was slightly higher than the concentration for South Korea for 1995 and 1996.

Figure 15

D. Geographic Concentration

Just as the technology mix of Chinese applications to PTO has become more concentrated, so has the geographic mix. Figure 9 illustrates how the mix of applications has evolved over time. The results focus on the following regions: Guangdong province, Beijing municipality, Shanghai municipality, Jiangsu province, Zhejiang province, and other regions. At the beginning of the millennium, more applications came from Beijing municipality (28 percent) than from any other region. At that same time slightly less than 20 percent of the applications came from Guangdong province. However, the growth in the rate of patenting by inventors in Guangdong province greatly outpaced overall growth in China for the next several years so that, by 2006, applications from Guangdong accounted for nearly 50 percent of all applications from China to the PTO. Guangdong's share has consistently remained at over 40 percent since then. Over the most recent time period, the three dominant regions have been Guangdong province (45 percent) and the Beijing (21 percent) and Shanghai (14 percent) municipalities. These three regions currently account for 80 percent of all applications from China.

Figure 9

Patent giant Huawei Technologies is headquartered in the technologically prolific Guangdong province. As discussed in Section 3 of this paper, China's Huawei Technologies has greatly increased its R&D spending in recent years and now owns over 50,000 patents.

As a measure of the concentration of the geographic mix, HHIs were calculated for each year from 2000 onward.⁷¹ The results show that applications to the PTO from China have become more geographically concentrated since the turn of the millennium. However, the most recent trends (from 2009 to 2012) seem to indicate that geographic mix may be becoming less concentrated. Such a trend was exhibited between 2006 and 2008, but it quickly reversed itself.

According to one critic, the concentration of innovation in China is “fundamentally driven by agglomeration forces, linked to population, industrial specialization, and infrastructure endowment.”⁷² In ‘mature’ innovation systems like the United States, patenting activity is spread among a greater number of regions than in emerging systems like China, where patenting is concentrated in Guangdong, Beijing, and Shanghai. However, it should be noted that geographic patent concentration in China is not much different than in the U.S., where 25% of the innovation market is based in Silicon Valley.⁷³

This polarization in China is enforced by an emerging trend among Chinese local authorities. These local authorities engage in territorial competition in order to attract external resources from both international investors and the Chinese central government. Authorities from these regions have more wealth and political power, and they promote the concentration of innovating activities at the expense of neighboring territories. Further, the enactment of Special Economic Zones (SEZs) in 1978 increased territorial concentration in Chinese innovation. This spatially concentrated FDI flows and thus developed clusters of innovative activity in these regions.

India displays similar geographic concentrations.⁷⁴ Perhaps this is merely an indication that these countries technology industries are still maturing. However, this could over time be seen as an emerging new model. With cities able to connect to global markets with less reliance on national government infrastructure, technology producing cities or clusters might be a more effective unit to study than nations as a whole when looking for patterns and trends.⁷⁵ In

⁷¹ See Appendix, Figure 10.

⁷² Crescenzi et al., *supra* note 52, at 1055.

⁷³ Mundambi, *supra* note 34, at min. 01:07:25-01:08:01.

⁷⁴ *Id.* at 1057.

⁷⁵ Indeed, Daniele Archibugi argues that countries may no longer be the relevant political unit in this area of study. Daniele Archibugi, Research Director, Italian National Research Council, Debate at DRUID Conference 2014: Let It Be Resolved That China Will Be The Leading Innovative

order to establish whether this is the case, future studies should compare the booming technology centers of China with those of the comparison groups or even cities like San Francisco and New York.

V. Implications

From this information, it appears China is not exhibiting exceptional patenting trends, but rather developing in a very similar manner as other innovative countries in east Asia, primarily South Korea.

The astronomical growth in the number of patent applications to SIPO from Chinese firms has been accompanied by similar growth in the number of applications to the PTO from Chinese inventors. The number of applications to the PTO from China grew at an average annual growth rate of 31 percent from 422 in 2000 to 10,511 in 2012. But the number of applications to the PTO was already growing steadily before the turn of the century. Between 1997 and 2007, the average rate of growth was roughly 40 percent. Such rapid growth is not unprecedented. The number of applications from South Korean inventors also increased at a yearly rate of roughly 40 percent from 1986 through 1996. In fact, using the South Korean experience as a guide, we should expect the number of Chinese applications to continue to grow steadily for at least the next decade.⁷⁶

While the number of applications from China has increased over the past decade, so has the level of relative concentration of these applications in particular technologies. In particular, the share of applications in high tech areas such as computing, telecommunications, and electrical engineering grew from 50 percent at the beginning of the decade to 68 percent by the end of the decade. At the same time, the share of applications in biotechnology and chemical and material engineering fell from roughly 28 percent to 14 percent. Our historical analyses indicate that this was the continuation of a trend that had been ongoing since at least the mid-1990s. We found a similar result for other major emerging economies, where the share of computing and telecommunications applications grew substantially and the share of biotech and chemical engineering applications fell significantly over the same time period. The technology mix was

Power by 2040 (arguing against the proposition), min. 56:00-57:35, *available at* <http://vimeo.com/98925171>.

⁷⁶ See Appendix, Figure 17.

more stable for Japan and South Korea, indicating that we may expect a more stable technology mix for Chinese applications as the Chinese economy matures.

Finally, the allowance rate for Chinese applications has steadily converged toward the allowance rate of South Korean and Japanese applications over the past decade. For applications filed in the year 2000, the ultimate allowance rate for South Korean and Japanese inventors exceeded the allowance rate for Chinese inventors by 10 percentage points (82 percent versus 72 percent). For applications filed in the year 2010 and disposed by February 2013, the difference between the two allowance rates was only 1 percentage point (79 versus 78 percent). This may indicate that Chinese inventors are learning how to better navigate the examination process at the USPTO. It may also indicate that the mix of inventors has changed and that more applications are coming from Chinese inventors who are working for multinational enterprises, which have more experience with the examination of patents in the U.S.

VI. Conclusion

China's power as an innovator is a topic of much debate and will no doubt be a critical factor considered in trade, policy, and business decisions of governments and corporations for quite some time. It is our hope that this data can be of use in making such decisions, as well as fuel further research in this area. In this Article, we use the data to explore whether China's recent surge of patent activity is novel or following some established development pattern.

To answer this question we have analyzed two sets of data. Both focus on the number of patent applications submitted to the USPTO, the allowance rate of these applications, and the technology mix of these applications. The first set of data compares these figures for China, the BRICS countries, and Japan and South Korea from 2000 to the present (2014). The second set looks at China, India and South Korea each during their respective 10-year period of highest growth in terms of patent applications.

The results indicate that China is following patenting trends similar to those exhibited by other East Asian countries, though at a more accelerated pace. China is submitting many more applications than other emerging economies, the patent-seeking technologies are more sophisticated, and the allowance rate is quickly converging with that of Japan and South Korea.

In addition to discrediting notions of Chinese exceptionalism, the results may support theories that the recent influx of R&D has been effectively converted into patentable technologies and that exposure to FDI and multinational corporations has helped develop a culture more accepting of and reliant on foreign IP protections.

