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MSc in International Business and Politics

Characteristics of an Ideal System of Intellectual Property Protection: The Case of the America Invents Act and its Impact on Innovation

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Abstract

In this thesis I explored which criteria should be present in a system of Intellectual Property protection to foster innovation in the ideal way. For this purpose, a specific case was assessed, namely the America Invents Act (AIA), a US federal statute that came fully into effect in 2013. Due to the AIA's relative recent introduction, this thesis constitutes the first empirical assessment of the Act. Based on the proxies used for innovation - R&D expenditure, the R&D funds to sales ratio and patents - I find that the AIA had a significant positive effect on innovation in the US overall. Contrary to literature which projected a negative impact of the AIA on small companies, I find no significant impact. The assumed consequence, that medium & large companies were positively impacted by the AIA was however confirmed. This can be explained by the switch from the first-to-invent to the first-to-file system. Building on literature that implies a stronger impact on companies/industries that are more exposed to IP litigation, I find that on the contrary, that only industries which are less exposed to litigation experience a significant positive impact. Finally, I show that the passing into law of the AIA hasn't succeeded in curbing the operations of non-performing entities, or patent trolls, backed up by the results of an event study.

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1. Introduction and General Outline

1.1. The Underlying Debate on Intellectual Property Protection

When looking at the protection of intellectual property (IP) from a historical perspective, it becomes clear that various approaches have been pursued over decades. On the one hand there have been strong patent laws in place, on the other hand, there were more lenient patent laws encouraging knowledge sharing. Yet the question has always been – which are the characteristics of an IP protection system that encourage innovation in society the most? This is the most fundamental question underlying this thesis. This question shall be broken down into more specific sub-questions that focus on a specific case. This case is the Leahy Smith America Invents Act (AIA), which came fully into effect in March 2013 in the United States and the changes to the US system of IP protection that were effectuated by it. The Act has been considered as the most important change to US patent law since the 1950s (Goldman 2011). The most significant changes are the switch from the first-to-invent system to the first-to-file system for patents and the introduction of provisions that create alternative legal procedures for contesting patents. Focusing on the specific case will on the one side lead to important implications for determining the effect that this legal change had on innovation. More importantly, it will also contribute to the wider literature on the ideal system of IP protection that fosters innovation.

There is a basic trade-off between protecting innovation, thereby encouraging firms to innovate, and between firms exploiting their protection-induced monopoly, which can lead to a loss in consumer welfare. Moser (2013) argues based on historical evidence, that stronger patent laws for the early generation of inventors discourage innovation. In turn, policies that encourage the diffusion of ideas and competition, encourage innovation. For example, negative effects could be caused in particular when the boundaries of intellectual property are poorly defined, which leads to an increased risk of litigation for later generations of inventors (Moser 2013). It has been postulated that more litigation, in turn, leads to companies being less incentivized to invest in Research and Development (R&D), which discourages innovation as a whole (Jaffe et al. 2005). Another negative effect of a badly outlined IP protection system is that bad quality patents raise transaction costs which are then passed on to consumers (Merrill et al. 2004).

Even though this thesis is set in the broad subject area that has just been outlined, the research objectives are more specific and targeted. It shall be assessed specifically what impact the AIA has on innovation; whereby different proxies are used for innovation. The results then contribute again to the big picture discussion of which system of IP protection is most conducive to innovation.

Firstly, the general research outline is set up and important terms that are used in this thesis are defined, together with proxies for innovation. Then, the AIA and its most relevant provisions are introduced, and its hypothesized impact on innovation is discussed based on prior literature. Based on this literature review, hypotheses are formulated. Since the research touches upon different specific subject areas, additional literature reviews have been conducted at the respective sections. In a next step, impacts of the AIA on innovation are analyzed based on two effect mechanisms: firstly, the direct effects of the AIA are explored and secondly, the indirect effects. The results are in a last step summed up, and implications for the research question are derived, which then can be transformed into suggestions for policy makers.

1.1. Research Outline

This thesis seeks to explore on a general level, what the characteristics of a system of IP protection are, that lead to a higher degree of innovation in a society, by drawing on the example of the AIA. Therefore, the main research question can be formulated as "What are the characteristics of a system of IP protection that foster innovation?". To tackle this research question, the main focus of this thesis lies on exploring the impact of the AIA on innovation and linking it back to the main research question.

There are two broad ways in which the AIA is assumed to have an impact: directly and indirectly. Firstly, the AIA can have a direct impact on innovation by encouraging firms to increase their R&D spending as well as their patent applications. This could be due to more favorable conditions that lead companies to see they can earn the additional expenditure back by reaching higher returns or being less at risk of losing any output of their R&D expenditure. However, differentiated effects could be observed in certain groups of companies or industries, which might be more strongly impacted than others. Secondly, the AIA can have an indirect impact on innovation. This causal chain focuses on the impact that the introduction of the AIA has on litigation – and then in a next step on the impact that the change in litigation has on innovation. In this thesis, the focus will lie on a specific aspect of litigation, namely litigation by NPEs (Non-Performing Entities), also known as PAEs (Patent Assertion Entities) or patent trolls. These names are used interchangeably in the following.

