# Innovation in China: Measuring innovation in China through patents

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Measuring innovation in China through patents

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Bachelor thesis


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*"One would not, therefore, of all faculties, or qualities of the mind, wish, for a friend, or a child, that he should have that of invention. For his attempts to benefit mankind in that way, however well imagined, if they do not succeed, expose him, though very unjustly, to general ridicule and contempt; and, if they do succeed, to envy, robbery, and abuse"*

~ Benjamin Franklin (1755)

# Introduction

In recent times the debate surrounding the origins of countries' prosperity and how to achieve this prosperity has started to shift. One publication that has contributed in a significant way to this shift is *Why Nations Fail* by Acemoglu and Robinson (A&R). They propose a theory in which institutions are the crucial determinant for a country's development. If their theory on historical institutionalism is true, this has major implications for how countries try to achieve sustainable development. Because it would mean that to achieve prosperity, countries should strive to build democratic institutions and empower civil society rather than solely focus on economic policy.

This theory has been criticized by many scholars (Paldam & Gundlach, 2008; Zhu, 2012; Lee, 2013, p.19). In these critiques the one country that is most often pointed to as the major exception that disproves A&R's theory is the People's Republic of China. Over the past few decades China has achieved large economic growth, averaging about 8% GDP increase per year since the late 1970s (Maddison Project Database, 2018). A&R propose that this growth is merely temporary and "unlikely to translate into sustained economic development" due to China's political and economic structure (Acemoglu and Robinson, 2012, p.437). This is because A&R suggest that in a country that has 'extractive' political and economic institutions, economic growth is not sustainable (Acemoglu and Robinson, 2012, pp.124-151). China is classified as a country with these extractive institutions by A&R. Their theory claims that unless the most populous country on earth and the world's largest economy changes its institutions, it is bound to reach a dead end in its development.

Institutions are inclusive if they create a level playing field that facilitates widespread participation. In this level playing field, property rights are secured and there exists an inclusive market economy (Acemoglu and Robinson, 2012, pp.103-104). If these two conditions are met, incentives to innovate will exist. Institutions are extractive if they

concentrate power and opportunity in the hands of a small elite. There is no level playing field, a lack of property rights and no inclusive free market. Without these two requirements innovators run the risk of getting their ideas stolen or not being able to make a profit from them. Therefore, few incentives to innovate will exist.

In both inclusive and extractive systems, the political institutions reinforce the economic institutions and vice versa. Thus, to have inclusive economic institutions, inclusive political institutions are also required.

There is broad agreement from academics that innovation is a crucial component of sustainable economic growth (Solow, 1956; Verspagen, 2006). The closer an economy comes to the technological frontier the more important innovation becomes for growth in productivity (Acemoglu et al., 2006). Innovation is "the implementation of ideas in the production process (by which is meant the entire process of producing and distributing goods to consumers)" (Schweitzer, 1961, p.152). This implementation can result in various improvements to the product itself or in the production of the product. In the implementation of this idea the old process gets removed and replaced with a new process that provides a better-quality product or increases production efficiency. Removing the old process and replacing it with new ones is known as 'creative destruction' (Schumpeter, 2013, p.81-85).

A&R (2012) propose that the incentives for innovation do not exist in an extractive economic system, since elites will use their political power to protect their own interests in established industries (pp.79-82). When creative destruction threatens these established industries, elites will try to protect them by removing incentives to innovate and stopping innovation from taking place. In doing so they thus prevent creation of new industries that could compete with their interests in the established industries.

As China is being ruled by the authoritarian communist party, it lacks inclusivity on the political level. Therefore, this should make institutions on the economic level extractive as well. According to A&R this means that innovation does not exist in China and that its economic growth is not be sustainable. This does not seem to align with what we observe however, as China has experienced unprecedented economic growth for the last 40 years and continues to do so. A&R argue that all this growth is extractive and as a result, unsustainable. However, China's growth does not seem to stop any time soon and has already outlasted many other nations that do have inclusive institutions.

If A&R are right, then no widespread innovation should have taken place in China in the last 40 years. We should be able to observe this lack of innovation and find few incentives for it. The institutions that normally provide these incentives, such as intellectual property rights or marketization of ideas, should not function properly in China. However, A&R's theory may be proven wrong if incentives to innovate do exist in China despite its extractive institutions.

There might also be pathway to innovation without inclusive institutions. It could be the case that if elites do not feel threatened by innovation to a large enough extent, they may allow it to occur. China could provide space for inclusive dynamics to occur, for instance in Special Economic Zones where free market dynamics are more commonplace. The notion that strong patent laws and marketization are both necessary requirements for innovation to exist could also be worthy of review. Strong patent laws also have some drawbacks, they limit how much an innovation can spread in society, to name just one example (Lin, 1991). If innovation is tied to incentives, then these incentives could potentially come from the government, in for example in the form of R&D spending, instead of coming from the market (Tan, 2010). Institutions that are not influenced by market dynamics such as universities and the military can also innovate with the help of active government spending (Mazzucato, 2011).

To shed light on innovation in China and thereby assess A&R's influential theory this paper will try to answer the question: Is there innovation in China? To answer this question, I analyse A&R's logic on intellectual property rights and marketization, measure innovation in China through patents and review opposing theories.

This paper will measure innovation by using patents as a proxy for innovation. Using three indicators the status of Chinese patents will be measured: total amount of patents granted, renewal rate of patents and citation rate of patents. The number of patents show us when an idea is registered, and by examining the renewal of the patent and its citation rate we can also conclude whether if the registered idea is implemented. This paper assumes that if a patent is implemented, it starts earning a profit and is useful enough to be renewed. Furthermore, if a patent is often cited, this indicates that it contributed an improvement important enough that others want to implement it. If no innovation were to take place in China, then patents would rarely get granted, rarely be renewed, and rarely get cited.

Firstly, this paper establishes a theoretical framework in which it discusses A&R's theory on inclusivity on innovation more thoroughly and strengthens it with other literature. Then, a set of indicators that asses the quality of China's patents are given and their accuracy as a proxy

in measuring innovation is examined. These indicators are measured for multiple countries to allow for comparison with China's patents. The data for these indicators comes from several different patent databases and previous research. Patents are measured from China's accession to the WTO in 2001 to present day. China's accession meant it had to conform with the Agreement on Trade-Related Aspects of Intellectual Property Rights, fundamentally changing the Chinese patent market into what can be overserved today (Jefferson et al., 2006, p.6). Based on the measurements of these indicators this paper finds that, contrary to A&R's claim, innovation does take place in China. The implications that these results have for A&R's theory on Chinese growth are discussed in the final section. Alternative theories that might provide a better explanation for these results are also reviewed in this section.

# Theoretical framework

This chapter explains A&R's theory on innovation and inclusivity in depth and expands upon it with relevant literature. The application of this theory on extractive countries and how it applies to China is also discussed. Furthermore, the concept of innovation is defined to provide the parameters for the indicator selection in the next chapter.

**Extractive institutions and innovation**

Current elites have an interest in established industries and therefore will try to protect them. They might do so by supporting their own established industries or more importantly by blocking new arising industries. New industries can threaten the established industries by means of innovation and creative destruction. Thus, to block new industries from appearing, innovation itself must be stopped. In pluralistic political systems the elite have a hard time 'capturing' the political means to use them to stop innovation. This is due to the widespread participation in the political institutions that distribute power, which makes them inclusive. Within these inclusive societies being an elite does not increase your political power significantly as power is distributed equally amongst all people. Thus, the shared interest of the many in new innovative industries will prevent blockages to be put into place that only bring prosperity to the few. However, in an extractive and authoritarian political system like China, power is not distributed equally. Through their political power, the Chinese elites can take control over relevant economic institutions. They will subsequently use these institutions to support their own (old) industries and supress new industries. They will also dismantle any institutions that seeks to promote innovation. Thus, innovation will be heavily hampered in an extractive system.

To ensure innovation is fostered intellectual property rights must be secured and ideas must be marketable. Without these two institutions, innovation will not occur. If the first condition is not met, then the risk of intellectual property theft will discourage innovation. This risk can be taken away by having a strong patent system in place (North, 1994), which protects innovators' ideas. Without patents, the inventor only has secrecy to protect their ideas. Secrecy is a very weak form of protection and can quickly fail, leaving patents as the only safe option to ensure a path to profits.[1] The second institution, marketability of ideas,

[1] Secrecy is only used a strong form of protection in industries where applying for a patent and having it published would mean instant copying by the competition. The food industry is a good example of this where the practice is still common, the Coca-Cola recipe for example is often considered as one the best kept secrets in the world. Still these industries would also much rather work with something in the vein of a patent, because in

determines the extent of this profit. Even if intellectual property rights are secured, but no market is in place, then despite ideas appearing, there is no profit to be made from them. A market is always needed so that when the idea is implemented the product can be sold. Without a market, there are few incentives to invest time and money to execute and produce ideas in the first place (King & Levine, 1993). Elites have incentives to supress both institutions and are likely to do so in extractive society. Thus, innovators will not invent because potential profits are blocked and even if they try, elites will block the implementation of their ideas further down the road.