Analysis of geographic concentration tends to distinguish China from more established innovative economies. However, future research should focus on whether shifting away from heavy geographic concentration has historically occurred as countries develop, or whether the global innovative city is becoming the new model.

Future research could also hone in on factors responsible for increase in allowance rates. For example, what is the impact of working with foreign corporations or a more globally integrated education system? Are the increasing Chinese allowance rates the result of more Chinese inventors gaining an awareness for how the US patent system functions or are more working for MNCs already familiar with the process. Additionally, the comparative data provided here could be supplemented with other economic indicators (workforce population, employment, wealth gap, etc.) to help establish whether there is any pattern in where along the development spectrum this boom of innovation occurs. This could also be helpful in forecasting whether or when the patenting activity is likely to peak or plateau. For now, if China continues to follow the pattern established by South Korea, it appears the number of Chinese patent applications will continue to rapidly increase for at least the next ten years before slowing.

Figure 1: Growth in the Number of Utility Patent Applications to the USPTO from China and Other BRICS Economies, 2000-2012

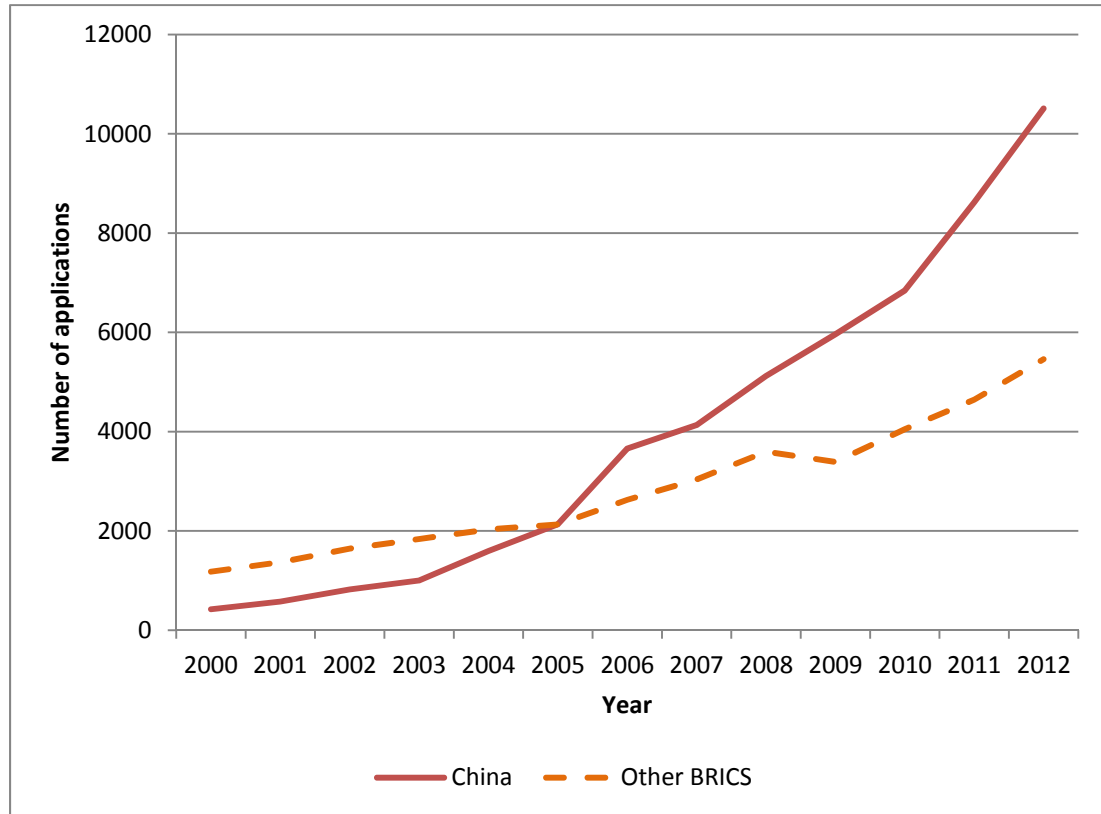


Figure 2: Comparing the Rate of Growth of USPTO Utility Patent Applications from China to the Comparison Groups, 2000-2012

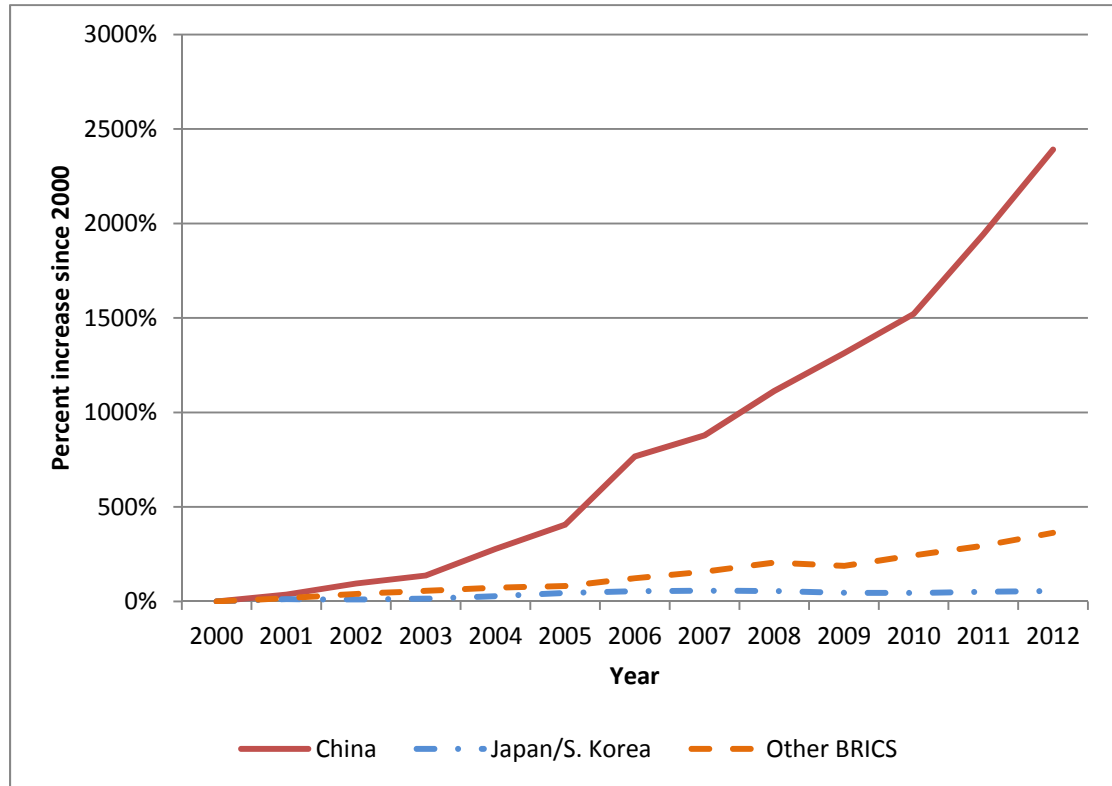


Figure 4: The Growth of USPTO Utility Patent Applications from China by Technology Area, 2000-2012

