Erasmus
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Economics

# The effect of a disclosure journal on the value of patents

An analysis into the value difference of patents that have and have not cited the Xerox disclosure journal


**Elias Yusoufzai**

ERASMUS UNIVERSITY ROTTERDAM
Erasmus School of Economics – Bachelor

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| Name student: | Elias Yusoufzai |
| Student number: | 478203 |
| Supervisor: | Ajay Bhaskarabhatla |
| Second assessor: | Thomas Peeters |



***The views stated in this thesis are those of the author and not necessarily those of the supervisor, second assessor, Erasmus School of Economics or Erasmus University Rotterdam***



**Abstract**

In this research the influence of a particular set of intellectual property on the value of following patents is investigated. In 1975 Xerox signed a consent decree with the FTC because it had engaged in anti-competitive behaviour. The consent decree forced Xerox to license their patents for a small royalty and stop their anti-competitive behaviour. Xerox subsequently published certain innovations in a journal which was free to use for the public. Previous research has shown that such journals have increased the value of patents that have cited those journals. First a literature review is performed on the purpose of patents, the alternatives for patents and how patent value can be measured. Second, the knowledge gained by the literature review is applied on the data using regression analysis. This showed that patents that have cited the Xerox disclosure journal have more value than those that do not.

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## Introduction

In early 2020 the world got to know what a pandemic looked like in modern times. After mask mandates, lots of hand sanitizer and worldwide lockdowns in late 2020 multiple drug companies started producing vaccines against the coronavirus in order to bring the pandemic to a halt. In April 2021 countries and significant people started to promote the idea of a patent waiver for the vaccine so that poorer countries would also be able to produce and therefore have easy access to the vaccine. The pharmaceutical companies had patented their vaccines in order to protect their intellectual property and make sure that their profits were secured.

When companies innovate, they will have incurred large research and development costs. They will want to recuperate these costs and make sure that nobody will be able to 'run away' with their innovation and reduce their profits. Companies can use different strategies to protect their innovations. Cohen, Nelson and Walsh (2000) describe that a company can also choose for secrecy. When a company chooses to keep their innovation a trade secret, they will have their staff sign a non-disclosure agreement or some other legally enforceable contract. This means that the innovation does not have to be published and therefore excludes competitors from using it, yet the company can still use the innovation to make profits. Secrecy has proven to be very effective. The recipe for the Coca-Cola drink is an illustrative example of trade secrecy. However, one of the most important ways to protect intellectual property for a company is still to secure a patent on the invention. In Dutch patent law a patent is issued when the invention has novelty over prior art. The patent then allows the company to exclusively exploit the invention for a certain number of years. In the Netherlands a patent is valid for 20 years and bans others from making, using, reselling, renting, delivering, offering, importing, and warehousing your invention (van Engelen, 2020). That means that all other parties are excluded from using the invention, unless the patent holder has licensed the technology to them.

Although the basic idea behind patents is to allow companies to secure the returns on their inventions and therefore increase the incentive to innovate, companies have historically used patents for different goals. Patents have for example been used to deter competitors from entering into an industry by building so called 'patents walls' (Cohen et al, 2000). These patent walls consist out of a combination of patents that combined increase the barrier to entry significantly. Because an incumbent is the owner of these patents, it is hard for others to enter the industry.

These patent walls can be so high that industry leaders have been accused of near monopolistic behaviour. Certain companies have even had infringement suits opened upon them by regulators because their behaviour caused an uncompetitive and monopolistic market.

One of these examples is Xerox. Xerox introduced the first widely usable photocopier in 1959. Before 1959 photocopiers were available, but they were expensive and complicated to use. Xerox changed the photocopying industry with their Xerox 914 and became a bestseller in the market (Thompson, 2015). By 1973 Xerox had amassed a position in the market and an accompanying patent portfolio that the Federal Trade Commission (FTC) regarded as uncompetitive and monopolistic. The FTC therefore issued a complaint against Xerox in 1973. McKeown (1974) describes in his paper what the reasoning behind the suit was. The FTC brought ten specific accusations in their complaint. In summary the allegations were that Xerox did not only use their patents to protect their intellectual property, but also used their patents to increase barriers for competitors in order to monopolize the markets in which they operated. This monopolistic behaviour was deemed unwanted by the FTC. Because of this behaviour the FTC offered Xerox to enter into a consent decree to resolve these issues. The decree contained two measures to introduce competition again into market. The first measure meant that Xerox had to all license all of their current patents that covered photocopiers without cost to anyone. The second measure meant that Xerox had to license the patents that they might obtain in the 20-year period after the decree came into effect for a reasonable price. In 1975 the FTC and Xerox came to a settlement and the consent decree entered into force. The measures were however slightly altered. Xerox had to stop its uncompetitive patenting behaviour and infringement suits. Xerox also had to license their patent for a small royalty (Tom, 2000). Shortly after Xerox started a patent disclosure journal in which they pledged their inventions to the public, while at the same time blocking others from patenting the invention. When an invention is pledged, the information becomes public knowledge and is therefore not patentable by anyone (Baker & Mezzetti, 2005).

Since the patents that Xerox had accumulated, blocked competitors from entering into Xerox' markets, one can assume that these patents are quite valuable and that competitors

would use them once they were available to them. There is also prior literature on this. In 1956 Bell also entered into a consent decree with the FTC because of monopolistic behaviour. Watzinger, Fackler, Nagler and Schnitzer (2020) showed that there was an increase in use of the patents that fell free because of the consent decree. An interesting research question would therefore be whether the same is true for the patents that were entered into the Xerox disclosure journal after the consent decree.
The effect of subsequent pick up of valuable patents has however already been extensively covered in previous literature. The research question will therefore be deepened to see whether the effect carries on to a patent that cites a Xerox patent. That means that what will be looked at is whether patents that cite a Xerox patent are more valuable than patents that do not.

Therefore, the research question of this thesis is:

*"Are patents that cite the Xerox disclosure journal more or less valuable than patents that do not cite the journal?"*

This thesis will review whether the patents that cite the Xerox disclosure journal are more or less valuable than patents that do not cite the journal. The data that is used to answer the research question was kindly provided by Mr. Bhaskarabatla, the supervisor of this thesis. The dataset contains market level data, firm financial data, and patents. The dataset is combined out of a dataset that was used in a previous paper by Kogan, Papanikolaou, Seru and Stoffman (2017) data from Compustat for market data and WRDS to link the two datasets. The dataset is then supplemented with various variables that are used in analysing the data. Lastly the data is analysed by using ordinary least squares regression and negative binomial regression.