These blockages to innovation can be seen through myriad examples throughout history. For instance, in 1589 a German inventor in England tried to apply for a patent on a method to obtain salt from seawater from Queen Elizabeth. The patent was refused by Elizabeth stating that: "there are diverse of her own subjects who have taken upon them to make salt….and she cannot without hindrance to them give any such privilege" (Hughes, 1980, p.31-48). A few years before this incident, Elizabeth had exercised her 'crown right' to issue a patent on salt itself in England, hence the queen's stated "hindrance to [her subjects]" was a hindrance to herself. With the patenting of salt, she had ensured that all that profits of salt production went to her. This German inventor's idea was a threat to her interest in the salt industry and therefore she blocked his invention from coming to fruition.

A similar story resulted in a different outcome for an inventor in 19th century United States. In 1868, U.S Army Captain Burns licensed a design for a type tent to the U.S. Army for which he had a patent (O'Connor, 2012, p.158). However, after the officer with which Burns had signed the deal defected to the Confederate army, the U.S. army stopped paying Burns. When Burns objected, the U.S. Army defended itself by saying they could exercise the right to claim any patent based upon the precedent of the crown right (O'Connor, 2012, p.161). The same crown right that Elizabeth had used to obtain a patent on salt itself. If Burns had lived under the same extractive institutions as the German inventor in England, his innovation would also have been stopped in its tracks and his profits taken away. However, Burns lived in a country with inclusive institutions and an independent judiciary which kept the government elites accountable. Burns sued the U.S. Army in a landmark case, which eventually went to the Supreme Court. The Court determined that: "[the United States] government cannot, after a patent is issued, make use of the improvement any more than a

time all their ideas will be reverse engineered. This can be seen by the numerous of increasingly better getting Coca-Cola clones that you can find in your local supermarket today.

private individual, without license of the inventor or making compensation" (*United States v. Burns*, 1871). Thus, Burns was put in the right, he was given his profits, and ensuring that any innovator in the US would be free from the threat of the government stealing their patents. This is a threat that will always exist under extractive institutions, be they Elizabethan England or the modern Chinese state today.

However, this all does not mean that growth is impossible under extractive institutions. Growth can still occur as the elites have an incentive to increase their own wealth and increase wealth extraction. They might do this by upgrading backwards industries to modern ones through an often costly and inefficient reallocation of resources. Economic growth can be induced this way, but it will always be a game of catch-up with technologies that other economies develop. Furthermore, without innovation there is a hard limit to this strategy due to inevitable diminishing returns in labour and capital productivity. When this limit is reached the economy will start to decline. Industrial upgrading can be done without threatening the position of the elites because no new industries are formed, no technological change takes place and thus no creative destruction occurs (Acemoglu & Robinson, 2012, pp.124-127).

This upgrading is exactly what happened in Soviet Union after the Second World War, moving from mainly agricultural society to a heavy industrial one. Yet the lack of creative destruction and therefore innovation in the Soviet Union eventually contributed to its economic downfall (Hanson, 2014, p.250). Still, the Soviets made innovations in some key areas, such as their military and space programs. For instance, they managed to put a satellite, an animal, and a man in space before any other nation did. However, these innovations occurred due to huge inefficient investments made by the state through more resource reallocation. Just as in the wider economy this had a limit, which was quickly reached, and ultimately saw the US take the lead in space technology. It should also be kept in mind that these industries were not commercially viable in the first place. Nobody makes a profit of a space program (only recently space flight has become commercial)[2] or the military and thus to innovate in these areas, government funding is always necessary.

Given these industries do not produce products that are aimed at consumers, they do not seek out profit nor do they operate under any other market mechanisms. Therefore, they do not

[2] It would be interesting to further observe how the commercialization of space flight will affect the Chinese space program. NASA is already getting outpaced by companies such as SpaceX or Blue Origin. If A&R's logic is correct, then space flight will never be allowed to become commercial in China because it will threaten the elites. And even if it is allowed, any innovation in this industry will be blocked.

threaten the elites' interests in established industries. Industries, such as the military, will be referred to as 'non-threatening' industries. These kinds of industries are often invested in by the elite because they may serve to strengthen their own power. Be that in military force or for propaganda purposes. These industries also do not produce any goods that form a direct economic benefit to society. Putting a man on the moon does not objectively improve the quality of life of your citizens and neither does developing a new type of gun, at most it may give them more safety.

To develop in these industries, resources must be reallocated; this is a highly inefficient process. Without a free market there are no incentives to optimize this allocation. Even in inclusive countries like the United States the military is indicative of this inefficiency (Riddell, 1985). Meanwhile reallocation takes away resources from the economy and this means that even more innovation is needed in the industries where the resources are taken from to compensate for this. If innovation in the rest of the economy does not happen in extractive countries, these large space and military projects just speed up the inevitable downfall. The Soviet space program did not help the Soviet-Union's economy, it only deteriorated quicker because resources were wasted. This should also be the case for innovation in space and military engineering in China. Innovations could be made but according to A&R's "true innovation [in China] will not arrive" (2010, p.442). It could be that all of China's innovation comes from these non-threatening industries. However, looking at patent applications they are rarely made by these non-threatening industries in China (Lei et al., 2012).

**Defining innovation**

Before indicators can be assigned to measure innovation, first innovation should be defined. A&R never explicitly state what they view as innovation. However, a definition can be derived from how they use the concept in their book. The main mechanism in their innovation logic is the concept of creative destruction. In using Schumpeter's theory, they also took over his definition of innovation: "new combinations of productive means" (Schumpeter, 1983). This is different from 'invention', as invention is the act of coming up with a new idea, whereas innovation is the implementation of this idea in societies production process (Schweitzer, 1961).

Invention can still occur under extractive regimes, as people will always come up with new ideas. Otherwise the rejection of ideas as happened with the German inventor in Elizabeth's England would not have happened in the first place. The idea itself was not rejected but the implementation of the idea and what it meant for the economy was rejected. The elites felt threatened by the innovation that resulted from the idea, not by the idea itself. Despite this, it is important to recognise that being aware that elites may block the implementation of the invention means that the act of invention itself is often also discouraged. The exception is for when the elites see these inventions as useful, which only happens when the invention is to be implemented in non-threatening industries. This also occurred in the Chinese past such as the invention of gunpowder or the navigational compass under the highly extractive Tang and Song dynasty, respectively. Both inventions barely saw any commerce and were meant for military purposes to strengthen the elites' position (Acemoglu and Robinson, 2012, p.231). In modern day China, invention may occur, but innovation should *not* occur according A&R's account, except in the non-threatening industries (which carry all the previously discussed drawbacks).

Another distinction that is often discussed in the literature is the difference between radical and incremental innovation (Ali, 1994; Ettlie et al., 1984; Germain, 1996). Radical innovation as opposed to incremental innovation has a "risky departure from existing technologies" (Ettlie et al., 1984). It signals a change in both the process and in the output of the product. Incremental innovation can suffice with only a change in the process. Radical innovations change the previous production setup by bringing in new knowledge that incurs costs and risk when implemented (Germain, 1996). Incremental innovations do not bring these costs or risks or do so minimally. The difference is hard to determine, and the line is thin, but A&R seem focus only on radical innovations. Creative destruction implies a cost

that only these radical innovations bring. Incremental innovation does not form a credible threat to the elite, but neither will it account for enough technological innovation to sustain long-term economic growth.

A distinction that is also important for this research is the difference between input and output innovation. Input innovation are factors that are meant to encourage innovation such as R&D subsidies or investments in education (Adams et al., 2006). They heighten the chance that innovation takes place by raising the knowledge level or providing greater monetary incentives. This contrasts with output innovation which consists of the new ideas' implementation either in process or product (Duran et al., 2016). A&R mention input innovation in their book, such as through education, but their theory only looks at output innovation. Input innovation does not always directly translate to output innovation. The roadblocks that the elites put in to protect their industries will however directly hamper this translation or prevent it outright.

This research only looks at output innovation, to follow A&R's framework. This seeks to avoid the mistake commonly made by various academics to use input innovation such as R&D investment as a measurement of innovation (Yilmaz, 2018; Gao & Jefferson, 2007; Sun & Cao, 2014; Van Noorden, 2014). Input innovation can also be easily adjusted by an extractive state. The government, captured by the elites, can start investing more in R&D through subsidies or try to attract more reputable scholars to their universities. However, if the institutions stay extractive this increase in input should not translate in output innovation, because this innovation still threatens the elites' position.

In short, this means that the indicators that are selected in the next chapter for the measurements of patents will measure innovation not invention, radical not incremental innovation, and outputs not inputs.

# Patents in China

This chapter looks at patents to determine if innovation takes place in China. This is done by measuring three major indicators. Combining these indicators give us an accurate picture of both the amount and quality of patents applied for in China. These indicators are number of patents granted, renewal of granted patents and citation frequency of granted patents. First, the justification of these indicators and their sources are provided. Afterwards the results are discussed at length. Implications of these results for A&R's theory and the potential shortcomings of this research are discussed in the following chapters.

**Patents as indicators for innovation**

Patents are considered one of the most important tools in measuring innovation (Jefferson et al., 2006; Greenhalgh & Rogers, 2010, pp.60-61; Nagaoka et al., 2010). A&R also use patents in their book to illustrate innovation (Acemoglu and Robinson, 2012, pp. 32-34,182-183,202-206) Patents are the main way in which innovation is protected, not just in the domestic setting but also in the international setting (Granstrand, 2006).

Patents are internationally registered at the World Intellectual Property Organization (WIPO) which helps promote similarity in patent applications. China also signed the Agreement on Trade-related Aspects of Intellectual Property Rights, when joining the WTO, ensuring that the WIPO patent standards are also enforced in their applications. This agreement makes patent applications highly comparable across all 164 member states.