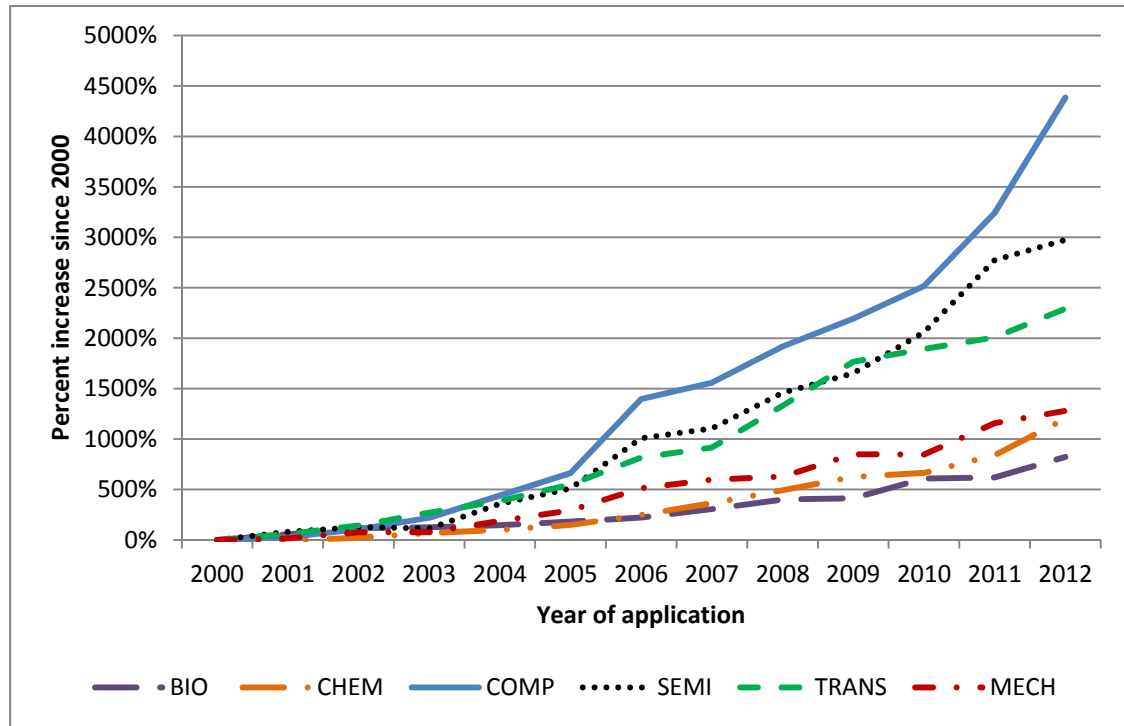


Figure 5: Change in Technology Mix, Applications to the PTO from Various Countries, 2000-02 to 2010-12

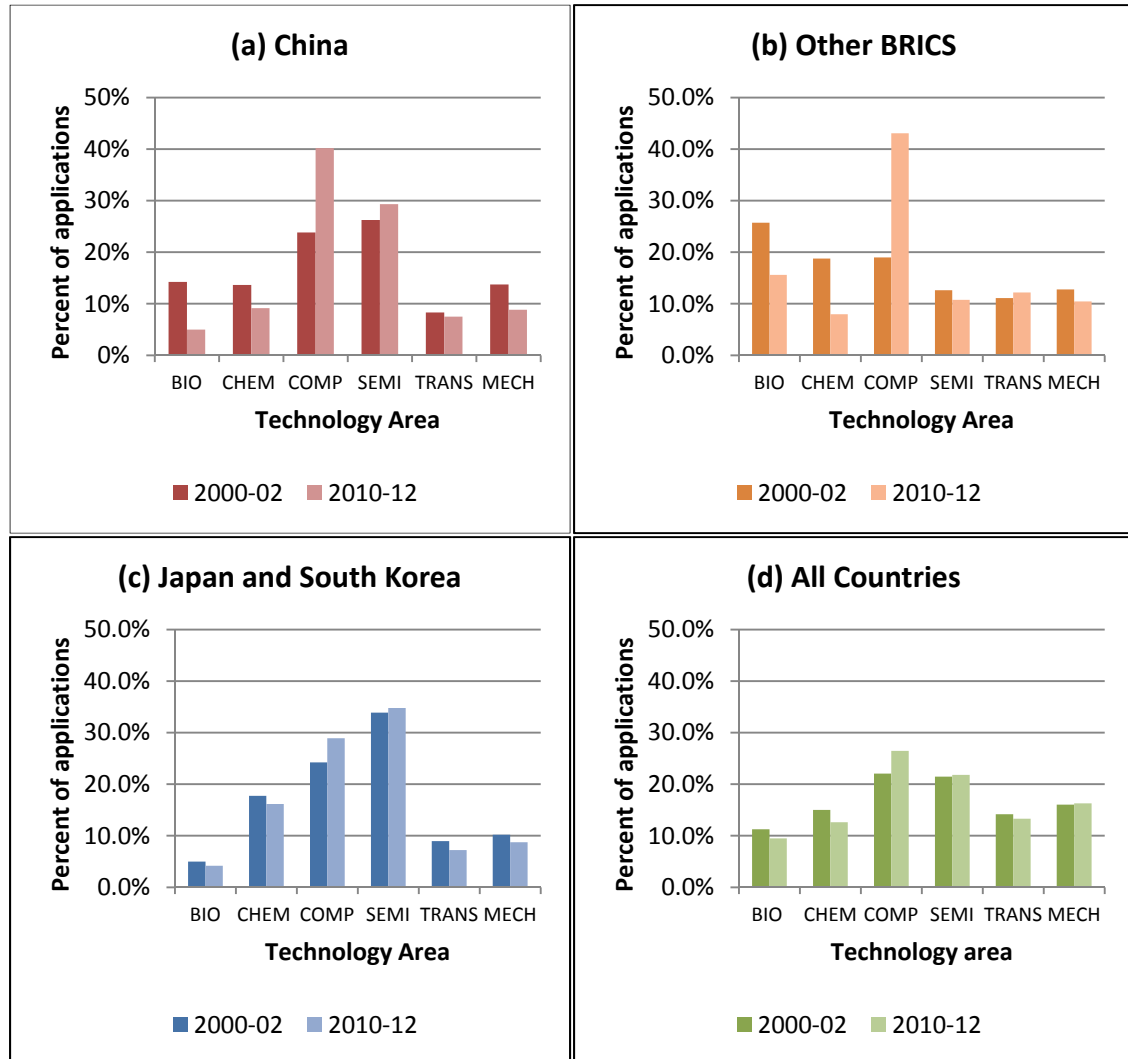


Figure 7: Technology Mix Concentrations of Applications from China, Japan and South Korea, and Other BRICS Economies, 2000-2012