1.2. Definition of Innovation and Proxies

Based on the research outline, the impact of the AIA on innovation is the subject that is examined in this thesis. A variety of definitions of innovation for it have been used in literature which is why a clear-cut definition of innovation is essential. Moreover, it is discussed in the following which proxies serve best to measure innovative activities on a firm and industry-level. Both the advantages and disadvantages of using a specific set of proxies are illustrated.

Schumpeter (1934) developed a definition for innovative activities which is still widely accepted, and which states five points as the main criteria for innovation to be deemed present. This will be the definition of innovation that is also adopted in this thesis:

1. The launch of a new product or a new species of an already known product;

2. Application of new methods of production or sales of a product (not yet proven in the industry);

3. The opening of a new market (the market for which a branch of the industry was not yet represented);

4. Acquiring of new sources of supply of raw material or semi-finished goods;

5. New industry structure such as the creation or destruction of a monopoly position (Sledzik 2013).

Possible proxies for innovation that have been used in prior research can be divided into two groups: firm-based and market-based. A firm-based proxy that has been frequently used is R&D expenditure. It has however been suggested that a rise in R&D expenditure doesn’t coincide with a rise in innovations produced by a firm (Acs and Audretsch 1989). This is due to the fact that R&D expenditure captures not the actual innovations as end-results, but rather captures all resources that are allocated for research geared at generating innovation, regardless of the research producing a success or not. Moreover, financial reporting rules give firms leeway in their classifications of activities, which leads to unexamined biases in the data (Cohen and Levin 1989). These disadvantages are offset by the advantage of the data being easily publicly available due to the duty to report it in official filings. This enables researchers to be able to reperform analyses that have been conducted based on this data.

Another firm-based proxy that is commonly used is patents. Researchers, like Jalles (2010) argue that patents have a positive effect on innovation, which subsequently leads to economic growth. However, it has been criticized that they measure invention rather than innovation. Not every invention carries enough economic and scientific value to be patented or is simply not patented due to employing other ways of protecting it, e.g., through trade secrets, because of them being more effective. The preference of other means of protection for patenting is rooted in the fact that when patenting an invention, valuable information about it needs to be disclosed publicly, meaning competitors can access it. As such, a great majority of patents is never exploited commercially or never serves as the base for major technological improvements (Cohen and Levin 1989). Furthermore, different industries see variation in the levels of inventions being patented, and patents differ greatly in the economic impact they bring with them (Acs and Audretsch 1989). Considering it from another angle, an economic impact can also be the publicity attained through patenting, that can be positive in some industries. This is the case when patents are used as an IP protection method serving as a signal for technological competence to their investors, which is especially important for smaller companies (Cohen and Levin 1989). Nevertheless, in spite of these shortcomings, Acs and Audretsch (1989) find that patent counts serve as a reliable representation of innovative activity.

The most direct firm-based proxy is counting direct, reported cases of innovation. The main obstacle when pursuing this path of research is the availability of recent data. The last time a survey has been carried out by the Small Business Administration (SBA) was in 1982 (Black 2004). Even though this data has been widely used, it contains various biases, due to the method of collection that employed different technical experts to identify significant innovations. That is why there are differences in the economic value of the innovations, and numerous unexamined biases set to be included (Cohen and Levin 1989).

Finally, a more recent approach to capturing innovation directly is through the newly designed Business R&D and Innovation Survey (BRDIS) which is conducted annually by the US Census Bureau and is the successor of the Survey of Industrial Research and Development (SIRD). The new survey has been introduced in 2008 and also captures companies that don’t have officially reported R&D spending and innovations in the service industry (Xu 2015). Since data from this survey has been used to conduct analyses, the content and specifications will be discussed in more detail in the data description part in section 2.3

The second group of proxies are market-based measurements of innovative ability. In prior research, the market value model, i.e., the markets' evaluation of a firm's assets including all available information and expectations, has been linked to measures of innovation (Czamitzki and Kraft 2004). Specifically, one line of research assessed the stock markets' response to patent grants and R&D spending change and concluded that stock markets reacted more strongly to changes in a firms R&D expenditure than to patent grants (Cohen and Levin 1989). Newer literature introduces the notion of using the credit rating score as a proxy for the quality of innovative activities. Czamitzki and Kraft (2004) conclude that innovative firms achieve better ratings, however, when firms pursue too many innovative activities, the rating is reduced. Another market-based measurement of innovation has been discussed by Hall et al. (2005), who discovered a correlation between Tobin's q ratio (calculated by dividing a firm's total market value by its total asset value) and the ratios of R&D to assets stocks, patents to R&D and citations to patents. Xu (2015) elaborated on this point and found that past values of Tobin's q ratio are powerful predictors for the intensity and scale of future innovations.