The first way in which patents will be measured is in total amount of patents granted. Patents granted means that the patent application was deemed as valid and distinct enough to warrant a patent. If you were to only look at patents applied, you would also measure rejected patents, which do not form a good indicator for innovation. However, even when a patent is granted this means that only the idea is registered, which constitutes invention not innovation. Governments can also artificially heighten these numbers by promoting industries to apply for as many (useless) patents as possible. Importantly this is a practice which China also engages in, by providing subsidies for patent applications (Li, 2012). Earlier research has found that this increased the number of patents granted by China by more than 20% (Dang & Motohashi, 2015). This is partially caused by Chinese companies putting in fewer claims per patent and filling for more patents with less claims (Lei et al., 2012). Other governments have also engaged in this practice in hope of lowering the barrier of entry to register an idea and

innovate. However, China engages in this practice a lot more actively than others (Dang & Motohashi, 2015).

Therefore, to accurately measure innovation, the quality of the patent will also need to be evaluated. This will be done in two ways. Firstly, the number of patents that get renewed will be looked at. If the patent is not reapplied for, then it is likely that it was never implemented and therefore no innovation occurred (Thoma, 2013). Renewal always incurs a fee and if this fee is paid it is reasonable to assume that the patent successfully made a profit. (Gupeng & Xiangdong, 2012). Furthermore, patents that are renewed to a full-term expiration are more cited and seen as more valuable (Harhoff et al., 1999). Secondly, the number of citations that granted patents have received. Patent citation can come in the form of both forward and backwards citation. Forward citation indicates if other patents have used this patent as a reference while backward citation indicates how many patents are cited as a background in the applied patent. Forward citation thus more accurately reflects the level of innovation that the patent has brought (Fleming, 2001).The more a patent is forwardly cited the more it is being implemented or used by others and the higher the patent is valued (Trajtenberg, 1990; Harhoff et al., 2003). Therefore, this paper will only look at forward citations. The patent value can matter a lot, as small percentage of patents represent most of the value of all patents in the world (Nagaoka et al., 2010). This statistic is so skewed because it is common practice for companies to apply for patents not because they are about to innovate but just to block out the competition from applying for a patent. Patent citation has also been found to positively correlate with market value and increase total factor productivity (Bloom & Van Reenen, 2002). This likely indicates that the innovation contributes to the firm's profit.

As stated in the previous chapter, the indicators need to measure innovation not invention, radical not incremental innovation and output not input innovation. By looking at these three indicators, patents meet all those requirements. When accounting for renewal and forward citation patents indicate not only invention but also innovation. Patents inherently measure radical innovation because incremental innovations will be filtered out in the application process, as a too small of a difference from a previous idea is not worthy of getting a grant. If a patent is granted this means they have met the bar for significant change. If quality is kept in mind, patents also measure output as opposed to input innovation.

For patents granted, this research looks at five patent databases. Firstly, the domestic China National Intellectual Property Administration (CNIPA). Most Chinese patents are applied for in China itself, so this database gives the most accurate picture of the total amount of granted patents in China. The WIPO collects information from all these national or regional patent databases such as the CNIPA and the statistics in this research are retrieved from this central WIPO database. The WIPO also manages their own international patent system, the Patent Cooperation Treaty (PCT). Through this treaty patents can get filed that receive protection in all 153 member states, including China. A smaller number of patents are applied for due to the higher requirements and fees in the PCT. However, these patents do carry more weight because they are internationally recognized, must follow stricter rules, and must show a higher degree of uniqueness in their claim.

Since this research looks for any amount of innovation, comparisons per capita or per GDP are not necessary per se but are examined to give a sense of the scale of innovation. These statistics are taken from the World Bank development indicators. The data that is collected for China also are collected for Germany, India, Japan, South-Korea, Russia, and the United States. Germany, Japan, South-Korea, and the US have historically been the top patent filing countries and their patents are also measured from the data of their respective databases. They should form a good comparison to get a sense of the level of innovation in China. The US is the only country comparable in size of the economy, and India is the only country with a comparable population size. Japan and South-Korea are culturally and geographically closely tied. Germany is a good representation of most European countries and constitutes more than a third of the applications at the European Patent Office (EPO). Russia is the only other large economy with extractive institutions. Moreover, five of these countries are also seen as highly inclusive, which allows for the difference between politically inclusive countries and extractive countries such as Russia and China to be seen more clearly.

These statistics range from 2001, when China joined the WTO and reshaped its own patent system, to 2018 which is the latest year that the WIPO has data for. The patents looked at are ‘residential’, meaning that they are applied for in the home country rather than abroad. Because the WIPO database gets their information from the CNIPA database, it lacks some independence. CNIPA is managed by the Chinese government, which has an interest in reporting good numbers and as discussed before, engages in practices that heighten these numbers. To ensure that more independent statistics are considered and to provide a more accurate picture of the quality and worth of Chinese patents abroad, this research also looks at

patents granted at foreign patent bureaus directly. Chinese patents granted at the EPO, The Japanese Patent Office (JPO) and the United States' Patent and Trademark office (USPTO) are examined. The EPO has data from 2010 till 2019, the USPTO from 2001 till 2015 and the JPO from 2005 till 2015.

For patent renewal the same databases are looked at, also collected by the WIPO database. Patent renewal is examined by analysing patents still active vs total patents granted ratio. The ratio is determined by dividing the number of active patents in the relevant year by the total granted patents (PCT and national) over the past twenty years. So, for the earliest year 2004 (first year that the WTO started collecting data on patents in force) the data reaches back to 1994. The period looked at is twenty years, because patents cannot be renewed anymore after these twenty years as determined by the TRIP in article 33 (WTO, 1995).[3] All seven countries have signed the TRIP.

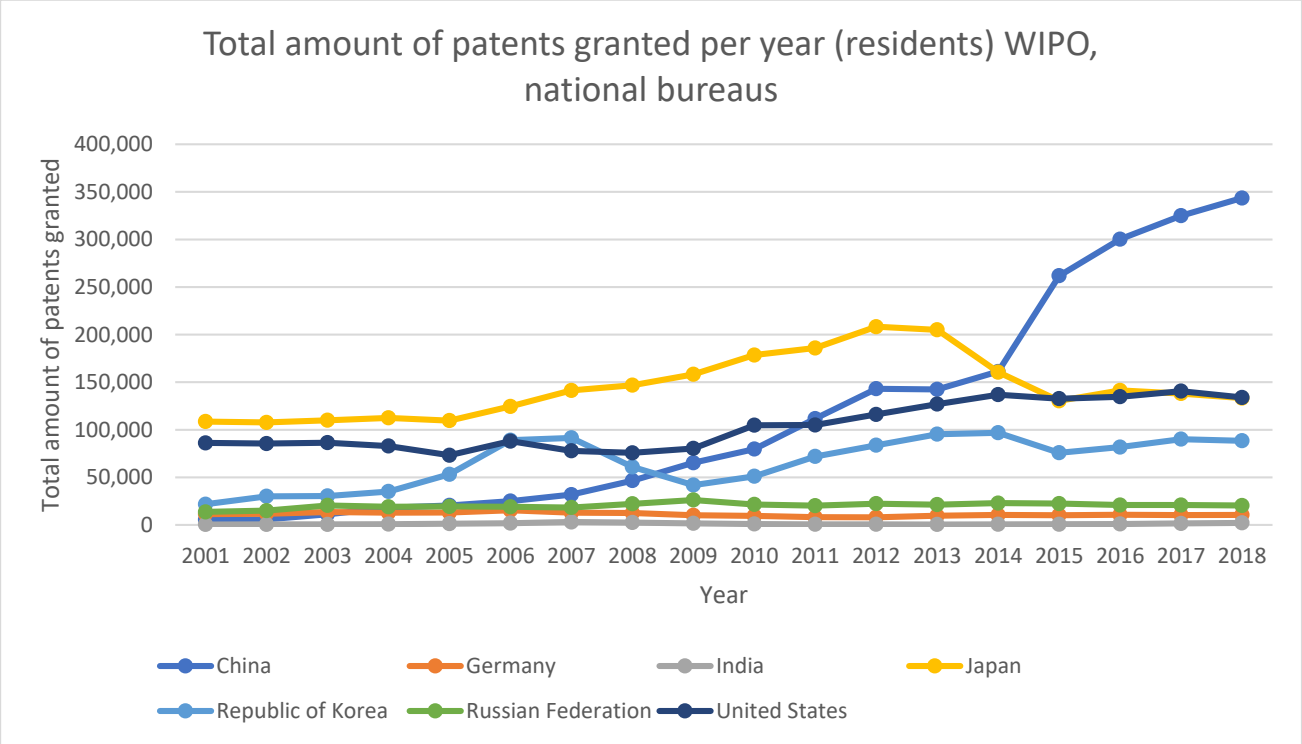
For patent citation only the EPO has established a full-fledged citation database. However, analysing these complex and hard to find statistics on patent citation is beyond the scope of this research. Therefore, this paper discusses the results of research done by Fisch et al. (2017), which has extensively reported on forward patent citation. They take their data from PATSTAT, which is the EPO managed database that includes databases from other non-EPO countries such as China and combine this with PCT patents from the WIPO database. Instead of looking at the total amount of patents they have taken randomized samples of 10,000 patents from each of the examined countries. The sample runs from 2000 to 2010.