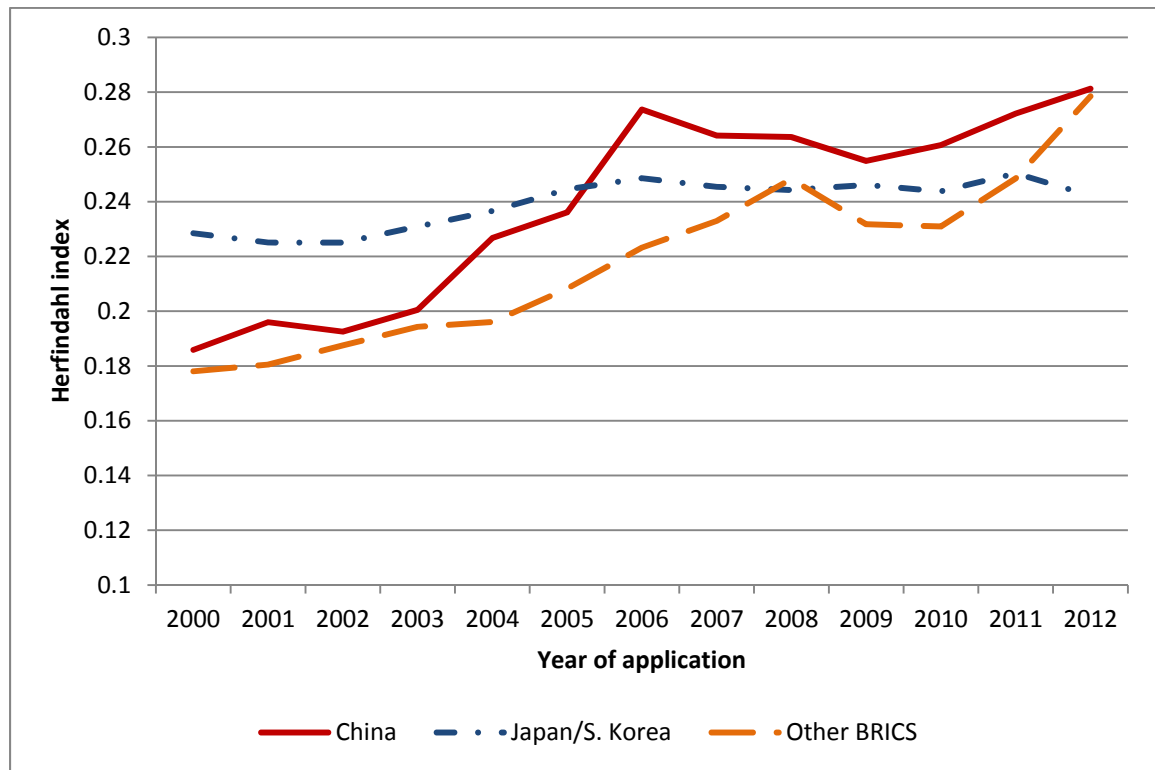


Figure 8: Comparing Allowance Rates of Disposed Applications, 2000-2010

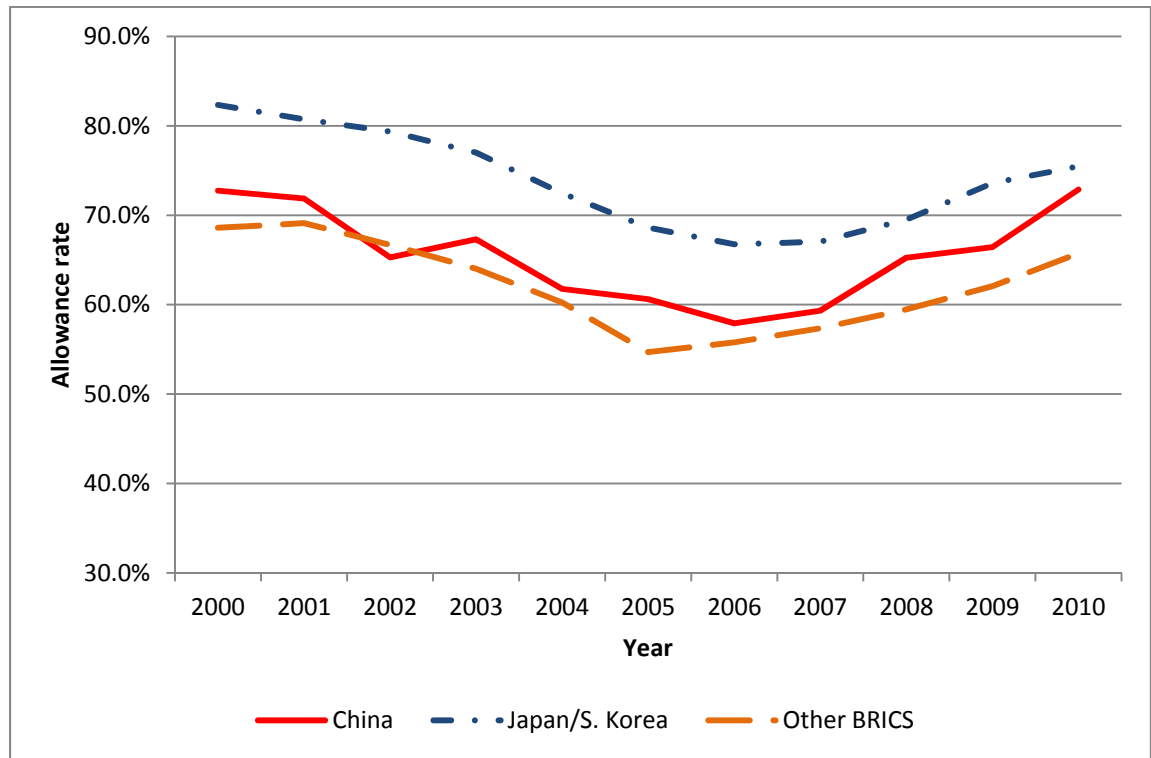


Figure 9: The Geographic Mix of Applications from China, 2000-12