This thesis consists out of five further chapters. Chapter 2 discusses relevant existing literature, chapter 3 discusses the data used in further details, chapter 4 discusses the methodology, chapter 5 discusses the results and finally chapter 6 concludes the thesis and contains the discussion.

## Theoretical framework

To answer the main research question first the different academic views on the subject matter need to be identified. The first topic is what the patenting landscape looks like in Europe and the United States and what their differences are. In Europe there is the European Patent Office (EPO) which administers and grants patents for its contracting states of which there are 38. Those contracting states are all countries in the Europe Union and some additional countries that have close ties with the EU. The EPO does not grant a single European patent, instead it grants individual national patents from all contracting states. It is however also possible to file for a European patent that only covers certain countries. This is for example done when an applicant is not concerned about a particular country and wants to reduce the fees by excluding that country from their application. In the United States there is the United States Patent and Trademark Office (USPTO). The USPTO grants and administers patents within the United States. Both the EPO and the USPTO handle a maximum validity period of 20 years and require renewal fees. The EPO handles yearly renewal fees and the USPTO requires renewal fees at 3 points in time over the 20-year validity period. Kim and Lee (2015) examine in their paper the patent databases of the USPTO, the EPO, the JPO and the KIPO. The JPO is the Japanese Patent Office and the KIPO is the Korean Intellectual Property Office of South Korea. They chose these patent databases because they are the most used databases so far in academic research.

Kim and Lee (2015) focus in their research on which patent database is suitable for which kind of research. The motive for their research is that there are more studies being conducted with patents as their underlying data and that it is therefore important to identify which database is more suitable for which kind of research. According to Kim and Lee (2015) there were various reasons to use a particular database before they conducted their research. The USPTO was considered the most suitable database for research because of its size and ease of use. The EPO was most widely used to research the technology progress European economies. They also stress that even though the USPTO database is the largest database, it is not the most representative. This is because certain companies for example might not patent their invention or innovation in the United States. This can be because of a variety of reasons. For example, because they expect that there is little place in the market in the United States or because the technology is predominantly developed in Europe and there is therefore no need to file a patent in the United States. This means that when research is being conducted into the innovation of a particular technology, the database of the EPO might be a more suitable database than the database of the USPTO.

The purpose of the research of Kim and Lee (2015) is therefore to find out the characteristics of each database in order to identify when which database should be used. They first collected all patents that were filed between 2008 and 2010 in the databases of the USPTO, the EPO, the JPO and the KIRO. They then identified in which two classes the most patents were filed in those years. From those classes they collected the statistics on how many patents were filed in those classes between 1992 and 2011. They then established three perspectives through which they could analyse the databases. The first perspective was the degree of innovation, which was determined by looking how actively/often patents were filed into each database. The second perspective looked at how many companies and individuals filed patents and which companies, or individuals filed the most patents. The third and last perspective looked at which fields of technology the patents covered, and which fields of technology were the biggest.

Regarding the first perspective they found that patenting activity increased between 2008 and 2010 in the United States and Japan, the average growth rate per year was 15.48% in the United States and 12.22% in Japan. However, in Europe and Korea patenting activity decreased with on average 0.85% and 5.03% per year respectively. According to Kim and Lee (2015) this could be attributed to the fact that both Europe and Korea have large firms that operate in automobile, building and consumer goods. Those firms were especially hurt during the 2008 financial crisis and therefore consequently reduced their R&D budgets.

Regarding the second perspective they found that between 2008 and 2010 companies and individuals from 128 different countries filed for a patent in the United States. For Europe this number was 95 and for Korea it was 78. The JPO does not disclose the nationalities of applicants. Kim and Lee (2015) also found that the top three nationalities of all four patent databases had filed at least 60% of the patents in the year 2008 to 2010.

Regarding the third perspective they found that the United States had by far the most diverse patent database. In the United States there were 258 different patent classes in which a patent was filed. In Europe there were 121 different classes in which patents were filed, in Japan there were also 121 different classes and in Korea 122. While there was more diversity regarding the classes in which patents were filed in the United States, the same was not true for the distribution of the patents. The top three classes in which patents were filed represent 43.4% of all patents that were filed. In Europe this number was 27.27%, in Japan it was 12.34% and in Korea it was 34.16%.

From these results Kim and Lee (2015) concluded that the USPTO database was indeed the most suitable database to use when conducting a study into technological innovation. This is because the USPTO database has more patent activity, more diverse patenting population and more diverse patenting classes than the other databases. This does not mean that the other databases are not suitable to use when conducting scientific research. However, when using the EPO database, one should take into account that it has less data than other databases and when using the JPO database one should consider that accessibility of data might be restricted. Lastly, the patenting population of the KIPO database is not as diverse as other databases with only 78 different nationalities and Korean companies representing 73.74% of all patents that were filed between 2008 and 2010. This means that the KIPO database best reflects the domestic Korean technology market and innovation output.

The second topic that needs to be covered is why companies might file a patent and which alternatives exist. Cohen et al (2000) describe in their paper why companies might patent their inventions and which other methods exist to protect their intellectual property besides patenting. For this paper a survey was conducted in the R&D facilities of the US manufacturing industry to which 1478 responses were received. The strongest motivation for companies to patent was to prevent competitors from copying their inventions or coming up with substitutes, essentially blocking competitors. This effect was mostly found in so called 'discrete' product industries, such as drugs or chemicals. Other motivations include the ability to license the patent, to protect against infringement suits and to have more bargaining power during negotiations with competitors. These were the main reasons for companies operating in 'complex' industries, such as telecommunications. When a company is able to patent their invention, they can protect their invention in order to extract all potential profits without interference of their competitors. This can be amplified by patenting the initial invention and also patenting substitutes and complementary inventions. This is the practice of building so-called patent walls to further hinder competitors from further entering the market. A company can however also protect their inventions in other ways. These methods are typically used more than patents and the most used methods are secrecy, lead time and complementary capabilities. Secrecy is the act of keeping an invention or piece of information secret within the company. This is usually enforced by having staff sign a non-disclosure agreement or other legally enforceable agreements. Lead time is the time between the start and finish of a particular process. When a company exploits lead time, they will try to beat their competitors to market in order to obtain the benefits that come from being the first to offer a product. Complementary capabilities are the capabilities that a company has that complement the initial invention. This paper shows that patenting is not the obvious and first choice in order to protect intellectual property. It also shows that the motivation to patent an invention is not universal across industries, but different industries might have different motivations to patent. This paper however does not go into the topic of disclosing inventions.