[3] There are exceptions to this rule with Supplementary Protection Certificates, which are handed out to compensate for the administration time that the patent application might have taken. But this rarely happens, and it is safe to assume this is the same for all countries in all years thus not affecting the ratio.

**Patent measurements**

As can be seen in *Figure 1* the total amount of patents granted in China has increased steadily since 2001 with a very sharp rise beginning in 2014. During this rise the total patents granted for the other countries remained relatively stable and Japanese patent numbers even dropped. With almost 350,000 patents granted, China now has by far the most patents granted in the world. When these numbers are adjusted for GDP and for population (appendix A) this trend remains mostly steady, but is less pronounced, and seem to drop off somewhat in recent years when adjusted for GDP. When adjusted for population, China has a lower number than the US, South-Korea or Japan, but when adjusted for GDP only Japan has higher numbers. Such a quick rise to these high numbers is unprecedented.

**Figure 1**



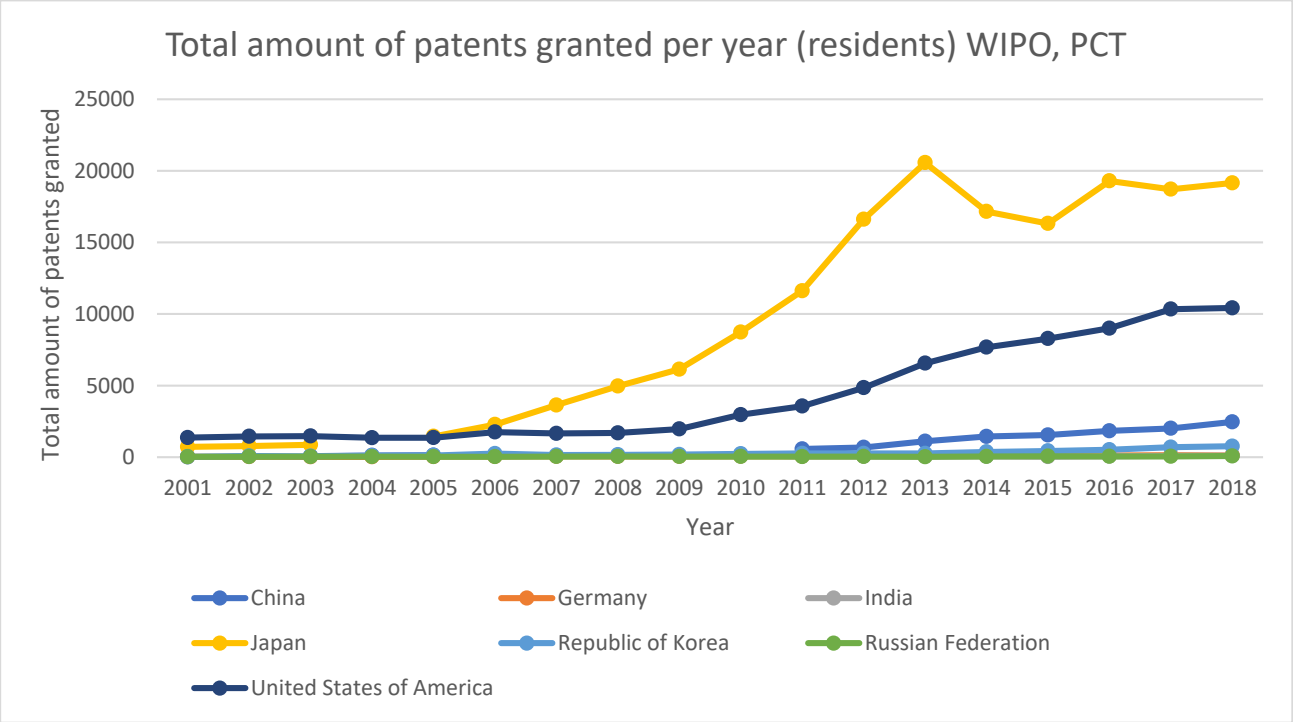

*Source:* WIPO statistics database (2020)

In *Figure 2*, the statistics for the more valuable PCT patents are presented. China is also growing in this area, but not as quickly as in grants to their domestic bureau. Compared to the US and Japan the number of patents granted is still relatively small. This highlights how China has more trouble getting their patents granted under a stricter rule set, tending to focus more on their domestic bureau. Germany's amount is negligibly small, but this can mostly be accounted for by the fact that they focus more on EPO applications, which already grants them exclusive rights for all their neighbouring countries and their most important markets.

With the lack of an East-Asian regional patent bureau, China does not have that luxury. South-Korea also has lower numbers in this figure, but is among the top countries when adjusted for GDP or population as shown in appendix B. When adjusted for GDP the recent rise of China becomes more apparent, having more than triple the numbers of Germany, Russia or India in 2018.

In all figures, clear trends can be seen concerning India. As the only country with a comparable population size to China and one that is seen to be comparatively inclusive, it shows numbers in all statistics that are often close to zero. This is largely due to India having a notoriously large patent backlog (Mueller, 2007). This is partially due to only recently allowing for patents to be granted in their largest innovative industry, pharmaceuticals. In 2005 the laws changed, and it took until 2013 when the Supreme Court ruled in favour of these laws before they actively came into effect. Most of this backlog, however, is explained by the inefficient Indian patent office which makes it very hard to get a patent or even apply for one (Milstien et al., 2007). None of these things seem to take place in China where applying for patents has been made easier throughout the years and is actively encouraged by the government.

**Figure 2**

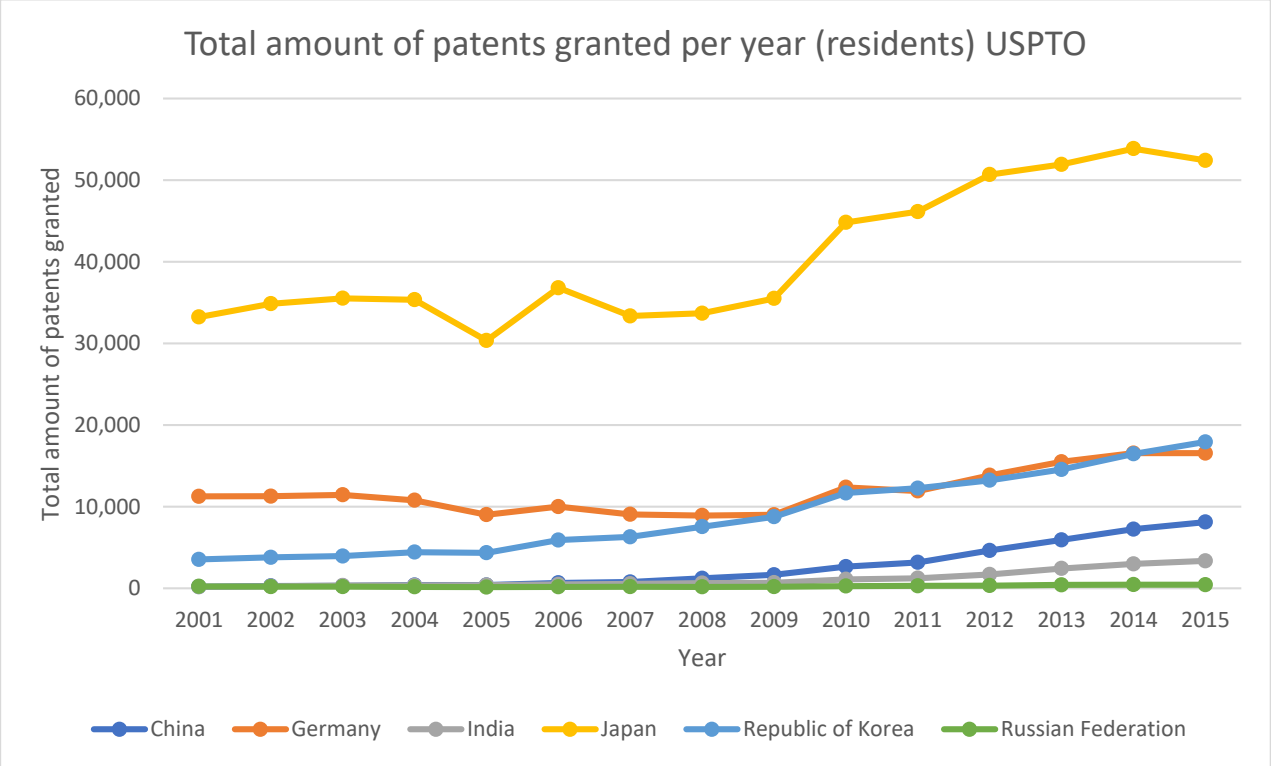



*Source:* WIPO statistics database (2020)

*Figures 3, 4 and 5* show the patents granted for the USPTO, EPO and the JPO. The trend that was shown in the PCT patents is even more pronounced at these patent bureaus. At the USPTO, the number of patents granted is very small, they are not even half that of Germany's or South-Korea's total amounts per year. Likewise, at the EPO and JPO, numbers for China are significantly lower than the US, Germany, South- Korea or Japan. In contrast, their number at the EPO seems to be rising in the last 4 years. This shows again that when it comes to getting a foreign patent, China is still performing worse than other countries.