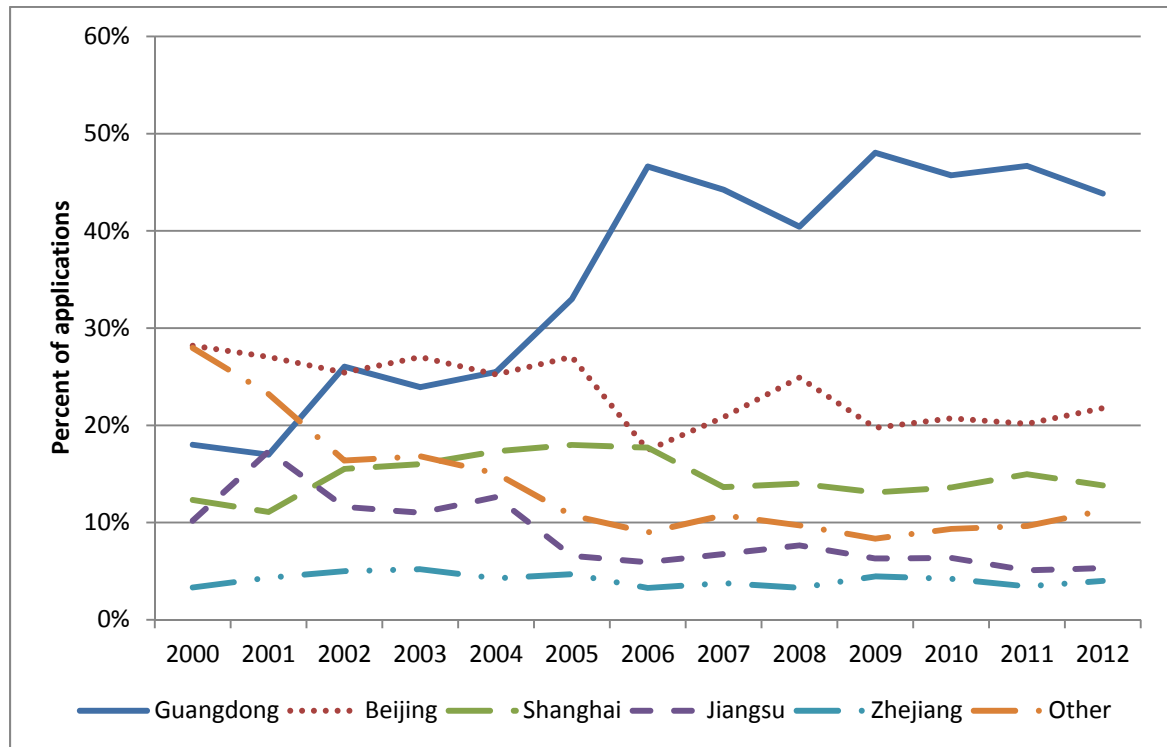


Figure 12: Change in Technology Mix, Chinese Applications to the USPTO, 1996-2006

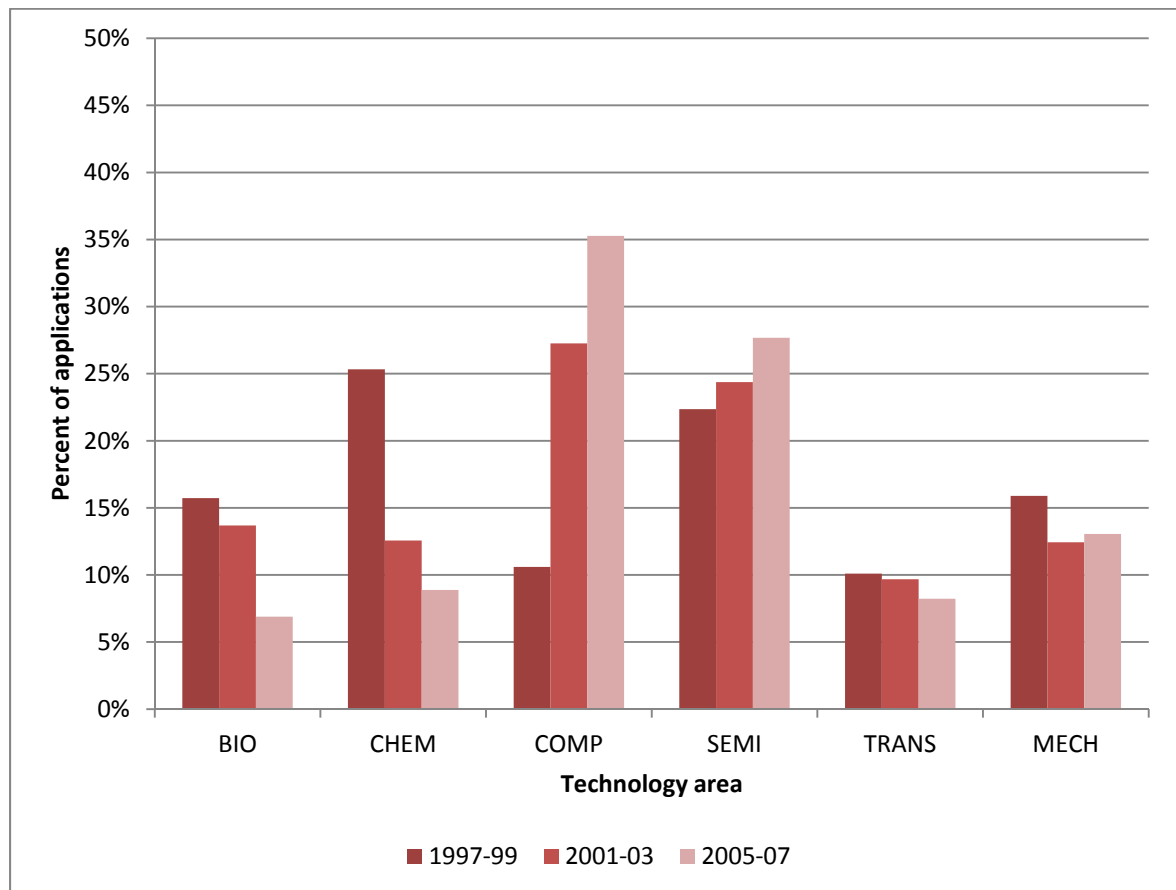
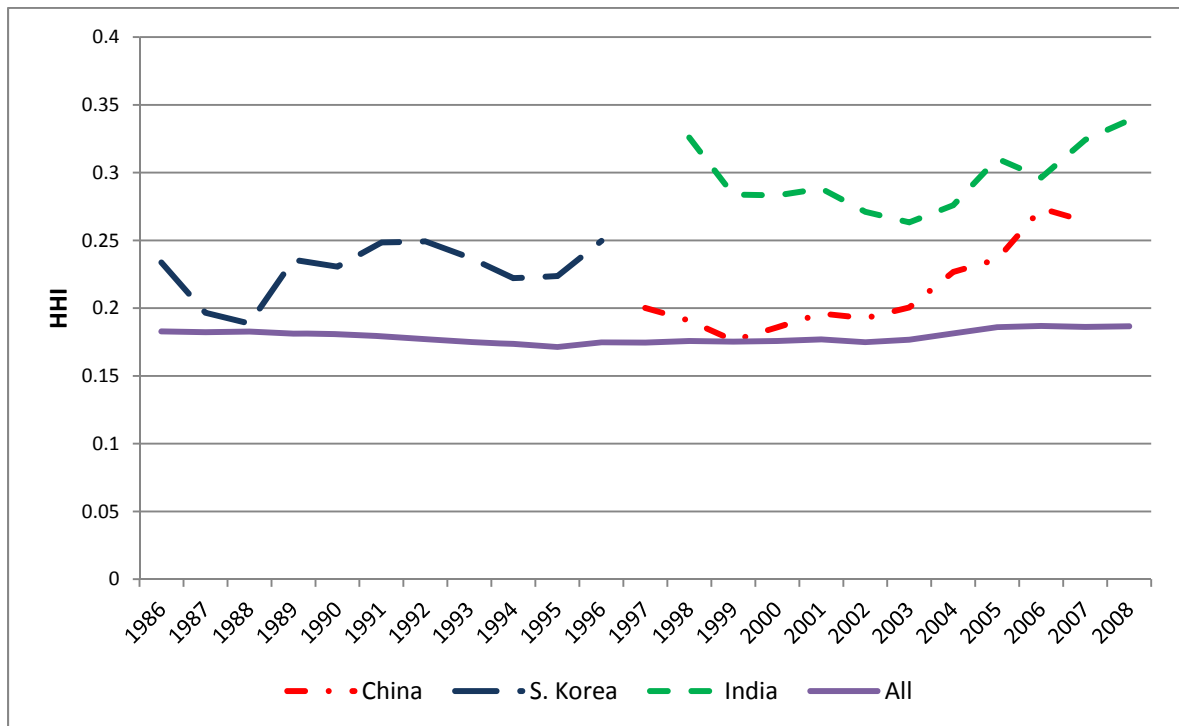
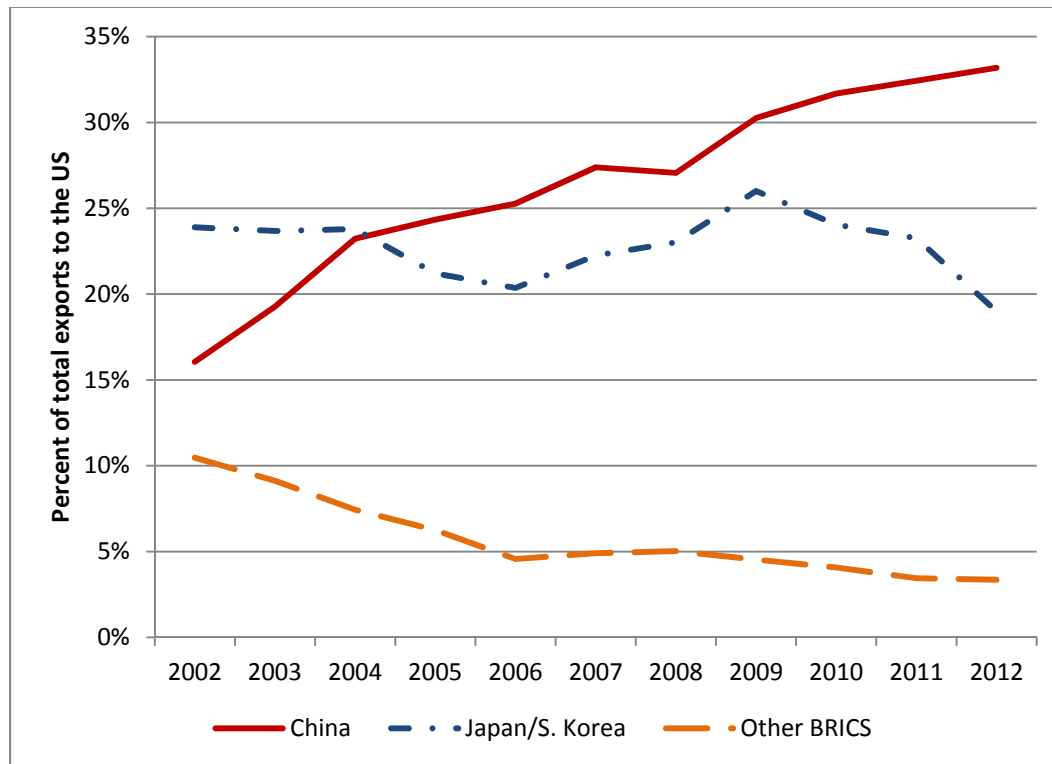