1.3. Introducing the America Invents Act (AIA)

1.3.1. US patent law and general objectives of the AIA

To understand the impact that the America Invents Act had on innovation, it is important to understand the legal system of the US that includes patent law. Patent law clauses are found in the United States Code (USC), which is maintained by the Office of the Law Revision Counsel (LRC) of the House of Representatives. It is defined as "a consolidation and codification by subject matter of the general and permanent laws of the United States" (Office of the Law Revision Counsel 2018). Title 35 of the USC governs all aspects of patent law in the US, other forms of intellectual property protection are governed in different Titles which are scattered throughout the USC. Title 35 is then structured again into five parts which contain sections:

- Part I – United States Patent and Trademark Office (sections 1 to 42)
- Part II – Patentability of Inventions and Grant of Patents (sections 100 to 212)
- Part III – Patents and Protection of Patent Rights (sections 251 to 329)
- Part IV – Patent Cooperation Treaty (sections 361 to 376)
- Part V – The Hague Agreement Concerning International Registration of Industrial Designs (sections 381 to 390)

There are two ways, in line with the US legal system, in which major changes in the US patent system are brought about: by introducing new legislation and by decisions of the US Supreme Court thus focusing on case law. Legal changes to patent law by new legislation are authorized by the US Constitution, Article One, section 8, clause 8 that gives Congress the power “To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries;” (USA). One such introduction of new legislation produced a federal statute that is at the heart of this thesis: the Leahy–Smith America Invents Act (AIA) which was signed into law by then-president Barack Obama in 2011 and became fully effective in 2013. This statute has been considered as one of the most significant changes to the patent system, since 1952, when the Patent Act was introduced (Goldman 2011).

The main objectives of this act were, according to one of its sponsors, Senator Patrick J. Leahy, to “[…] improve the application process by transitioning to a first-inventor-to-file system; improve the quality of patents issued by the USPTO by introducing several quality-enhancement measures, and provide more certainty in litigation.” (Congressional Documents and Publications 1/25/2011) Another major objective of lawmakers for the act was to curb activities of so-called patent trolls (also known as Patent Assertion Entities – PAEs, or Non-Practicing Entities – NPEs), whose activity has risen sharply in recent years (Hasford 2017). These are entities solely focusing on patent litigation which do not produce goods or provide services, i.e., their business model consists of buying existing rights and enforcing them against other entities that are producing goods/providing services (Davis and Jesien 2015).

Regarding legislative procedure, both the House of Representatives and the Senate had initially voted on similar bills. Afterward, they needed to conference together to create a common version the bills, after which each chamber would need to vote separately on the common, single, streamlined bill that is ultimately the America Invents Act (Goldman 2011).

1.3.2. Specific changes introduced by the AIA

In the next section, the AIA and the specific changes it introduced and their impacts on the US patent law are discussed. Furthermore, a literature review on each of the changes is included, based on which hypotheses are formulated subsequently.

1.3.2.1. From "first-to-invent" to "first-inventor-to-file"

The first and most significant change focuses on the first step in the life of a patent, the filing process. The system for filing patents changed from the previously employed "first-to-invent" to the more internationally wide-spread "first-inventor-to-file" principle. Under the old system, if two inventors wanted to patent the same invention, the patent would be given to the inventor with evidence on conceiving the idea earlier. Under the new system, priority in filing will usually be the decisive criterion for being granted a patent (Harvard Law Review 2012). The new system is codified in 35 USC § 102(a). However, exceptions to the first-to-file priority have been introduced in 35 USC § 102 (b), most notably with a so-called grace period. This enables the inventor to publicly disclose his invention less than a year before filing for a patent without it being classified as "prior art" for the inventor. Without this exception the existence of prior art would make a potential patent invalid. Third parties are locked out from this exception, since the disclosure is considered as prior art towards them, regardless (Macedo 2013).

Projected consequences of the new system

On a hypothetical basis, various outcomes have been predicted by researchers after the AIA has been presented. In favor of the new system, it has been argued that the AIA leads to a more transparent and predictable system, harmonized with patent procedures in other countries (Hasford 2017). Skeptics have argued that the new standard would favor large enterprises, which might be better equipped to submit applications quickly than smaller firms or individuals (Harvard Law Review 2012). This is of particular importance since small inventors have a disproportional beneficial effect on the whole system of innovation. For example, in high technology and pharmaceuticals, small firms and individual investors supply innovative inputs to larger enterprise (Bird 2013). Prior research focused on Canada's change of patent systems in 1989 from a first-to-invent to a first-to-file system. A statistically significant decline in patent applications in the group of individual inventors was found, compared to applications by firms. This could be rooted in the fact that legal expertise as well as bureaucratic competence is required to master the new system accordingly (Abrams and Wagner 2013).

Miyagiwa (2015) created a theoretical model to assess the impact of the change to the first to file-system and argued that the prior first-to-invent system is weakly more conducive to innovation than the latter, newly introduced first-to-file system. It has been mentioned that innovation may be undermined by rewarding the person who files the patent quickest, rather than the person who invented it first (Miyagiwa 2015). Also, it has been argued that consequently a "race to the patent office" will be started and thus, the number of patent applications would increase. However, the AIA has tried to mitigate the negative effects with regards to small companies by establishing a new micro-category of small applicants which reduces fees for qualified applications by 75 percent and in addition, established the position of an ombudsman who manages concerns of small businesses. These provisions are not permanent, as they can be limited under certain conditions (Bird 2013). Lastly, as a further consequence it has been mentioned that the quality of patents might decrease, since inventors would rather try to file as quickly as possible than wait and refine their inventions.