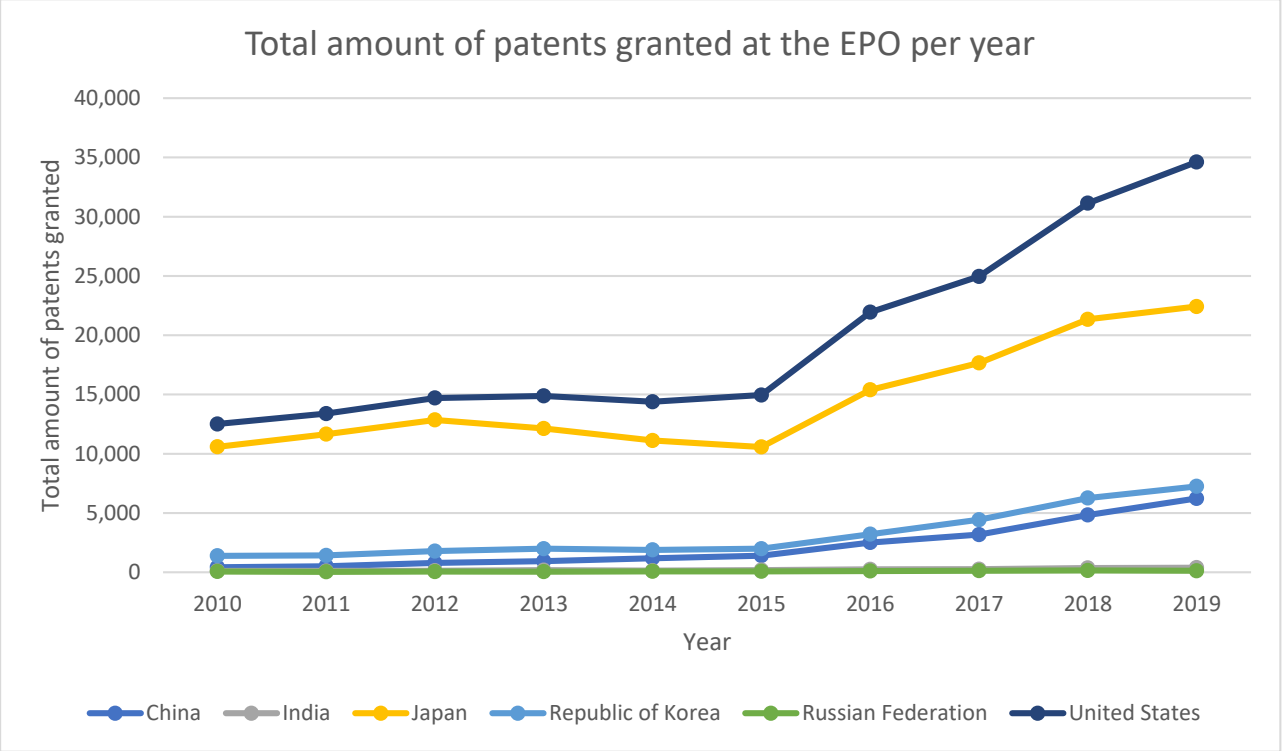
The high numbers reported by the Chinese CNIPA database seem much less impressive when these numbers at international bureaus are so low. Inventions that can get a patent in China do not seem to be able to just as easily get one abroad, questioning the quality of the invention in the first place. It could of course be that Chinese innovators focus more on the domestic market and only apply for patents in China itself. But accounting for the size of the Chinese economy and its connectedness with the rest of the world, this seems an unlikely explanation for such a big difference with the comparison countries.

**Figure 3**



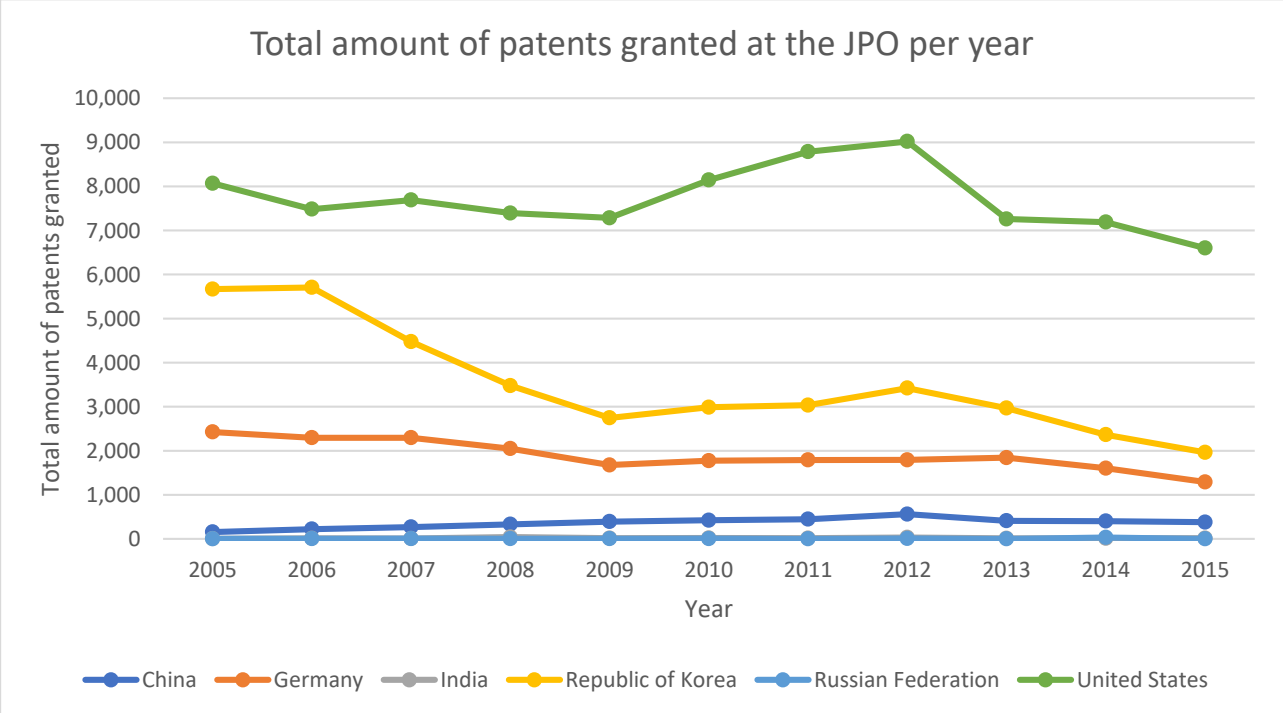

*Source:* USPTO general patents statistics reports (2015)

**Figure 4**




*Source:* EPO statistics (2020)

**Figure 5**



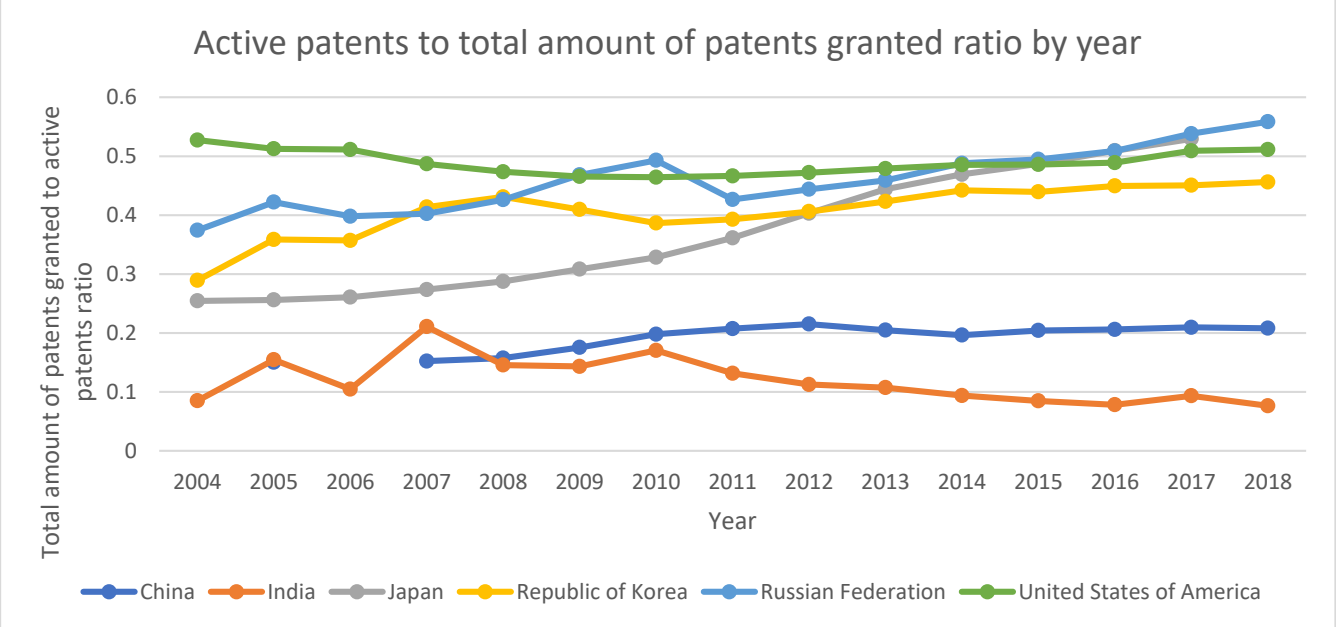

*Source:* JPO statistics data (2016)

The lack of quality in Chinese patents also seems to be confirmed by F*igure 6.* Here we can see the number of active patents in the relevant year divided by the total amount of patents granted 20 years prior. For China, this ratio seems to be relatively stable since 2007 and hover around 0.2. That means that less than a quarter of the Chinese granted patents in the previous 20 years are still active in the year measured. Keeping in mind that most patent applications in China were processed in the past few years with very few before 2010, as shown above, most of this 0.2 ratio is made up of very recent patents. Therefore, the actual patent renewal rate of Chinese patents is even lower than 0.2. This indicates that most Chinese patents do not get renewed after a couple of years.