Figure 15: Change of the Concentration of the Technology Mix for Applications from the Three Countries and for All Applications (HHI Measure)



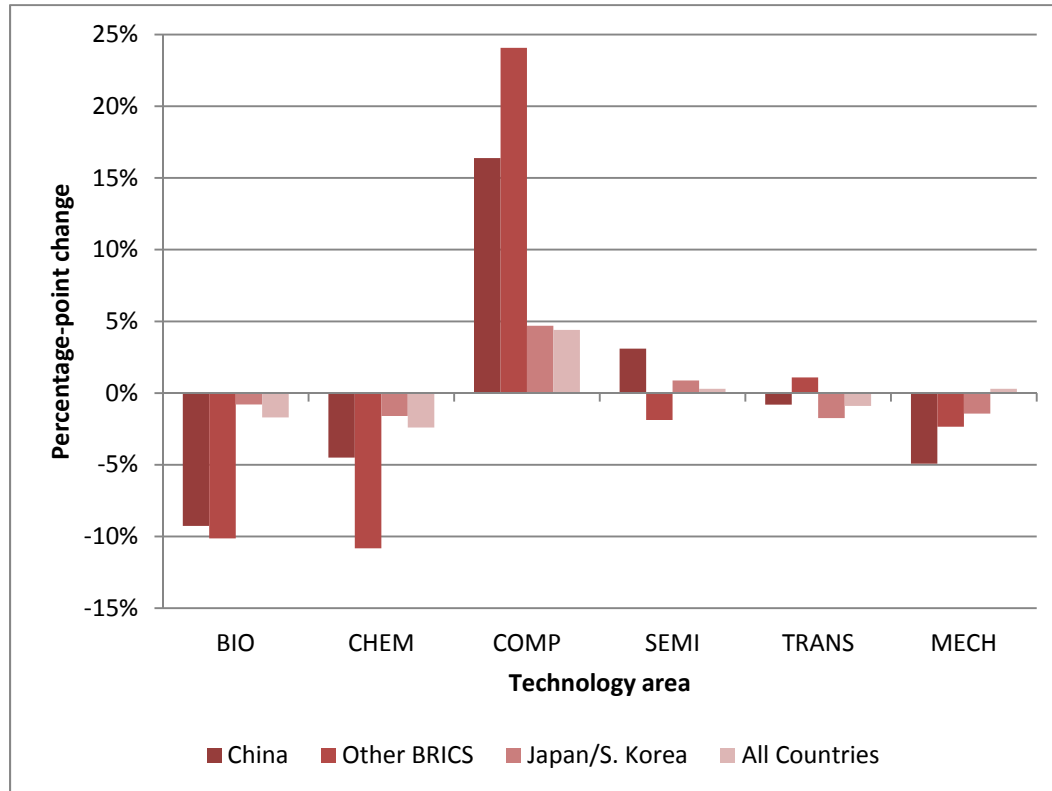
VII. Appendix

Figure 3: Share of Total Exports to the US that are Classified as Advanced Technology Products (ATPs), China and Comparison Groups, 2002-2012



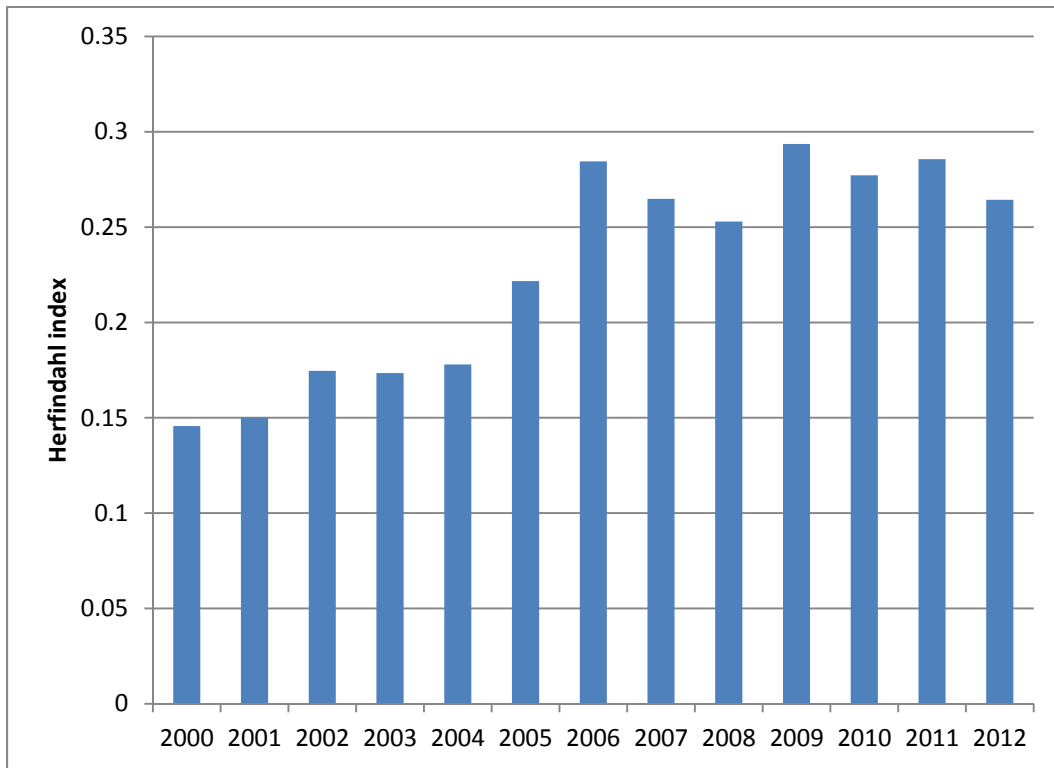
Source: Authors' calculations using data from the Foreign Trade Division of the U.S. Census Bureau.