In the case of Xerox, patenting is not the best option because of the consent decree. Xerox instead pledges certain inventions in their disclosure journal. Baker and Mezzetti (2005) researched why research firms might want to disclose their inventions to a patent office rather than patent the invention itself. They argue that intuition brings some scenarios forward in which disclosure is a better choice than patenting. For example, when there are technological limits that the company is facing and therefore it cannot develop its invention further. By disclosing their invention to the public someone with more knowledge might be able to break down this barrier and allow the company to further innovate. They however also argue that patent attorneys will look at disclosure from a different angle. From a patent attorneys' perspective, disclosure can be used to defend a company's invention. Patents are only granted when they carry enough over prior art and by disclosure a company can increase the prior art. When prior art has increased, a rival company will now need to have more novelty in their innovation in order to qualify for a patentable invention. A company might choose for this tactic when they do not wish to further pursue that field of technology and deem a patent application to be costly. Yet, they do not want to run the risk of someone else patenting something close to their innovation and consequently rendering their research and development worthless. Baker and Mezzetti (2005) then remark that the scenarios that they have described all cover the case of a firm that does not want to apply for a patent. They develop a model in their paper with which they examine whether disclosure is also a good tactic for a firm that is planning on patenting their invention. This

model then shows that by disclosing their inventions firms can buy time to patent their inventions. If a company discloses their invention to the patent office, they create prior art, which means that any subsequent invention must be developed further than the disclosed invention. That means that a competitor will have to develop further to come to a patentable invention. This in turn allows the company that disclosed their invention to work on their invention in the meantime and get ahead of their competitor. This shows that the practice of disclosing does not only protect the invention of a company by blocking others from patenting that invention, but also allows them to develop their invention without the fear of being overtaken in the patent race.
They finally also present empirical evidence by looking at the IBM disclosure journal. They assembled 2300 patents that were issued to IBM between 1996 and 2001 and that had cited their disclosure journal. They argued that if there was a long lag between the publication in the disclosure journal and subsequent patent application, this could be because IBM truly abandoned and revisited the technology. However, if there was a short lag this could be evidence of IBM employing patent disclosure as a tactic to extend the patent race. They found that 54% of inventions were applied for within 5 years after disclosure in their journal. According to Baker and Mezzetti (2005) it would be surprising if IBM would shift their priorities that quickly and it therefore seems fair to claim that IBM employs patent disclosure as a tactic.

Johnson (2014) researches in his paper why firms might choose defensive publishing over secrecy and patenting when they have an invention. All methods have their benefits, secrecy forces the competitor to innovate the invention themselves. Patenting allows the firm to exclusively use the invention and also blocks competitors from using their invention. Defensively disclosing an invention means that no one can patent the invention, that means that the firm that made the invention can also use the invention. There are however also downsides to the various methods. The disadvantage of secrecy lies in the fact that competitors can still patent the invention after they have discovered it themselves. That means that even though the firm discovered the invention first, they can still be excluded from using the invention. The disadvantage of patenting is that the procedure to patent an invention is very costly, which dissuades firms from patenting. Lastly, the disadvantage of defensive disclosing is that competitors also receive access to the invention and are also free to use the invention in their own firms. According to Johnson (2014) defensive publishing is mainly of use in sectors and for inventions that are not technically challenging and are easy to innovate around. This is because secrecy and patenting are less optimal in that situation. When a firm protects their innovation by using secrecy, competitors will still be able to discover the invention on their own because the invention is not technically challenging. Once the competitors discover the invention, they will also be able to patent it and then block the firm from using it. Patenting is also not optimal in this situation, because the process of applying for a patent is costly. Since inventing around the invention is easy, competitors will be able to innovate in a similar way without making the cost of a patent application. The second finding is that defensive publishing is also beneficial when the invention is not easily copied or when there are no competitors willing to copy the invention. When there is no threat of a competitor walking away with the invention, it is more important for the company to protect their right to apply the invention than to block others from using the invention. In that case defensive publishing is the best option, because it blocks others from patenting the invention which means that the company can continue to use the invention. These papers show that disclosure or defensive publishing is beneficial to stay ahead of competition and to block competitors from the ability to copy their invention in certain situations.

So far it has been established that defensive publishing and pledging of invention is beneficial in situations in which the company can choose freely in which way they want to protect their invention. Xerox however also had to license their patents for little or no cost to whomever wanted to license it. Watzinger et al (2020) analyze in their paper what the effect is of forcing a company to license their patents for free when that company has assumed a near monopolistic position or is engaged in uncompetitive patenting behavior. They do this by studying effects of the consent decree from 1956 against Bell System. Bell System signed this consent decree after it was accused of monopolistic behavior. The consent decree forced Bell System to license all their prior patents at no cost and all their future patents at an acceptable price. These patents represented 1.3% of all US unexpired patents at the time and they covered a wide range of technologies. Bell System was also not allowed to enter any other markets except for telecommunications.

Watzinger et al (2020) focus on three effects in their research. First of which is the direct effect on following innovation, they measure this by looking at patent citations of Bell Systems patents. Second, they study the effect on the entire US economy by looking at overall patent output in the United States. Third, they examine what the effect of the consent decree was on the innovation output Bell System.

To study the first effect, they construct a control group to compare the patents of Bell System with. The control group consists out of patents that were filed in the same year, in the same patent class and had the same number of citations before the consent decree was enforced. Their finding was that after five years subsequent innovation grew by 12 percent, but this did not show in all industries. The effect was only measured outside of Bell System's core market, which was telecommunications.

To study the second effect, they analyzed the change of the total number of patents in the technology classes in which Bell System was active after the consent decree came into effect. That change was then compared to the change of the total number of patents in which Bell System was not active after the consent decree came into effect. The outcome of this analysis was that overall patent output went up in the United States by 3.6 patents in each patent class in which Bell System was active. This effect was however again only measured in technology classes that are not related to the telecommunications industry.

To study the third effect, they compare the actual patent output of Bell System with the patent output of a 'synthetic' Bell System. The 'synthetic' Bell System was constructed by calculating the share of Bell Systems patents in each patent class for the years 1946, 1947 and 1948. They then assume that Bell System would have grown as much as other companies in order to keep the share of Bell System the same in the patent class. This results in the 'synthetic' Bell System patenting only slightly more than Bell System did.

What can be concluded from these findings is that a consent decree and the subsequent forced licensing of patents meant that innovation increased in all sectors, except for the telecommunications market. The forced licensing was not effective in changing Bell Systems near monopoly position, but it was effective in spurring following innovation in other sectors. Bell System continued to conduct research and development and focused itself purely on telecommunications after the consent decree. This caused Bell System to intensify their efforts to stay market leader, which eventually led to them being broken up 1984.