To create a basis for the further analyses, the following null-hypotheses and alternative hypotheses are formulated based on available literature:

> H1o: The AIA didn't have any significant impact on innovation in general.
>
> H1a: The AIA had a significant negative impact on innovation for individual inventors and small firms.
>
> H1b: The AIA had a significant positive impact on innovation for medium and large firms.

The point that was mentioned on patent quality hasn't been tackled in this thesis, due to the relatively short time span between the introduction of the AIA in 2013 and the time this thesis was written (September 2018). A proxy that is often used in literature to assess patent quality are patent citations. However, since the time from submitting a patent application to the time it is approved, processing times of more than two years are not seldom. Adding to this the delay that is incorporated in the collection and reporting of statistical figures. These factors together lead to the logical conclusion, that at this point, for patent quality no conclusive evidence can be generated and as a consequence, no reliable outputs based on analytical procedures can be conducted.

1.3.2.2. Post-grant opposition

The next change relates to a later stage of life of a patent, namely the enforcement of patents. In general, there are various ways to challenge an existing patent. One option is litigation, meaning that a case needs to be brought to trial with all the adjunct procedures. Litigation is often a costly endeavor (Petersen 2014). Besides litigation, there are three other ways to challenge a patent: the post-grant review (PGR), the inter-partes review (IPR) and the ex parte re-examination (EPR). The first two (PGR and IPR) were created in the AIA as a two-step model and are processed in front of the newly established Patent Trial and Appeal Board (PTAB). The latter one (EPR) has been existent since 1981 and is processed through a patent examiner (Rossi 2015).

The post-grant review may be initiated for challenging a patent on any grounds of invalidity within the first nine months of the grant of the patent (Harvard Law Review 2012). Any party is now able to call into question any patent (Hollinger 2012). This is based on paragraph (2) or (3) of Section 282(b) of the Patent Act, 35 U.S.C. § 282(b). The review may be granted by the PTAB when it is either likely that a claim made can't be patented, or that the case is a precedent for other patents or patent applications (Rossi 2015). After the nine-month period, at any time during the life of the patent, any party can request the inter-partes review. It allows filing for canceling at least one claim as unpatentable, drawing on prior art consisting of patents or printed publications (Rossi 2015). A lower standard of proof than in trial litigation applies (Harvard Law Review 2012). The ex-parte reexamination is similar to the IPR, as it is also only based on prior art and publications and since it's also available at any time during the life of the patent. It is granted when a substantial new question of patentability arises (Rossi 2015).

Projected consequences of the new system

A positive impact of the AIA on innovation is argued to be caused by introducing the two new post-grant proceedings, with which the PTAB offers a cost-effective alternative to litigation (Hasford 2017). This argument has been supported by research that focuses on the impact of the loss of patent rights on subsequent innovation and comes to the conclusion that the impact is large for small and medium-sized firms, especially where they face many large competitors (Galasso and Schankerman 2015). In turn, this means that when there is a lower rate of loss of patent rights (which is a hypothesized impact of the AIA), there is a positive impact on innovation for these firms. In general, it has been shown that a rise in litigation leads to a decrease in innovation (Jaffe et al. 2005). Scott Morton and Shapiro (2015) however, argue that the AIA doesn't have such a strong positive effect since is mainly targeted at the issuance of patents rather than at the assertion of existing patents. As such it is hypothesized to have only a limited effect on the litigation side (Scott Morton and Shapiro 2015).

Another argument which suggests a positive impact of the AIA is that by having the opportunity to challenge the patent in the first year after issuance, the quality of the patents improves. As such patents that shouldn't get asserted in the first place would get removed as being invalid. A point that can be seen from both a positive and negative angle is that during the procedures before the PTAB, it examines patents according to the "broadest reasonable interpretation" (BRI), which considers more prior art than the "plain and ordinary meaning" standard used in court. As such the chance of a patent found invalid is higher with the BRI (Dutra 2016). Marsnik (2013) argues that the impact on the quality of patents might not be as high as initially assumed. He compares changes in the US system to the European system and concludes that the AIA will not increase the quality of patents. The author argues that the fee structure must be adapted to make the cost of filing and entering into post-grant review an option, to protect small and medium-sized firms and independent inventors from misuse (Marsnik 2013). Based on this literature the following null-hypothesis is formulated:

> H2o: The introduction of new patent enforcement procedures didn't have a significant impact on litigation and as a consequence innovation.

1.3.2.3. Other changes

Another change is that false marking lawsuits have been restricted by the AIA. Before, any party could sue a manufacturer who used wrong or expired patent numbers to mark a product, and the government and the suing party would split the penalty. Since it was abused by aggressive litigants such as PAEs, it was changed insofar as now only the federal government may sue for such penalties (Harvard Law Review 2012). Relating to this points, the so-called estoppel effects of the new proceedings are more extensive than previous procedures, which is suggested to lead to a decrease in abusive patent litigation (Hasford 2017). This can, in turn, lead to negative effects on the business operations of PAEs. Based on this a null-hypothesis and an alternative hypothesis can be formulated:

> H3o: The AIA didn't have any significant impact on the business operations of PAEs.