This ratio is very low compared to other countries such as Japan, South-Korea, Russia, and the United States. All these countries have more than double the Chinese ratio. The ratios of these countries are lower than shown in this statistic due to also having more patents granted in recent years, but the difference in number of patents granted in recent years is significantly less skewed than the Chinese one.

India has the reverse problem of China. With their large backlog most patents are filed in earlier years thus their reported ratio is probably lower than it should be. This ratio also does not seem to grow for China, while Japan and South-Korea have shown growth. However, the Chinese ratio albeit low is not zero, therefore China still has a consistent number of patents that do get renewed consistently.

**Figure 6**




*Source:* WIPO statistics database (2020)

For patent citation rates this paper uses data gathered by Fisch et al. (2017). The statistics that they reported can be seen in F*igure 7*. Germany is not included individually in the set but is combined with the other EPO members. The lack of quality in Chinese patents again becomes apparent in these statistics. The first notable percentage is the number of Chinese patents that received a forwarded citation. Patents from South-Korea are more than three times as likely to receive a citation and with the other comparison countries this is at least four times as likely. On average it also takes Chinese patents half a year longer to get cited than the comparison countries.

Since citation is the main way to determine patent quality these results weigh heavily. Although China does have some high-quality patents, its numbers are significantly lower than other countries. Fisch et al. (2017) also reported from which source the patent applications came from. It is notable that in the comparison countries more than two thirds of the applications were from private companies, while this is only the case for just under half of the Chinese applications. The patent applications coming from universities is also small for most comparison countries while one fifth of the Chinese applications are from universities. This means that the recent surge in patent applications in China stem in a significant part from the *public* sector. This could be due to the lower level of free market dynamics in China compared to the other countries. Governments also have an easier time boosting the number of patents applied by universities, because they are under public control.

**Figure 7**

| *Country* | *Citation received* | *Citation lag* | *Company* | *University* | *Other* |
|---|---|---|---|---|---|
| China | 11,9% | 31,9 | 45,9% | 19,3% | 34,7% |
| US | 67,1% | 21,7 | 85,3% | 2,5% | 12,1% |
| Japan | 51,8% | 28,1 | 81,3% | 0,6% | 17,9% |
| Korea | 36,9% | 27,8 | 76,6% | 3,0% | 20,2% |
| EPO members | 56,0% | 27,2 | 78,3% | 2,8% | 18,9% |

Notes: Citation lag = mean citation lag in months, Others includes i.a. individuals and research institutes

*Source:* Fisch et al. (2017)

**The status of Chinese patents**

In short, these results show that the number of patents granted in China has risen dramatically over the past few years. This rise mostly comes from domestically applied patents and partially from an increase in university applied patens. However, despite the number of total patents being high, the quality of the patents is significantly lower than of other (politically inclusive) countries. Patent quality in China also seems to be stable on this low level across the past ten years. Chinese patents are granted at international bureaus, but on a smaller scale than would be expected of a country of this size with such a large and well-connected economy. These results support research (Li 2012; Dang & Motohashi, 2015; Lei et al., 2012) suggesting that the recent surge in Chinese patents is partly due to the Chinese government trying to push companies and universities to apply for more patents; increasing the total amount of patents but lowering the quality of the granted patents.

Thus, while patents are being granted domestically, many inventions from China are not able to get patents internationally. Even if they do get approved, their citation and renewal rates suffer due to the low quality. Based on patents as an indicator for innovation, innovation does take place in China, but on a much smaller scale than would be expected. This scale is also smaller than most research that uses R&D data as a measure of innovation would predict (Yilmaz, 2018; Gao & Jefferson, 2007; Sun & Cao, 2014; Van Noorden, 2014). Yet these results also contradict A&R's claim that virtually no innovation would take place in China. Moreover, both India and Russia also do not meet A&R's prediction. India has low numbers across the board but is an inclusive country and while Russia does fit the theory across most statistics, the very few patents they do apply for seem to have a good quality despite its extractive institutions.

The next chapter discusses what the implications of these results are for A&R's claim, where this innovation in China might come from and the limitations of this research.

# Implication and discussion

If patents are taken as a proxy for innovation, then this research shows that innovation does take place in China. That means that A&R were incorrect in stating that "true innovation [in China] will not arrive" (2010, p.442). Patents get granted regularly in China, some of them get renewed and some of them are cited. This renewal and citation could not take place if some of these patents were not implemented and therefore some innovation must exist in China. By the measures of A&R's own theory, patents will provide incentives for innovation. Seeing that the patent system in China seems to be working to some extent, this means that the notion that there are no incentives to innovate in extractive regimes (Acemoglu and Robinson, 2010, pp.79-82), such as China, needs more qualification. Therefore, China's growth over the past forty years may also have been driven in part by this innovation and the Chinese economy could have potential to keep growing.

These results show that this might not only be the case for China, but also for nations with extractive institutions more broadly. Russia is another example of an extractive country and despite not having many patents granted, the ones that are granted seem to be of high quality. India also represents an outlier to A&R's theory. Their patent numbers can be explained through their patent backlog. But even then, it does not make sense that in a country that is inclusive, with patents laws and marketization of ideas, that these numbers would be consistently low. If innovation makes economies grow sustainably and innovation can exist under extractive institutions, then countries with extractive institutions can have sustainable growth. This means that A&R's advice on focussing on democratic institutions and empowering civil society to achieve development does not always hold true (Acemoglu and Robinson, 2012, pp.460-462). Development could be possible without these inclusive institutions.

The question now is: how to explain these outcomes? It may be that A&R are possibly wrong about where incentives to innovate come from. They may misunderstand the importance of inclusive institutions such as patents or marketization of ideas. Or their theory could be flawed when it comes to understanding the interest of elites.

**Alternative explanations**

One possible explanation for these results is that incentives to innovate are not always protected by patents, and monetary incentives do not always have to come from the market.

A&R deem patents to be important because they protect the innovator's ideas and therefore the innovation. However, every patent provides the inventor a monopoly on the product which only gives one party the ability to innovate with the patent. Even though innovation might occur more often if the idea is spread more widely. However, a stronger patent system might reduce this spread (Lin, 1991). One of the explanations for why India has a large patent application backlog is because up until recently they banned patents in the pharmaceutical industry. But this ban was put into place with intention, hoping that it would allow Indian pharmaceutical companies to acquire knowledge on a wide scale and then use this knowledge as a steppingstone to start innovating themselves. This tactic seems to have worked out in part, given the level of advancement that the Indian pharmaceutical industry has achieved.

Historically, Germany, the Netherlands, and Switzerland have successfully industrialized without a patent system (Kaufer, 2012, pp.41-54). In more recent times this seems to also have been the case for some developing countries (Lerner, 2009). Firms' R&D departments also do not deem patents to be that important for innovation. Lead time (advantage in latency of being able to produce a product before competitors) is deemed as the most important factor and after that, secrecy, with patents coming in last (Harabi, 1995).

However, there is also ample literature showing that patents laws do make a significant positive contribution to innovation (Greenhalgh & Rogers, 2010). Despite the development of India's pharmaceutical industry discussed above, it did eventually adopt patents to become more competitive on the world stage. R&D departments might not account for the financial flows behind a patent system. When James Watt invented the improvement on the Newcomen steam engine, he applied for a patent in 1779. Yet it took him another 7 years and multiple investors to make the steam engine commercially viable (Kingsford, 2020). It is doubtful that his investors would have stuck around for so long if he did not possess that patent. The risk of a competitor being faster than Watt and the lack of initial monopoly would have scared most investors of. Patents still play an important role, but this role seems to be overestimated by A&R's theory.

According to A&R, incentives come from the market in the form of profits. But monetary gain in innovation could also come from the government as a result of R&D spending, to

name just one example. Research has shown that with the right policies, investment in R&D yields higher returns in production regardless of the country's extractive institutions (Tsai et al., 2009). In China, it also seems to be the case that government R&D investment helps with the implementation of innovation. (Tan 2010; Jefferson et al., 2006). If incentives are provided by the government then inventors will still try to innovate to get these rewards, even if they do not come from the market. China has fully adopted this strategy over the past few years, being second in the world when it comes to government R&D investment (National Science Board, 2018). The increase in investment coincides with the rise of patents granted that we observed in the previous chapter.

If the government rewards the inventor instead of the market, the government could also make the innovation public, which leads to a 'socialization' of ideas (Schultz, 1971, pp.96-97). No charges are given to those who want to use the idea, everybody has access and the inventor is still rewarded. This dynamic becomes most apparent in low level technology sectors in which small improvements yield high returns. One such sector is agriculture where a small improvement in farming can improve the living condition of many others. In countries that have made much progress on agricultural innovation most research is done by non-profits which are funded with public money (Lin, 1991, p.58).

Even in developed countries in high-tech sectors, innovation is often linked to government investment. In the idea of the 'entrepreneurial state' it is the government, not the private market, who pushes for innovation and makes investments into areas that the market finds too risky (Mazzucato, 2011). For example, Apple grew massively with the development of the iPhone, but the first used touchscreen was produced by CERN (Beck & Stumpe, 1973), the GPS system that enables navigation was setup by the US Air Force (Sturdevant, 2007) and the internet was developed by DARPA (Hauben, 1994). Thus, the elements that made the iPhone so exceptional and what made it a smartphone were all government funded.