Galasso and Schankerman (2014) also explore in their paper whether patents increase or decrease subsequent innovation. They analyze this by looking at the patent citations of patents that were invalidated because of rulings by the U.S. Court of Appeals for the Federal Circuit. This court has the complete jurisdiction over disputes in which patents are involved. The patent can still be tracked even though the patent has been invalidated, because it is still mandatory for new patents to cite prior art. They find that when a patent is invalidated, this causes an increase of patent citations of 50%. Next to this they find that this does not happen in all industries. The effect is only visible in the sectors of computers, communications, electronics and medical instruments. There was no effect visible for the sectors of drugs, chemicals or mechanical technologies. Lastly, they find that the effect is only present when the patent of a large company is invalidated. When the patent of a small company is invalidated, the effect is not visible. Furthermore, they try to find the cause of why patent invalidation causes such an increase in citations. According to Galasso and Schankerman there are two main reasons. First, it could stem from the tactics that a company might employ to block competition in their sector. The patent would then be serving as a wall for competition and declining to license the patent could ensure that the company remains dominant in their sector. Second, it could be that there is information asymmetry between the owner of the patent and the licensee cannot come to an agreement to license the patent, even when an agreement would benefit both parties.
From the findings of both Watzinger et al (2020) and Galasso and Schankerman (2014) the following hypothesis can be derived: Patents from the Xerox Disclosure Journal are more cited than patents that are not in the journal. This hypothesis can however largely be answered by the research that Watzinger et al (2020) have done. A more scientifically challenging and interesting question would be whether patents that cite the Xerox Disclosure Journal are actually more valuable than patents do not cite the journal. Therefore, the hypothesis will be:

Hypothesis 1: Patents that cite the Xerox Disclosure Journal are more valuable based on citations than patents that do not cite the journal.

Harhoff, Narin, Scherer and Vopel (1999) researched whether patent citations are a good indicator of a patent's value. They hypothesize that valuable patents are cited more often than invaluable patents. This is first of all because cited patents are the prior art on which new patents build, meaning that more citations are an indication that the patent contains important prior art. They compare this with the scientific world in which journal article citations are indicative of the value of a research paper. Second of all, they argue that citations are also a good indicator of a patent's value because they can show the impact of patents on following research and patents. They however focus on the first reason why citations are a valuable indicator.

The sample construction builds on previous work by Lanjouw, Pakes and Putnam (1998), where it was found that more valuable patents are renewed longer than less valuable patents. A lot of nations require patent holders to renew their patents after a certain period in order to keep their exclusive rights. This means that if a patent is renewed for a longer period, that means that the patent holder expects his returns to be greater than the cost of renewing the patent. What also was found was that more valuable inventions are also patented in more countries than less valuable patents. This was because more valuable inventions, will require more protection.

They then focus on patents that were filed in 1977 in Germany. This was because the renewal period of the patents ended in 1995, because Germany had of the most meticulous patent systems and because the fees were progressive which meant that the effect would be more exaggerated. They then surveyed 1352 German patent holders and 485 US holders of patents in Germany with US counterparts. They asked the holders of the patents what the lowest price was for which they would sell their patents 1980 now that they know how profitable their patent was. This yielded 772 usable responses from German patent holders and 192 usable responses from US patent responders. Their results were however highly skewed. 12.9% of German respondents would have accepted more than $2.75 million and 9.4% of US respondents would have accepted more than $100 million.

They then found that there is a statistically significant positive relationship between the price that a patent holder would accept for the patent and the number of citations the patent had received. They also found that the US counterparts of the German patents that were renewed until their full-term were cited 15% more than the US average, which was 6.83 citations. For the German patent holders, they found that their full-term patents were 47% more cited than the patents that were not renewed until their full-term. The average patent citation in Germany was 0.470. The average patent citation is much lower in Germany

partly because the German patent database is a quarter of the size of the US patent database and partly because in the US all relevant prior patents have to be listed, while in Germany only patents that show the novelty of the invention must be listed.
In summary, Harhoff et al (1999) find that there is a two-stage relationship between the value of a patent and their citations. The first stage being that a patent that is renewed until full-term is cited more than a patent that is allowed to lapse before full-term. The second stage being that the price that the patent holders would accept for their patent increases with the number of citations.

Hall, Jaffe and Trajtenberg (2005) use the number of citations of a patent to assess the impact of patents on the stock market value of a company. By estimating Tobin's Q for patent citations to patents they find that when a patent receives an additional citation, the market value of the company goes up by 3%. This might seem significant, but then it is hard to obtain an extra citation. The citation of patents is very skewed, with the mean of patent citations being slightly more than 3 and that 25% of all patents receiving no citations. What is also worth mentioning is that they find that self-citations have a larger effect than citation by others on the stock market value. This comes from the fact that self-citation could implicate that a company has a stronger position in the market because their knowledge is cumulating compared to others.

Trajtenberg, Henderson and Jaffe (1997) introduce new measures that are constructed with citation data to quantify key aspects of innovation. The aspects in which they were mostly interested were basicness and appropriability. Basicness is how fundamental the research is, an invention is more basic when it does not solve a technological problem but rather answers scientific questions. Appropriability covers how the inventor is able to recover his R&D costs and subsequently make profit. They argue that these aspects affect innovation processes most because if an invention is more basic, it is less likely to turn a profit than a more applied invention. They used patents because they are the appropriate tool to research those topics because of a variety of reasons. First of all because patents contain detailed information on the invention, the applicability of the invention and the details of the inventor. Second, because of their nature patents must specify their citations which means that tracing innovation is more easily done. They however also note that using patents for such studies does have issues, namely that not all inventions are patented. This is because inventor might use different methods to protect their inventions, such as the tactics that Cohen et al (2000) described.

To investigate the relationship between basicness and appropriability, they matched samples of university and corporate samples. They did that to exploit their belief that university research is more basic than corporate research.

They then construct two sets of measures, one set consists out of forward-looking measures and one set out of backward-looking measures. The forward-looking measures contain what knowledge supersedes the patent and the backward-looking measures contain the knowledge that preceded the patent.

The first forward-looking measure is the importance of a patent, this measure contains the citations that a patent received and the citations of the patents that cited the patent. The second forward-looking measure is generality, generality looks at whether a patent has promoted innovation in a single technology field or whether it has promoted innovation in multiple fields. The third forward-looking measure is distance, which captures whether a patent that has cited another patent is in a further technology field. The final forward-looking measure captures self-citations, which is when a patent owner cites their own patents.

The first backward-looking measure is again importance, but this time it contains the citations that a patent received and the citations that the patents that it cited received. The second backward-looking measure is originality. Originality captures whether a patent has been constructed out of a single technology field or out of multiple fields. The last backward-looking measure measures whether the sources of knowledge are diverse. A patent is for example more diverse when it not only builds on previous patents, but also on scientific journals or books.