> H3a: The AIA had a significant negative impact on business operations of PAEs.

The AIA also enhanced the concept of prior user rights defense, i.e. giving the original inventor immunity for patent infringement of all innovations (Miyagiwa 2015). Another important point is that there is now a limit on the ability of patent holders to put multiple defendants in one single lawsuit (Scott Morton and Shapiro 2015). This can lead to an increase in the number of lawsuits even though there is the same number of defendants, and thus would need to be considered when interpreting litigation statistics.

A final point that could be observed when analyzing litigation statistics, is that the right of patent owners to obtain judicial review of an adverse decision of the US Patents and Trademark Office (USPTO) by the district court (35 U.S.C. § 306/ § 145) has been abolished. Thus, if a patent application gets rejected, the only legal recourse is to appeal to the United States Court of Appeals for the Federal Circuit (Miller and Archibald 2010).

1.3.2.4. Unresolved matters

Besides the many changes that were implemented by the AIA, there are also matters that remain unresolved. Many of the litigation tactics that PAEs use are still in place, as well as remedies that are awarded to patent owners whose rights have been infringed (Scott Morton and Shapiro 2015). Furthermore, problems associated with Standard-Essential Patents (SEPs) as well as with the treatment of patents by the International Trade Commission (ITC) haven't been solved yet.

1.3.3. Categorization of hypotheses

Based on this general literature review, hypotheses have been formulated. For the further course of this thesis, they are now summed up and categorized according to whether they shall be assessed for a direct or indirect impact, and thereby assigned in either of the two sections of this thesis. The following hypotheses will be addressed in the section that examines whether the AIA had a direct impact on innovation.

H1o: The AIA didn't have any significant impact on innovation in general.

H1a: The AIA had a significant negative impact on innovation for individual inventors and small firms.

H1b: The AIA had a significant positive impact on innovation for medium and large firms.

H2o: The introduction of new patent enforcement procedures didn't have a significant impact on innovation.

H2a: The changes in patent enforcement caused a positive effect on innovation.

The remaining two hypotheses will be the focal points of the section that assesses whether the AIA had an indirect impact on innovation, by potentially disturbing the business model and operations of PAEs.

H3o: The AIA didn't have any significant impact on the business operations of PAEs.

H3a: The AIA had a significant negative impact on business operations of PAEs.

2. Direct Impact on Innovation

2.1. Research Outline

In the following section, the focus will lie on exploring the direct causal impact by linking proxies for innovation as dependent variables to the impact of the AIA. The goal of the analyses that are performed is to find out more generally if the AIA had an impact on R&D expenditure/funds and patenting behavior of firms. More specifically, regarding R&D, it is used to assess whether the AIA had an impact that varies with criteria like firm size or exposure of firms. This thesis contributes to the prior literature by conducting empirical analyses to support or reject the hypothesized impacts of the AIA that have been discussed in Section 1.3.2. Furthermore, it contributes to the past literature which assessed the impact of other events in connection with the US patent system. This can in the following help to create a more consistent "big-picture" of how various legal changes affect innovation, and which combination of legal provisions would be most conducive to foster innovation in a society, a point that links back to the initial research question.

The analyses that are performed are structured on a first level according to the source of panel data, that is either drawn from the OECD database or the Business R&D Innovation Survey (BRDIS) in the US and will be discussed in more detail in section 2.3.2. For OECD data, exclusively the research design of a difference in difference (diff-in-diff) analysis has been employed. The goal of this analysis is to compare the trends in the US, the treatment group, to trends in other countries, which have been defined as control groups. For BRDIS data the interrupted time series approach for a single group, it being the US respectively different segments (small companies, etc.) within the US, is assessed. Both methods are described in detail in the following section.

2.2. Methodology

In this section, the basic methodology that is used for performing analyses is described in detail. Two research approaches have been used to conduct the analyses that lie at the core of this thesis: the difference-in-difference approach and the interrupted time series design.

2.2.1. Difference-in-difference approach

The difference-in-difference approach was first introduced by Ashenfelter and Card (1985). However, the logic underlying it has been first used in the 1850s by John Snow (Population Health Methods 2018). Essentially the simplest approach is to observe outcomes for two groups over two time periods, whereby one group is exposed to a treatment in the second period, and the other group is the control group, which is not exposed to any treatment over the two periods. Consequently, the average gain in the treatment group is deducted from the average gain in the control group. The process is structured in this way, to remove biases in the second-period comparisons between the groups that stem from the permanent difference between the groups, as well as to remove biases from comparisons over time in the treatment group that stem from trends (Imbens and Wooldridge 2007).