Figure 6: Changes in Technology Mix of Applications from China and Various Comparison Groups, 2000-02 to 2010-2012



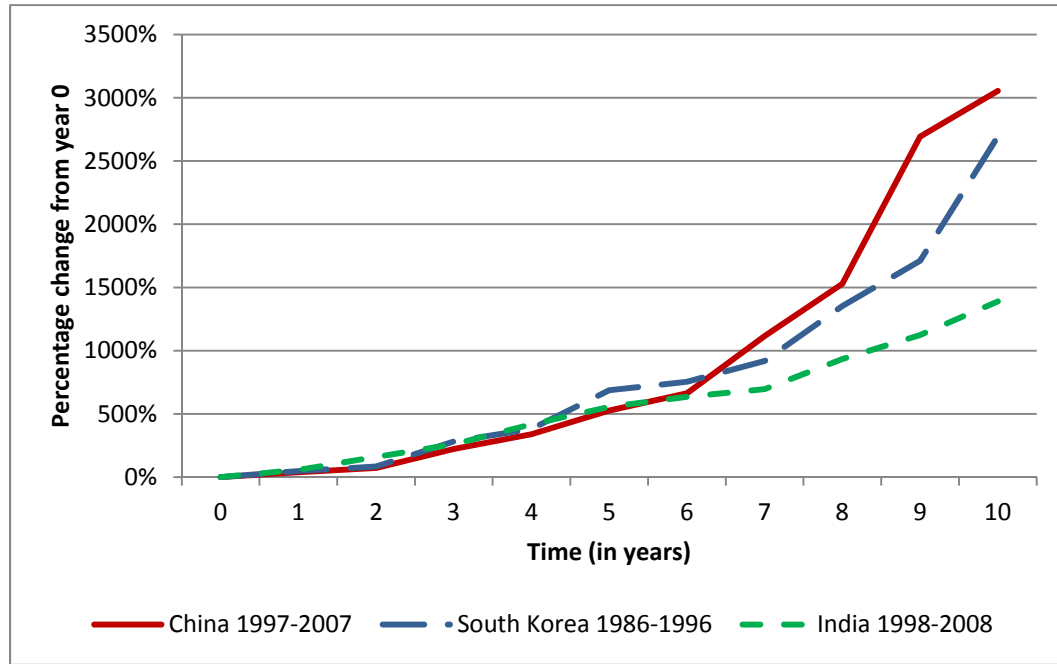
Source: Authors' calculations based on PALM data.

Figure 10: Geographic mix concentrations of applications from China, 2000-2012



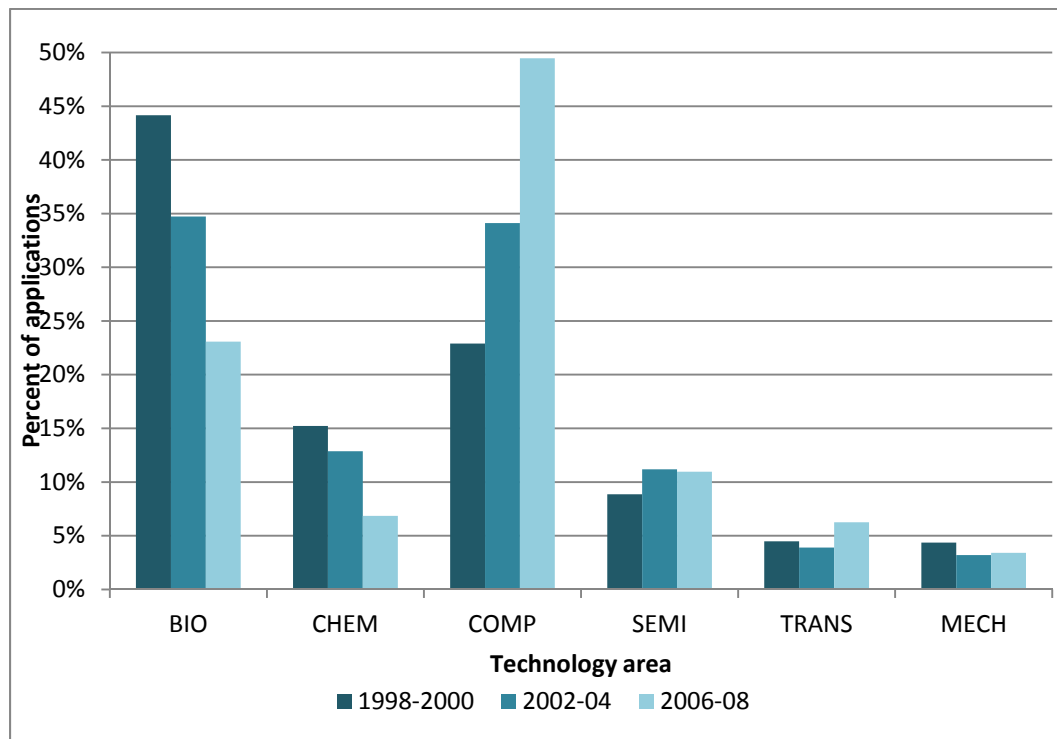
Source: Authors' calculations based on ??