However, the role of the free market should not be underestimated. Research on socialisation focuses on low level technology sectors while most of the technological frontier and patents are in high level technological fields. States can spur invention in financially risky areas, but it is often companies who make the invention useful for the society on a wider scale. This is also true for all the above inventions that are used in the iPhone. Even if these inventions all came into existence with public funding, it was Apple that combined them together. Protected by a strong patent system and well-functioning free market, Apple could sell its products and

shape the cell phone market as we know it today. For the government funded institutions that were involved, the innovation that we now value so much was merely a by-product, not meant to be used in the ways that we do today. Like patents, the market does play a role in incentives, but it might not be as essential as A&R suggest.

But why do extractive governments then provide incentives for innovation when it is against their own interest? A&R might be incorrect in their conclusions about how elites protect their interests. If innovation helps elites to stay in power, it might be in their interests to provide some of these incentives. In China for example the mandate of the CCP is heavily based on the economic growth they deliver (Zhao, 2009). Thus, to stay in power, economic growth is of paramount interest to elites due to fear of losing this mandate. The CCP elite makes personal sacrifices and lose some power in the short-run to make sure that in the long-run they stay in power. If they stay in power, eventually new opportunities will arise to make up for the economic loss they made in their sacrifice. They could for example expropriate a newer industry later. Even if they do not make up for these losses, any power might still be better than none in the eyes of the elite. If innovation and new industries do not form a credible threat to the elites' power and the sacrifice is not too big, elites allow for some innovation to achieve economic growth and thus stay in power longer.

China engages in economic policies that follow this logic, creating for example Special Economic Zones across the country. In these zones the market mechanisms that A&R talk about are given more space, economic institutions are more inclusive, and elites choose to interfere less (He et al., 2011). For example, one of most successful technological areas in China is Zhongguancun science park in Beijing. Before the rise of Shenzhen, this was considered the Silicon Valley of China. Large technological companies such as the Founder group or Lenovo originate from here. Special cuts in government R&D funding, setting up more market mechanisms for financing and providing stronger patent protection were the main policies used to set up this science park (Tan, 2006). Thus, Zhongguancun forms an example of the Chinese elite allowing for some innovation in an otherwise extractive regime.

It is important to keep in mind that even though the results of this research show that while innovation does take place in China, despite A&R stating that it would not, it takes place on a scale much smaller than expected from the largest economy in the world. A&R might be wrong in the totality of their theory, but they do seem to be on the right path. Other factors discussed above might encourage innovation as well, but they have their own criticisms.

A&R's view on patents and the marketization of ideas does seem to be too simplistic, but more importantly, their view on how elites protect their interests does not account for the fact that innovation could be in the elites' interest in the long run.

**Limitations**

The implications for A&R's theory only hold true if this research correct, but it has its own limitations. First, this paper is limited in scope. It only focuses on one indicator of innovation, patents. Patents serve as a proxy to measure innovation, but they do not measure innovation directly. Other research would need to be conducted that either looks at other indicators for innovation, such as venture capitalism, to create a more holistic image or focuses on direct evidence for innovation by examining specific cases in China. By only focussing patents, this research also opens itself up to other vulnerabilities.

As discussed in the analysis, China engages in practices to heighten patent numbers, but the extent of these practices is not clear. This makes it hard to evaluate the worth of the number of total amount of patents granted in China. Looking at international patents could help, but it could also be the case that Chinese innovators are not interested in these markets. For instance, Germany cares little for PCT patents because they have the EPO. It could be the case that China, despite its economic size and international ties, is focussed more inward when it comes to innovation than the comparison countries. Therefore, it does not report as high numbers in international patents. It seems unlikely, but more research on what industries in China apply for patents domestically compared with those that apply for patents internationally could shed some more light on this issue.

In accounting for patent renewal and citation, an attempt is made to assess more accurately the worth of Chinese patents. However, due to the Chinese rise being so recent, these numbers are skewed, and the renewal rate is different than this research shows. However, the exact amount of skewness is hard to ascertain. The statistics that Russia reports on its renewal rate are also interesting. It does not fit the expectation of A&R and the reasons as to why they have such a high rate is unclear. With citation rates, Fisch et al.'s (2017) data sets are already out of date and do not contain data after 2010 and China's meteoric rise only started years later. The analysis could not be replicated due to difficulties in obtaining the data. It would be interesting to see if the Chinese citation rates are still this low today and what the citation rates for Russia are.

China also displays growth in patents granted and in the renewal rate, so to truly see if innovation takes place even through the proxy of patents, this research will have to be repeated later. It could very well be that China only has started innovating recently and that is why the numbers are so low but, in the future, they will be on the same level as comparison countries.

Despite the above limitations, this paper was looking for any form of innovation to dispute A&R's theory and this research has provided ample evidence to challenge some of their conclusions.

# Conclusion

This paper set out to find evidence for innovation taking place in China to disprove or reaffirm A&R's theory on extractive institutions and economic growth. According to this theory economic growth in countries that have an extractive political regime, such as China, is not sustainable due to a lack of innovation. Using patents as an indicator for innovation this research shows that innovation does take place in China. China shows an ample amount of granted patents and part of these patents get renewed or cited, the latter two being crucial criteria for innovation. These results dispute A&R's claim on innovation in China and therefore, by extension, imply that extractive countries can achieve sustainable growth.

In the last sections of this thesis I suggest that the reason for this counterintuitive result, is that elites have not been able to fully hamper innovation in China, despite having the political means to do so. This in part because A&R seem to overestimate the importance of patents and marketization of ideas in influencing innovation. Moreover, it seems that Chinese elites do not have an interest to stop innovation and allow for some innovation to occur, provided it does not threaten their interests.

However, the level of innovation in China is significantly lower than would be expected for an economy of its size. This could either be because A&R are mostly right and China will never achieve high levels of innovation., or it could be that China simply has not come to that stage yet in their economic development. Only research in future years can provide us with an answer to that problem. As in general with A&R's theory on development, only time will show who was truly right and what the path to prosperity looks like.

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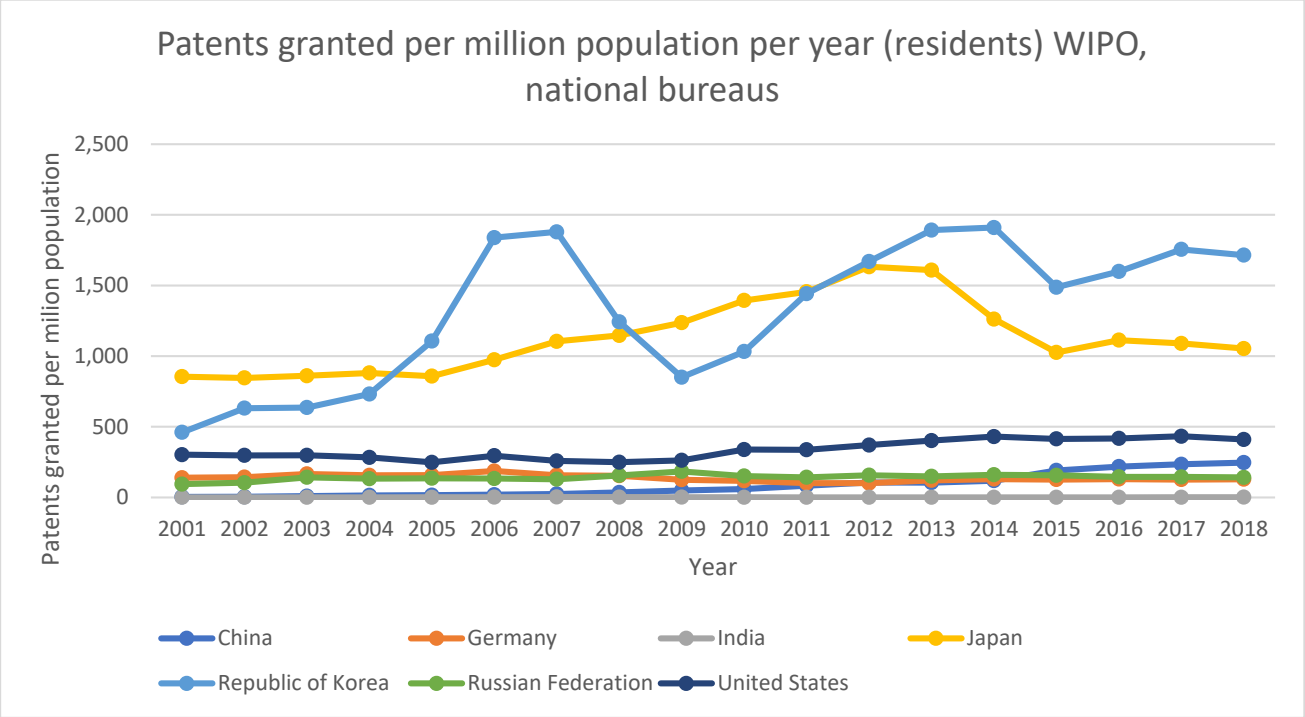
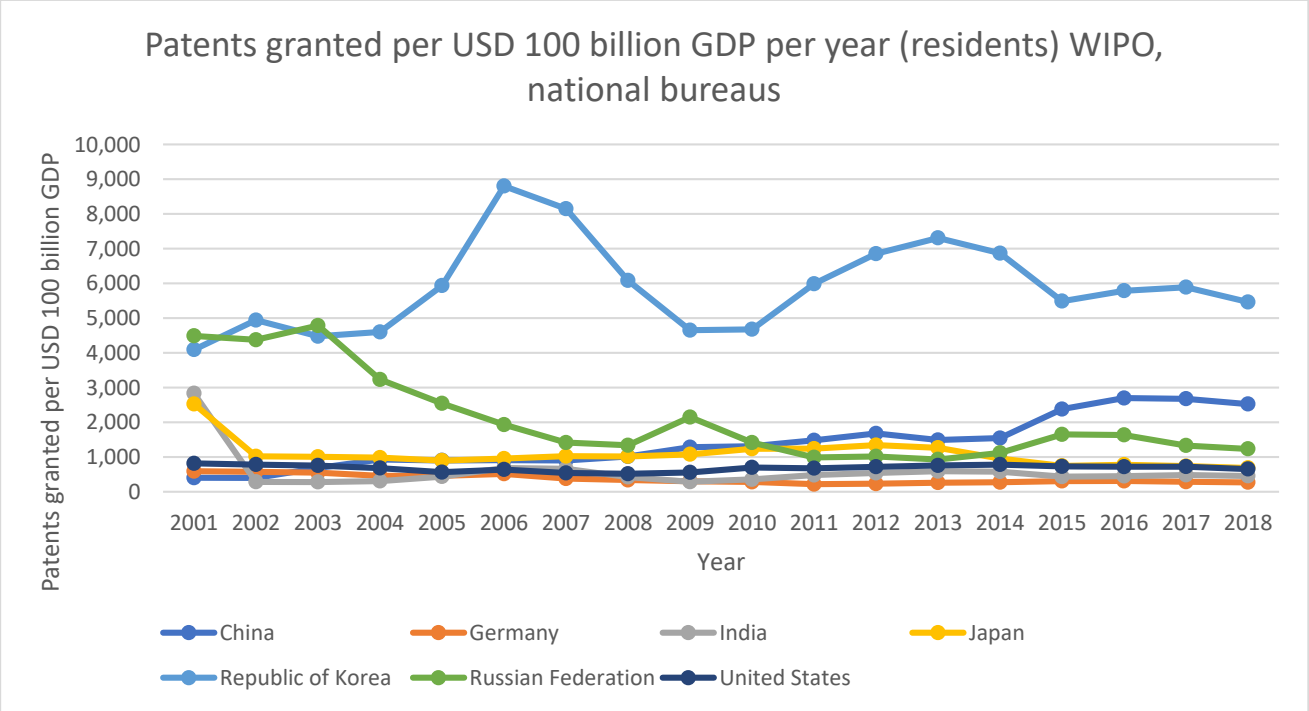
# Appendix A