The data consisted out of all university patents that were assigned in 1975 and 1980, those patents were then matched to the patents that were granted to the 200 most R&D performing companies in 1986 in the US. The patents were matched based on patent class, application year and grant date.

Their findings for the forward-looking measures are first that in terms of importance university patents receive more first- and second round citations than corporate patents. Second, they find that in terms of generality university patents promote innovation in multiple technological fields, unlike corporate patents which at first promote innovation in the same technological field and over-time spill-over into other fields. Their third and last finding was that corporate patents had more self-citations than university patents. For the backward-looking measures they first find that in terms of importance corporate patents tend to use more and more important patents as their basis. Their second finding is that university patents indeed use more diverse sources as their basis than corporate patents. Trajtenberg, Henderson and Jaffe (1997) conclude that their forward-looking measures support the hypothesis that university patents are more basic than corporate patents because university patents have fewer self-citations and cause more diverse following innovation. From their backward-looking measures they conclude that university patents are again more basic than corporate patents because university patents use fewer patents and more diverse research as their basis.

Kogan et al (2017) construct a measure with which they can estimate the value of a patent. Before this paper, there was already consensus that technological innovation is a key driver of economic growth. The models that could predict this effect, were however lacking in some respects. According to this paper, the predictions of those models were hard to test and verify because there were too few directly observable measures to control with. To measure the effect of technological innovation properly and reliably, a new measure is needed that captures the economic value of new inventions via multiple angles and is comparable across both industries and time. Kogan et al (2017) introduce a measure to determine patent value that combines the economic value of companies and patent grants. The economic value of companies is distilled from stock market reactions to patent grants. They argue that using financial data is a good fit to measure the value of patents. Financial data does not only include the value of the patent today, but also the potential value it could bring the future. This is therefore a more inclusive measurement because it also includes future payoffs. Their patent sample consists out of all US patents that were granted up to that point and their stock market data is obtained from the CRSP, their final sample consists of out 1801879 patents.

They further distinguish between the scientific value and the private value of the patents. These two values do not necessarily overlap because a patent can have little scientific value but can be very effective in blocking competitors and therefore have large private value. The scientific value is the number of citations, and the private value is the value that the patent carries for the company. The value of a patent for the company can for example lie in the fact that it blocks competitors from using the invention. The private value is estimated by looking at the stock market value of the company in the days after it announced a new patent. They find that in the days after a patent is issued the stock of the company is traded more often. They also find that on days that patents are granted the returns are more volatile than on non-grant days. This indicates that the market reacts accordingly to the issuance of patents. To make sure that only the private value is measured, they filter for various factors that could influence the stock price.

To illustrate what the relationship between stock market value and patent issuance is, they give the example of a patent that was granted to the Genex Corporation. The stock price went up by 67% more than the market average in the following three days and the patent had received 775 citations. They consequently find that their measure is successful in predicting a positive relation between stock market value and patent citations. Depending on the different control measures included, one extra patent citation causes an increase between 0.1% and 3.2% in the value of that patent. This number is close to the increase that Hall et al (2005) found. They also find that one additional citation increases the patent value between $15000 and $500000 at the 1982 price-level. This number is close to the increase that Harhoff et al (1999) found in their research.

What makes this measure unique is that it derives the private value of a patent from the stock market. This means that the measure can be used in different sectors and that it is not exclusive to one industry because the value is measured in dollars. Citations and citation customs for example differ per industry and could therefore cause problems when trying to compare patents from different industries. This measure is an appropriate measure to supplement citations in judging patent value. Therefore, the hypothesis from the findings of Kogan et al (2017) will be the following:

Hypothesis 2: Patents that cite the Xerox Disclosure Journal are more valuable when judged by the Kogan measure than patents that do not cite the journal.

Maresch, Fink and Harms (2016) extend previous research in the effect of patents on the performance of firms by introducing competition and patent age into their model. Their sample consisted out of 975 patents from different industries. These patents were granted to firms under Austrian law. In their research they found that more recent patents have a larger impact on a firm's performance. They however also find that a patent contributes more to the firm's performance when there is more competition in a particular area. This is because when there are more patents in a particular industry's class, a single patent carries more economic value for the patenting firm. In order to further deepen the scope of this thesis, an effect that might be worth looking at is the effect of competition on the effects measured in hypothesis one and hypothesis two. The final hypothesis is therefore:

Hypothesis 3: the relationship in hypothesis 1 and hypothesis 2 is stronger when there is more competition in a particular patent class.

## Data

The research question of these question indicates that two types of data are needed, namely patent data and firm financial data. The patent data is required to obtain citations to judge the value based on citations. The patent data is obtained from a previous paper by Kogan et al (2017). This database consists out of all patents that were registered in the United States up to 2009. The patent data from 1976 to 2009 was downloaded from Google Patents. The patents up to 1976 were obtained by searching OCR-scanned documents for numbers that could indicate a patent number. Kogan et al (2017) then clean up the assignees in the database and match the patent data to historical stock market data, which is obtained from the Center for Research in Security Prices (CRSP).

In addition to the firm level historical stock market data that is obtained from the CRSP, firm level financial data is obtained from Compustat. Compustat is a database that carries financial information from public companies across the world. These financial databases are necessary to construct the Kogan measure and subsequently judge the patents based on the Kogan measure.

To merge the Kogan et al (2017) database with the data from Compustat, another database is needed. The reason behind this is that the CRSP database and the Compustat database filter companies using different identifiers. The Kogan et al (2017) database filters companies by using the identifier that the CRSP database uses. That identifier is the PERMNO, which is a five-digit number that is assigned to each type of stock that a company has issued. The Compustat database uses the CUSIP to identify individual companies. The CUSIP is a nine-digit code that identifies individual stocks and bonds.

To link these two different identifiers the WRDS database is used as this database carries both identifiers for public companies. With these three databases a new database is created in which there is patent data, market data for the firm and lastly firm level financial data. In this database there are now in total 4920 companies. Those companies have 1586566 patents of which 18443 belong to Xerox. The patents that belong to Xerox have received a total of 1139 citations. This creates a very complete database with a diverse set of companies of patents, since all technologies and sectors are represented in the dataset.