The model in its simplest form can be written as:

$$y = \beta_0 + \beta_1 dB + \delta_0 d2 + \delta_1 d2 * dB + u \qquad (1)$$

Where

y = outcome of the defined model

$d2$ = dummy variable for the second time period, captures factors causing change in y even in the absence of a policy change

dB = dummy variable that captures possible differences between the treatment and control groups prior to the policy change

δ_1 = coefficient of interest that multiplies the interaction term $d2 * dB$, which is equal to a dummy variable with the value of one for observations in the treatment group in the second period

u = error term

The difference-in-difference estimator is the difference in average outcome in the treatment group before ($\bar{y}_{B,1}$) and after treatment ($\bar{y}_{B,2}$) minus the difference in average outcome in the control group before ($\bar{y}_{A,1}$) and after ($\bar{y}_{A,2}$) treatment.

It can be described as:

$$\hat{\delta}_1 = (\bar{y}_{B,2} - \bar{y}_{B,1}) - (\bar{y}_{A,2} - \bar{y}_{A,1}) \qquad (2)$$

Where

$\hat{\delta}_1$ = coefficient of interest that multiplies the interaction term $d2 * dB$, which is equal to a dummy variable with the value of one for observations in the treatment group in the second period

There are three main assumptions that need to hold for the estimator to be considered unbiased: exchangeability, positivity, and Stable Unit Treatment Value Assumption. Firstly, the treatment needs to be unrelated to the outcome at baseline, i.e., the allocation of the treatment should not have been determined by the outcome. Secondly, the parallel trend assumption is considered to be the most critical assumption. It states that the difference between the treatment and the control group needs to be constant over time in the absence of treatment. Thirdly, the composition of control and treatment groups needs to be stable for repeated cross-sectional design, and there should be no spillover effects (Population Health Methods 2018). The potential problems that come with any DD analysis is that other unobserved, confounding factors might impact the dependent variables. The following is a graphical explanation of the diff-in-diff research design.

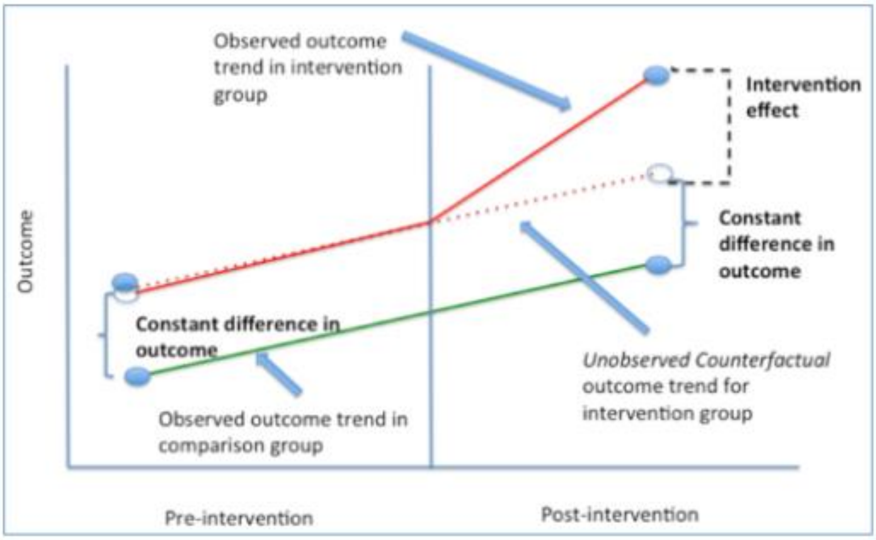

Figure 1. Difference-in-Difference estimation, graphical explanation, from Population Health Methods (2018)

2.2.2. Interrupted time series design (ITSA)

Another research design that has been used to assess the impact of large-scale interventions such as public policy changes is the interrupted time series design. It is a quasi-experimental pretest-posttest design, based on multiple observations of an outcome variable being available in preintervention and postintervention periods. One of its advantages is that it offers a potentially high degree of internal validity (Linden 2015).

There are two possible designs: single-group or multiple groups. Due to the format of the data used in this thesis that contains no comparison groups, it has been chosen to employ the single-group analysis, which is why only this form is discussed in more depth.

In its standard form the regression model is defined as:

$$Y_t = \beta_o + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \epsilon_t \qquad (3)$$

Where

Y_t	=	aggregated outcome variable at each equally spaced time point t
T_t	=	time since the start of the study
X_t	=	dummy (indicator) variable representing the intervention (after intervention =1)
β_o	=	intercept of the outcome variable
β_1	=	slope of the outcome variable until the introduction of the intervention
β_2	=	change in the level of outcome in the period immediately after the intervention
β_3	=	difference between pre- and postintervention slopes of the outcome
ϵ_t	=	error term

Assuming the random error terms are moving according to the first-order autoregressive process, they are defined as:

$$\epsilon_t = \rho\epsilon_{t-1} + u_t \qquad (4)$$

Where

ρ	=	correlation coefficient between adjacent error terms, such that $\|\rho\|<1$
u_t	=	disturbances that are independent $N(0, \sigma^2)$

As mentioned before, since there is no comparable control group in the single-group design, the trend before the intervention is projected into the post-intervention period and serves as the counterfactual. The underlying assumption of this method is that any time-varying unmeasured confounder is changing so slowly that it would be possible to distinguish it from the effect caused by the intervention (Linden 2015).