Figure 11: Growth in Utility Patent Applications to the USPTO from China (1997-2007), South Korea (1986-1996) and India (1998-2008)



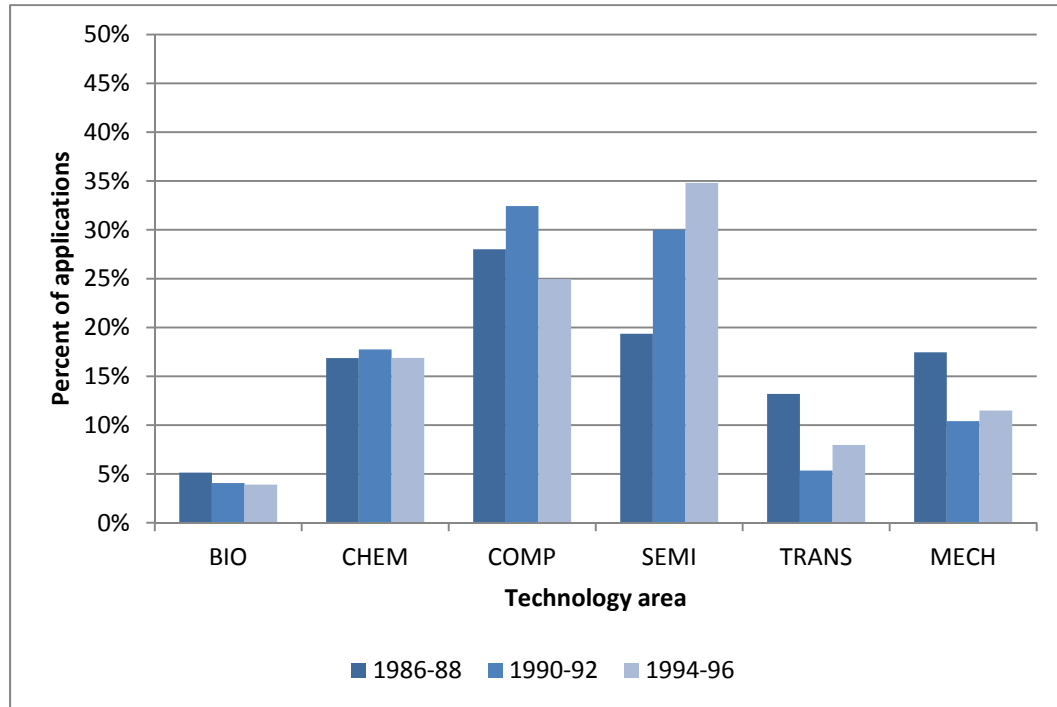
Source: Authors' calculations based on PALM data collected by the USPTO.

Figure 13: Change in Technology Mix, Indian Applications to the USPTO, 1998-2008



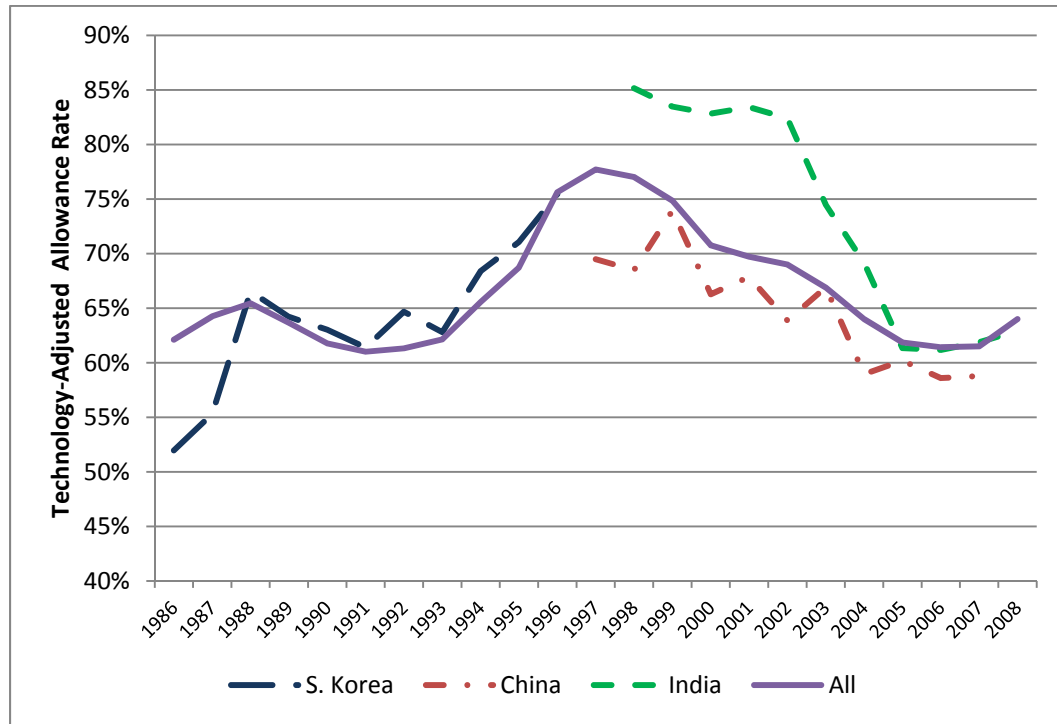
Source: Authors' calculations based on PALM data collected by the USPTO.

Figure 14: Change in Technology Mix, South Korean Applications to the USPTO, 1986-1996



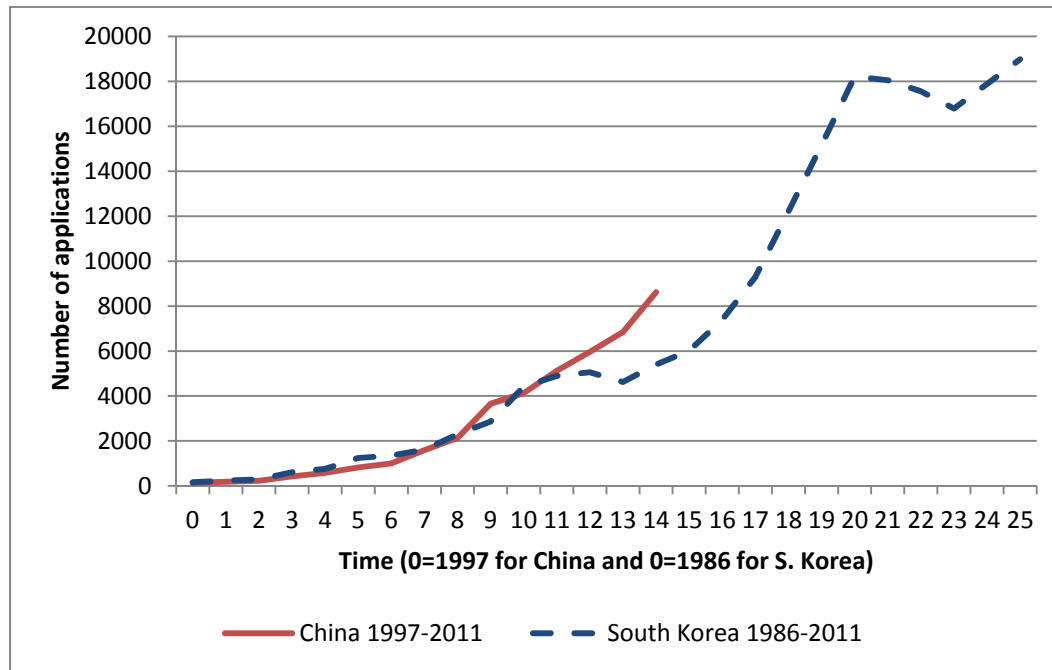
Source: Authors' calculations based on PALM data from the USPTO.

Figure 16: Comparing the Technology-Adjusted Allowance Rates for South Korea (1986-1996), China (1997-2007), and India (1998-2008)



Source: Authors' calculations based on PALM data from the USPTO.

Figure 17: The Number of Annual Utility Patent Applications from South Korea (1986-2011) and from China (1997-2011).



Source: PALM data from the USPTO.