After the construction of the final database the following variables are relevant for this thesis:

- Class, which indicates in which patent class a patent was filed
- Emp, which indicates how many employees a company has
- Fic, which indicates in which country the company is incorporated
- Ncites, which indicates how many citations a patent has received
- Xerox_nplcites, which indicates how often a patent has cited the Xerox disclosure journal
- Xi, which is the Kogan measure
- Year, which is the year in which the company applied for the patent

Alongside these variables, some variables are added in order to process the data. First, values without a patent class are removed from the dataset as these cannot be used for the purposes of this thesis. Second, a dummy variable is created to indicate whether a particular patent cites the Xerox Disclosure Journal. This variable assumes the value of 1 if the patent cites the journal and 0 if the patent does not cite the journal. Third, a variable is created to express the number of unique firms in a particular patent class. This variable is a continuous variable. Fourth, the class of the firm is encoded from a string to numerical to make it suitable to process further. Fifth, a variable is constructed to express competition in a particular patent class. This variable is constructed by multiplying the number of unique firms in a specific class with the variable that indicates how often a patent has cited the Xerox disclosure journal. This variable assumes the value of 0 if the patent has not cited the Xerox disclosure journal and if the patent has cited the journal, it will assume the number of firms in the patent's class.

## Methodology

To test the first hypothesis an ordinary least squares regression is used. In this regression the patent class, filing year, number of employees and country of incorporation are added to control for fixed effects that might be caused by those aspects. The patent class is used to control for effects that come from the technological field of the patent. It can for example be that in a certain industry very little value is attributed to patents, while in another industry patents are regarded as highly valuable. The filing year is used to control for effect that come from events in that year. In a year there can be multiple technological breakthrough that either increase or decrease the value of patents overall. The number of employees is used as a proxy for the firm size. A larger firm can for example have more prestige than a smaller firm, which may be reflected in a patents value. A larger firm can however also receive negative publicity, which can also be reflected in a patents value. A larger firm can also be less susceptible to competition because it can either block competition or innovate as well. The country of incorporation is used to control for effects that can be caused by the location of the patent holder. A patent from a firm from the United States can for example be regarded as more valuable because firms from the United States are known to produce innovative inventions, rather than a patent from a patent holder South-Africa.
The confidence interval is set at 5%, which means that a P-value of less than 0.05 is needed to obtain a significant effect of the variables. This regression uses a dummy variable for when a patent cites the Xerox disclosure journal and the patent class as the independent variables. The dependent variable in this regression is the number of citations.

$$\text{Number of citations} = \beta 0 + \beta 1 * \text{Dummy Patent Citing Xerox} + \beta 2 * \text{Patent class} + \beta 3 * \text{Filing year} + \beta 4 * \text{employees} + \beta 5 * \text{country of incorporation} + \varepsilon$$

For the second hypothesis the dependent variable is replaced by the Kogan measure. The Kogan Measure was already present in the do-file to construct the database. The confidence interval is again set at 5% and the Kogan measure is the dependent variable.

$$\text{Kogan Measure} = \beta 0 + \beta 1 * \text{Dummy Patent Citing Xerox} + \beta 2 * \text{Patent class} + \beta 3 * \text{Filing year} + \beta 4 * \text{employees} + \beta 5 * \text{country of incorporation} + \varepsilon$$

For the third hypothesis the variable competition is added to the regression that is used for the first hypothesis. The competition variable is added to control for competition in a patent class. To test the third hypothesis another ordinary least squares regression is used. Here the confidence interval is also set at 5%. Competition is defined as the number of firms that filed a patent in the same class in the same year.

$$\text{Number of citations} = \beta 0 + \beta 1 * \text{Dummy Patent Citing Xerox} + \beta 2 * \text{Patent class} + \beta 3 * \text{Filing year} + \beta 4 * \text{Competition} + \beta 5 * \text{employees} + \beta 6 * \text{country of incorporation} + \varepsilon$$

$$\text{Kogan Measure} = \beta 0 + \beta 1 * \text{Dummy Patent Citing Xerox} + \beta 2 * \text{Patent class} + \beta 3 * \text{Filing year} + \beta 4 * \text{Competition} + \beta 5 * \text{employees} + \beta 6 * \text{country of incorporation} + \varepsilon$$

There is however also an alternative to the more often used ordinary least squares regression. Since the dependent variable of the equation is a count variable in the case of citations, a Poisson regression model could also be used. The Poisson regression model however assumes that the variance and the mean are the same, which is not the case in this instance. The mean of ncites is 10,72 and the variance is 434,34. This is a sign of overdispersion, since the variance is about 40 times larger than the mean. In case of overdispersion a negative binomial regression model should be used. In that case the regression equation for the first hypothesis will be:

$$\log(\text{Number of citations}) = \beta 0 + \beta 1 * \text{Dummy Patent Citing Xerox} + \beta 2 * \text{Patent class} + \beta 3 * \text{Filing year} + \beta 4 * \text{employees} + \beta 5 * \text{country of incorporation} + \varepsilon$$

Since the negative binomial regression model is most suitable for count data, the Kogan measure will not be estimated using the model. Instead, the third hypothesis in the case of citations will be estimated. The regression equation for the third hypothesis in the case of citations will be:

$$\log(\text{Number of citations}) = \beta 0 + \beta 1 * \text{Dummy Patent Citing Xerox} + \beta 2 * \text{Patent class} + \beta 3 * \text{Filing year} + \beta 4 * \text{Competition} + \beta 5 * \text{employees} + \beta 6 * \text{country of incorporation} + \varepsilon$$

After the negative binomial regression model has been executed, the obtained coefficient will be transformed into incidence rate ratios in order to be more easily interpretable.

## Results

Table 1: Effect of citing Xerox disclosure journal on citations

| **Citations** | Coefficient | Robust Std. Err. | t | P > \|t\| | 95% conf. int. | |
|---|---|---|---|---|---|---|
| **Dummy** | 2.401397*** | .8651424 | 2.78 | 0.006 | .7057478 | 4.097046 |
| **Constant** | 19.53651*** | .9675113 | 20.19 | 0.000 | 17.64022 | 21.4328 |

Note: ***p < 0.05.; N: 1,559,928; $R^2$: 0.1478

The results from the regression for hypothesis 1 show that a patent that cites the Xerox disclosure journal receives 2.401397 more citations than a patent that does not cite the journal. The coefficient is highly significant (0.05 > 0.006) which means that it can be interpreted as such. The mean of the citations of patents that have not cited the Xerox disclosure journal is 10.71357. This shows that a patent that has cited the journal receives almost a quarter more citations than a patent that has not done so. This result falls between the results that Galasso and Schankerman (2014) and Watzinger et al (2020) obtained in their research. These results combined mean that hypothesis 1 can be confirmed.