2.3. Overview of Analyses and Description of Data

2.3.1.1. Overview of analyses based on OECD data

The table below illustrates the analyses in the diff-in-diff design that are performed based on OECD data. As mentioned before, both the general effect on all enterprises and the effect on enterprises that are categorized according to their size is assessed. In the column "Analyses performed" the assessed sub-groups (Total, Small Enterprises, Medium & Large Enterprises) are described. For each sub-group, the treatment group (US) and the respective control group for the analysis are stated. Furthermore, the hypotheses that have been formulated based on the literature review in section 1.3, are assigned to the matching parts of the analysis.

Table 1: Overview of performed analyses and tested hypotheses based on OECD data

<table>
<tr><th>Proxy for innovation</th><th>Analyses performed</th><th>Tested Hypotheses</th></tr>
<tr><td rowspan="3">R&D expenditure</td><td>Total (All Enterprises)
- US vs UK
- US vs Canada
- US vs Japan</td><td>H1o: The AIA didn't have any significant impact on innovation in general.</td></tr>
<tr><td>Small Enterprises
- US vs UK
- US vs Canada
- US vs Japan</td><td>H1a: The AIA had a significant negative impact on innovation for individual inventors and small firms.</td></tr>
<tr><td>Medium & Large Enterprises
- US vs UK
- US vs Canada
- US vs Japan</td><td>H1b: The AIA had a significant positive impact on innovation for medium and large firms.</td></tr>
<tr><td rowspan="2">Patents</td><td>Applications
- US vs Canada
- US vs EU</td><td>H1o: The AIA didn't have any significant impact on innovation in general.</td></tr>
<tr><td>Grants
- US vs EU</td><td>H1o: The AIA didn't have any significant impact on innovation in general.</td></tr>
</table>

The research procedures that are being performed in the framework of the difference in difference design based on OECD data require a control group which serves as a baseline to any potential changes by the AIA. Canada has been chosen as a control group since it presents an ideal setting for a difference in difference analysis due to its similarity to the US. Besides its geographic proximity to the US, Canada has a similar political and legal system. Also, there were no significant changes in Canadian patent law over the course of the study period, since Canada had been following the first-to-file system since the late 1980s. Furthermore, Canada and the US have been in the free-trade zone NAFTA since 1994, which implies strong trade ties and similarities on an economic level. These commonalities indicate that both areas have been exposed to similar trends and factors, which diminishes the number and scope of potential confounding effects and leads to a potentially more reliable result.

On top of Canada, further control groups have been defined: Japan, the EU, and when no data for the EU is available, the UK. The caveat here is that even though the countries/areas are highly developed and innovative economic zones, and for the UK there are similarities in the legal system of common law, they are geographically and economically distant from the US. No common free-trade zone between the US and the EU/UK exists, which indicates that there are different factors at play affecting the dynamics in each of the areas. Japan also shares a similar set of factors with the US that does the EU and the UK, yet, the country was added as a control group due to showing a similar trend in terms of R&D expenditure compared to the United States. This makes it a solid control group for the analyses, especially given the parallel trends assumption. Conducting analysis for these countries/areas can nevertheless yield interesting insights, which will be shown in the analyses.

Overview of analyses based on BRDIS data

Based on the BRDIS data, a single-group interrupted time-series analysis was performed for R&D funds to sales ratio for the categories of all companies; companies split up according to their size and companies split up in two groups based on whether they are more exposed or less exposed to litigation. These are described in the “Analyses performed” column, and the tested hypotheses are assigned to the respective analysis. As has been mentioned before the single-group design is based on the fact that BRDIS data is only reported for the US, therefore, no international control groups could be determined.

Table 2: Overview of performed analyses and tested hypotheses based on BRDIS data

Proxy for innovation	Analyses performed	Tested Hypotheses
R&D funds to sales ratio	Total of all industries	H1o: The AIA didn't have any significant impact on innovation in general.
	Small companies	H1a: The AIA had a significant negative impact on innovation for individual inventors and small firms.
	Medium & Large companies	H1b: The AIA had a significant positive impact on innovation for medium and large firms.
	Exposed & non-exposed industries	H2o: The introduction of new patent enforcement procedures didn't have a significant impact on litigation and as a consequence innovation.

2.3.2. Description of data

Two different data sources have been used in the analysis: data from OECD and data from the BRDIS database. The data will be described generally in the following and in more detail directly when the results are discussed, since the details carry important implications for the interpretation.

2.3.2.1. OECD

The first data source is the OECD.Stat portal. Specifically, the data on "Total Business enterprise R&D expenditure by source of funds and number of persons employed (organization size class)" was drawn. From the category "Patent Statistics" exactly the dataset "Patents by technology: Patents – total and technology domains", has been used for the analyses. The specific data points used for each analysis will be mentioned in section 2.4.