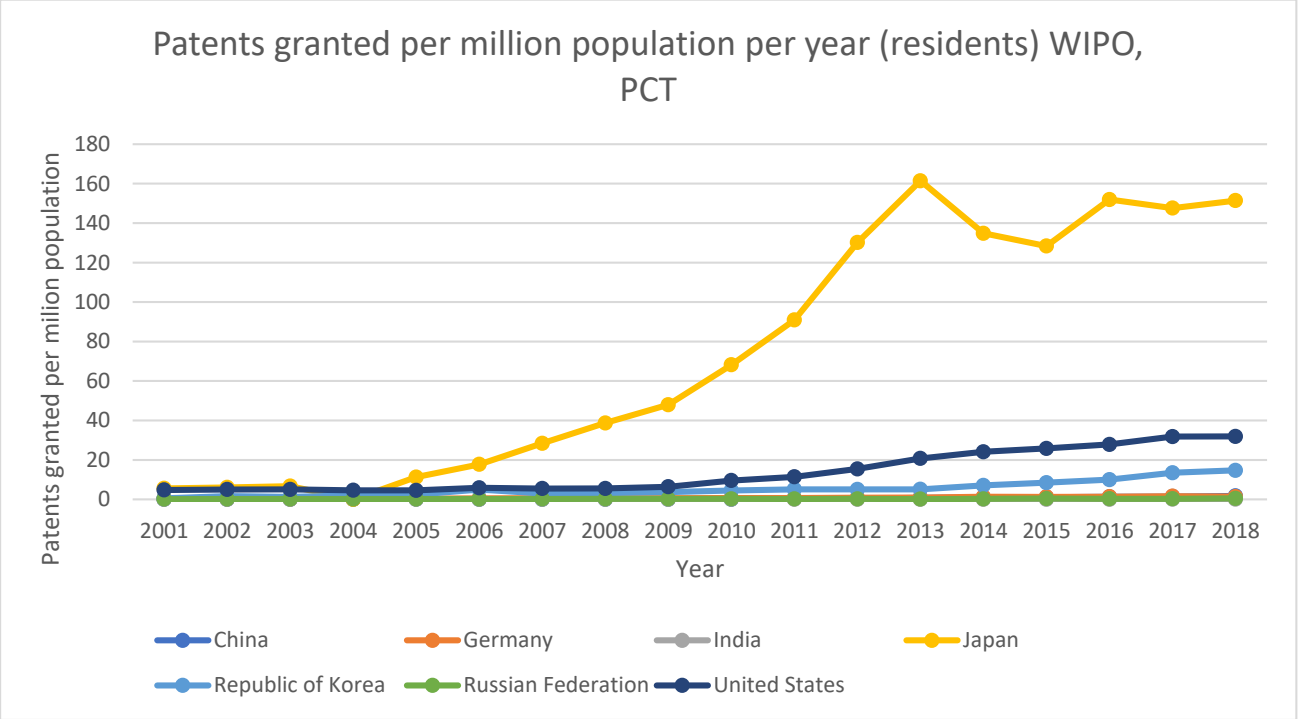



*Sources:* WIPO statistics database (2020); World Bank, World development indicators (2020)

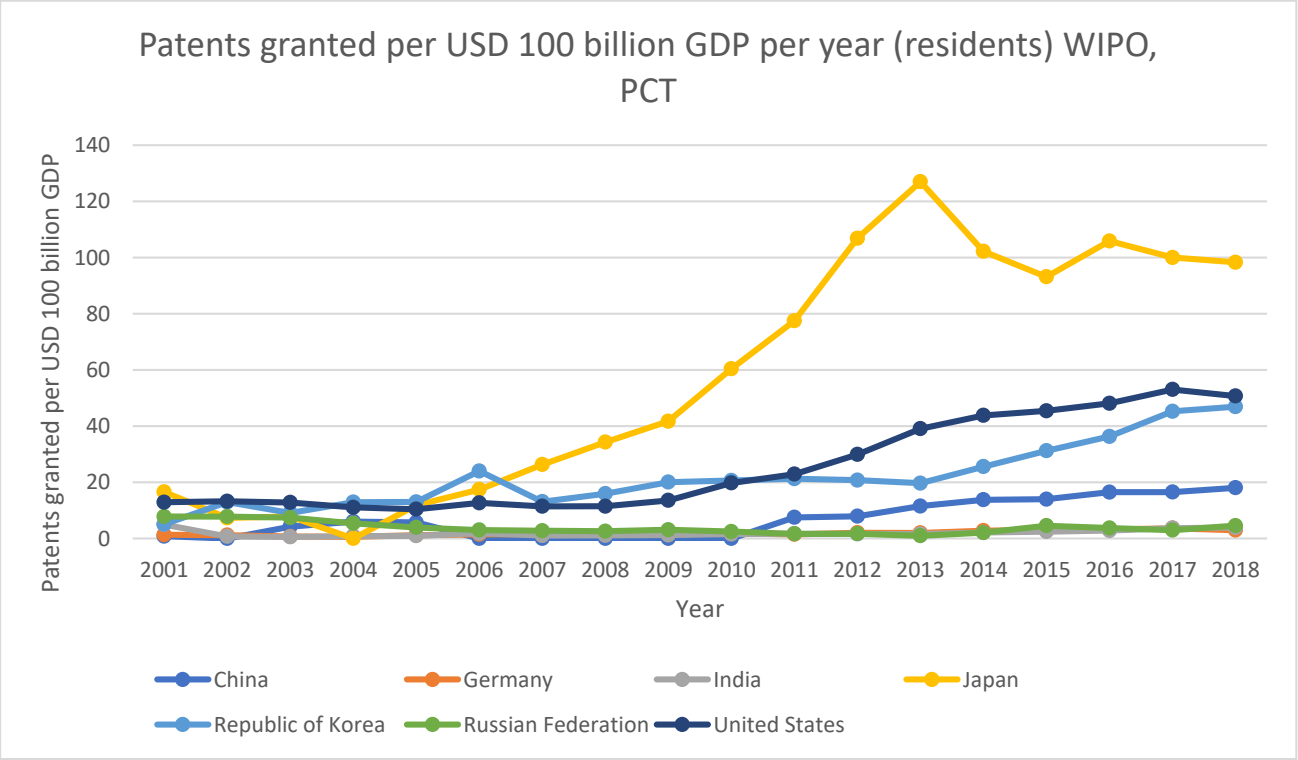



*Sources:* WIPO statistics database (2020); World Bank, World development indicators (2020)

# Appendix B




*Source:* WIPO statistics database (2020); World Bank, World development indicators (2020)




*Source:* WIPO statistics database (2020); World Bank, World development indicators (2020)