Table 2: Effect of citing Xerox disclosure journal on Kogan measure

| **Kogan Measure** | Coefficient | Robust Std. Err. | t | P > \|t\| | 95% conf. int. | |
|---|---|---|---|---|---|---|
| **Dummy** | -3.739543*** | .335273 | -11.15 | 0.000 | -4.396667 | -3.08242 |
| **Constant** | .9521945 | .9402006 | 1.01 | 0.311 | -.8905663 | 2.794955 |

Note: ***p < 0.05.; N: 1,559,928; $R^2$: 0.0990

The results from the regression of hypothesis 2 show that a patent that cites the Xerox disclosure journal has 3.739543 less value when judged by the Kogan measure. This seems counterintuitive to all the previous literature that implied that an extra citation would increase the value of a patent. The mean of the Kogan measure for patents that have cited the disclosure journal is 5.519759, whereas it is 11.20145 for patents that have not cited the journal. This also shows overall that patents that cite the disclosure journal have lower value when judged by the Kogan measure. The coefficient is however highly significant (0,05 >

0.000), which means that it can be interpreted as such. Another notable result is that the constant is highly insignificant (0.311 > 0.05). This result means that, although counterintuitive based on previous literature, the second hypothesis must be rejected.

Table 3: Effect of citing Xerox disclosure journal on citations when there is competition

| **Citations** | Coefficient | Robust Std. Err. | t | P > \|t\| | 95% conf. int. | |
|---|---|---|---|---|---|---|
| **Dummy** | 3.594511*** | 1.380668 | 2.60 | 0.009 | .8884491 | 6.300574 |
| **Competition** | -.0049465 | .0035352 | -1.40 | 0.162 | -.0118754 | .0019824 |
| **Constant** | 19.53601*** | .9674999 | 20.19 | 0.000 | 17.63974 | 21.43227 |

Note: ***p < 0.05.; N: 1,559,928; $R^2$: 0.1478

The results from the regression for the third hypothesis in the case of citations show firstly that a patent that cites the Xerox disclosure journal receives 3.594511 more citations than a patent that does not cite the disclosure journal. This is a higher value than the value that was obtained in the first regression. Secondly it shows that increased competition in a patent class decreases the citations that a particular patent receives by 0.0049465 citations per company in the technology class. This is again going in against previous literature (Maresch et al 2016). The coefficient is however highly insignificant (0.162 > 0.05) which means that it cannot be interpreted. Since the coefficient is insignificant in this case, there is not enough evidence to support hypothesis 3 in the case of citations. This means that hypothesis 3 must be rejected for citations.

Table 4: Effect of citing Xerox disclosure journal on Kogan measure when there is competition

| **Kogan Measure** | Coefficient | Robust Std. Err. | t | P > \|t\| | 95% conf. int. | |
|---|---|---|---|---|---|---|
| **Dummy** | -2.030892*** | .5224064 | -3.89 | 0.000 | -3.05479 | -1.006993 |
| **Competition** | -.0070839*** | .0018238 | -3.88 | 0.000 | -.0106585 | -.0035092 |
| **Constant** | .9514733 | .9402036 | 1.01 | 0.312 | -.8912935 | 2.79424 |

Note: ***p < 0.05.; N: 1,559,928; $R^2$: 0.0990

The results from the regression for the third hypothesis in the case of the Kogan measure show the same effect as the results from the regression for the second hypothesis. A patent that cites the disclosure journal has 2.030892 less value when judged by the Kogan measure compared to a patent that does not cite the journal. This value is lower than the effect that was measured in the second regression. Again, more competition decreases the value of a patent when judged by the Kogan measure by 0.0070839 per company in the technology class. In this case the coefficient of competition is highly significant (0.05 > 0.000) as is the coefficient of the dummy (0.05 > 0.000). However, the constant is highly insignificant (0.312 > 0.05), which means that it cannot be interpreted. This means that the third hypothesis must be rejected for the Kogan measure.

Table 5: Effect of citing Xerox disclosure journal on citations. Results in between brackets are the incidence rate ratio.

| **Citations** | Coefficient | Robust Std. Err. | z | P > \|z\| | 95% conf. int. | |
|---|---|---|---|---|---|---|
| **Dummy** | 0.247078*** | .0514227 | 4.80 | 0.000 | .1462915 | .3478646 |
| | (1.280279)*** | (.0658354) | (4.80) | (0.000) | (1.157534) | (1.416041) |
| **Constant** | 2.57686*** | .1138517 | 22.63 | 0.000 | 2.353714 | 2.800005 |
| | (13.15576)*** | (1.497806) | (22.63) | (0.000) | (10.52459) | (16.44473) |

Note: ***p < 0.05.; N: 1,559,928; $R^2_{pseudo}$: 0.0655

The results from the negative binomial regression for the first hypothesis show that a patent that has cited the Xerox disclosure journal can expect a 24.7078% increase in the expected citations when all other variables are held constant. When the 'irr' option is used to present the results as incidence rate ratios, it becomes clear that a patent that has cited the Xerox disclosure journal can expect 28.0279% more citations than a patent that has not cited the journal. The coefficient is highly significant in both cases (0.05 > 0.000) which means that it may be interpreted. This result is in line with what was obtained in the first regression and in previous literature, therefore it can be used to conclude that hypothesis 1 is again confirmed.

Table 6: Effect of citing Xerox disclosure journal on citations when there is competition. Results in between brackets are the incidence rate ratio.

| **Citations** | Coefficient | Robust Std. Err. | z | P > \|z\| | 95% conf. int. | |
|---|---|---|---|---|---|---|
| **Dummy** | 0.3587121*** | 0.0893717 | 4.01 | 0.000 | .1835467 | .5338774 |
| | (1.431485)*** | (0.1279342) | (4.01) | (0.000) | (1.201471) | (1.705532) |
| **Competition** | -0.0004725 | 0.000263 | -1.80 | 0.072 | -.0009879 | .0000429 |
| | (0.9995276) | (0.0002629) | (-1.80) | (0.072) | .9990125 | 1.000043 |
| **Constant** | 2.576823*** | 0.1138502 | 22.63 | 0.000 | 2.35368 | 2.799965 |
| | (13.15527)*** | (1.497731) | (22.63) | (0.000) | (10.52423) | (16.44407) |

Note: ***p < 0.05.; N: 1,559,928; $R^2_{pseudo}$: 0.0655

The results from the negative binomial regression for the third hypothesis in the case of citations show that a patent that has cited the Xerox disclosure journal can expect a 35.87121% increase in the expected citations when all other variables are held constant. This coefficient is significant (0.05 > 0.000), which means that it can be interpreted. The results also show that when there is more competition in the technology class, the expected citations go down by 0.04725%. The coefficient is however insignificant (0.072 > 0.05), which means that it cannot be interpreted. When the results are presented as incidence rate ratios, it shows that a patent that has cited the Xerox disclosure journal will receive 43.1485% more citations than a patent that has not cited the journal. This result is in line with what was obtained when an ordinary least squares regression was used. When there is competition, a patent can expect 0.0004724% fewer citations per company in the technology class. That coefficient is again not significant (0.072 > 0.05), which means that it cannot be interpreted. Like the third regression there is not enough evidence to support hypothesis 3 and it should therefore be rejected when a negative binomial regression is used.

## Discussion and conclusion

The main purpose of this thesis was to answer the following research question:

*"Are patents that cite the Xerox disclosure journal more or less valuable than patents that do not cite the journal?"*

According to the results obtained the answer to this research question should be that patents that cite the Xerox disclosure journal are more valuable than patents that do not cite the journal. A patent that cites the disclosure journal receives 2.401397, or 24.7078% when a negative binomial regression is used, more citations than a patent that does not cite the journal. This effect increases to 3.594511 citations when competition is introduced into the regression, but the effect cannot be interpreted since the competition coefficient was insignificant. When a negative binomial regression was used, the competition coefficient could also not be interpreted as it was again insignificant.

When judged by the Kogan measure, a patent that cites the Xerox disclosure journal has 3.739543 less value than a patent that does not cite the journal. This effect decreases to 2.030892 when competition is introduced into the regression. Both values cannot be interpreted however because in the first case the constant value was insignificant and in the second case the competition variable was insignificant.

A remarkable result is that competition is insignificant in the case of citations in both the OLS regression and negative binomial regression. A potential explanation for this effect could be that competition has no effect or that the effect cannot be measured with the used models. Also, with and without competition in the model the Kogan measure actually decreases when a patent cites the Xerox disclosure journal. A potential explanation for this effect could be that the Kogan measure is a more fine-tuned measure with a combination of both financial data and patent citations. Therefore, this result may be closer to reality, as it is a scientifically proven measure.

Lastly, the constant is insignificant in both regressions with the Kogan measure. A potential explanation for this could be that the models that were used in those instances were again not the most appropriate. Other models that could be used to explore the effects are however outside the scope of this thesis.

There are some ways in which this thesis could be improved. First of all, more aspects like the numbers of patents that a citing company already has, could be added into the regression to further narrow down the effect of the disclosure journal on citations or the Kogan measure. Second of all, specific patents could be investigated to see whether the measured effect is caused by the entirety of the portfolio or by a specific patent. It could for example be that a handful of patents cause the effect, but the effect is now accredited to the entire portfolio. Subsequent research could therefore focus on these effects, but it could also look at the differences and similarities between the Xerox case and other cases in which a large company was forced to publish their patents.

## Literature list


Baker, S., & Mezzetti, C. (2005). Disclosure as a Strategy in the Patent Race. *The Journal of Law and Economics*, *48*(1), 173–194. https://doi.org/10.1086/426879

Galasso, A., & Schankerman, M. (2014). Patents and Cumulative Innovation: Causal Evidence from the Courts*. *The Quarterly Journal of Economics*, *130*(1), 317–369. https://doi.org/10.1093/qje/qju029

Cohen, W. M., Nelson, R., & Walsh, J. P. (2000). Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent (or not). *National Bureau of Economic Research,* 7552

Hall, B. H., Jaffe, A., & Trajtenberg, M. (2005). Market Value and Patent Citations. *The RAND Journal of Economics*, *36*(1), 16–38.

Harhoff, D., Narin, F., Scherer, F. M., & Vopel, K. (1999). Citation Frequency and the Value of Patented Inventions. *Review of Economics and Statistics*, *81*(3), 511–515. https://doi.org/10.1162/003465399558265

Lanjouw, J. O., Pakes, A., & Putnam, J. (1998). How to count patents and value intellectual property: The uses of patent renewal and application data. *The journal of industrial economics*, *46*(4), 405-432.

Maresch, D., Fink, M., & Harms, R. (2016). When patents matter: The impact of competition and patent age on the performance contribution of intellectual property rights protection. *Technovation*, *57*, 14-20.

McKeown, J. (1974). The FTC v. Xerox Litigation: Implications for the United States Patent System. Cath. UL Rev., 24, 1.

Johnson, J. P. (2014). Defensive publishing by a leading firm. *Information Economics and Policy*, *28*, 15–27. https://doi.org/10.1016/j.infoecopol.2014.05.001

Kim, J., & Lee, S. (2015). Patent databases for innovation studies: A comparative analysis of USPTO, EPO, JPO and KIPO. *Technological Forecasting and Social Change*, *92*, 332–345. https://doi.org/10.1016/j.techfore.2015.01.009

Kogan, L., Papanikolaou, D., Seru, A., & Stoffman, N. (2017). Technological Innovation, Resource Allocation, and Growth*. *The Quarterly Journal of Economics*, *132*(2), 665–712. https://doi.org/10.1093/qje/qjw040

Maresch, D., Fink, M., & Harms, R. (2016). When patents matter: The impact of competition and patent age on the performance contribution of intellectual property rights protection. *Technovation*, *57–58*, 14–20. https://doi.org/10.1016/j.technovation.2015.11.009

Pacheco-de-Almeida, G., & Zemsky, P. B. (2011). Some like it free: Innovators' Strategic use of Disclosure to slow down Competition. *Strategic Management Journal*, *33*(7), 773–793. https://doi.org/10.1002/smj.971

Thompson, C. (2015, February 19). *How the Photocopier Changed the Way We Worked—and Played*. Smithsonian Magazine. https://www.smithsonianmag.com/history/duplication-nation-3D-printing-rise-180954332/

Tom, W. K. (2000). The 1975 Xerox consent decree: ancient artifacts and current tensions. *Antitrust Law Journal*, *68*(3), 967-990.

Trajtenberg, M. (1990). A Penny for Your Quotes: Patent Citations and the Value of Innovations. *The RAND Journal of Economics*, *21*(1), 172–187. https://doi.org/10.2307/2555502

Trajtenberg, M., Henderson, R., & Jaffe, A. (1997). University Versus Corporate Patents: A Window On The Basicness Of Invention. *Economics of Innovation and New Technology*, *5*(1), 19–50. https://doi.org/10.1080/10438599700000006

Van Engelen, Th. C. J. A. (2020). *IE-Beginselen: 2020* Boek 9.

Watzinger, M., Fackler, T. A., Nagler, M., & Schnitzer, M. (2020). How Antitrust Enforcement Can Spur Innovation: Bell Labs and the 1956 Consent Decree. *American Economic Journal: Economic Policy*, *12*(4), 328–359. https://doi.org/10.1257/pol.20190086