The R&D data provided by the OECD was collected according to the OECD "Frascati Manual" which defines the standard OECD methodology for R&D statistics. It was first developed in 2002 and has been replaced by a new edition that came out in 2015. This change may have had the potential to impact the reliability of the data, however, it has been stated that the main indicators are not changed significantly and that only terminology changes will occur (OECD.Stat 2018). The patent data by the OECD fully covers patent applications to and grants by the European Patent Office (EPO), applications to and grants by the US Patent and Trademark Office (USPTO), patents filed under the Patent Co-operation Treaty (PCT) and patents belonging to Triadic Patent Families. Thereby EPO and PCT patent counts are based on data that comes from the EPO and data on USPTO, and Triadic patent families are mainly based from the Worldwide Statistical Patent Database (PATSTAT) from the EPO (OECD.Stat 2018).

BRDIS

The second source of data is BRDIS. This is the abbreviation for the cross-sectional Business R&D and Innovation Survey which is conducted annually by the US Census Bureau, together with the National Center for Science and Engineering Statistics (NCSES) within the National Science Foundation (NSF). BRDIS has initially been conducted in 2008 and is the successor of the Survey of Industrial R&D (SIRD) that was initially conducted in 1953 (National Science Foundation 2018).

The survey is conducted in a way that a probability sample of for-profit nonfarm companies with five or more paid employees in the United States is chosen, which is categorized into select manufacturing and nonmanufacturing industries based on the North American Industry Classification System (NAICS). To illustrate the data collection, the population size in 2015 was 2,029,436 companies, and the sample size 44,824 companies (National Science Foundation 2018). The survey examines among others, variables for R&D performance, Total and R&D employment, Sources of R&D funding, R&D capital expenditures, Sales and Patenting, licensing and technology transfer activities. The latest available annual data is from 2015, which was published on 30 August 2018. For the analyses in this thesis, BRDIS data from 1999 to 2015 has been used, which states domestic R&D paid for by the company and others as a percentage of domestic net sales. However, a caveat is that the new survey has only been in place since 2008, as such there may be discrepancies between BRDIS and its predecessor.

2.4. Analysis

To make it easier to reperform the analyses that are conducted in this thesis in the future, the exact data used for each of the analysis is specified in the table below. The operative analyses have been performed in Stata. Within each section, first, the specifications for the dependent variables and then the specifications for the independent variables are described. Based on the OECD dataset, the specific data points that are elaborated in Table 3 have been used.

Table 3: Description of dependent variables for OECD-data-based analyses and data sources

Dependent variable	Analyses performed	Specific data point used	Used dataset
R&D expenditure	Total (All Enterprises)	Total	Dataset: Business enterprise R&D expenditure by source of funds and number of persons employed (organisation size class)
	Small Enterprises	Sum of "From 1 to 499 employees"	
	Medium & Large Enterprises	500 employees or more	
Patents	Applications	Patent applications filed under the PCT	Dataset: Patents by technology (by applicant's country of residence and Application date)
	Grants	Patent grants at the EPO for the EU and patent grants at the USPTO for the US	Dataset: Patents by technology (by applicant's country of residence)

The independent variables have been coded as two separate dummy variables (year and country), and an interaction terms (diff), also called difference-in-difference estimator, between the two dummy variables, as described in Table 4.

Table 4: Description of independent variables for OECD-data-based analyses

Independent variable	Description
year	Dummy variable coded as 1 if the year is 2013 or later
country	Dummy variable coded as 1 if the country is the US
diff	Difference-in-differences estimator. Result of the multiplication of Year and Country

Regarding the analyses based on BRDIS data, the specifications for the dependent variables and the data point used for each of them, are described in table 5 below.

Table 5: Description of dependent variables for BRDIS data-based analyses and data sources

Dependent variable	Analyses performed	Specific data point used	Used dataset
R&D funds to sales ratio	Total	All industries	BRDIS/SIRD annual survey data from 1998 until 2015[1]
	Small	Value under the section "Small companies" for 5-499	
	Medium & Large	Weighted average of the different sections under the category "Medium and large companies"	
	Exposed & non-exposed	All industries, coded as 1, if they have been more exposed to litigation and 0 if less exposed	

Three independent variables have been coded for each of the analysis as described in Table 6. Following the ITSA methodology there are two separate independent variables and one interaction term of the two variables.

Table 6: Description of independent variables for BRDIS-data-based analyses

Independent variable	Description
_t	▪ Time since start of study ▪ Shows trend prior to the intervention by the AIA
_x2013	▪ Dummy variable representing the intervention periods (post-intervention=1) ▪ Shows the impact in the year of the intervention
_x_t2013	▪ Interaction between _t and _x2013 ▪ Shows postintervention trend (relative to preintervention trend)

[1] More specifically, data is drawn from the category "Funds for industrial R&D as a percent of net sales of companies performing industrial R&D in the United States, by industry and company size". Due to the changes in methodology over the years this category was named differently, which however didn't have any impact on the quality of data.

2.4.1. Results for OECD data

Firstly, the results based on OECD data are discussed, since they are comparing international trends to the US. Moving to a more national, US-based focus, the analyses drawing on BRDIS data will be discussed in the next section 2.4.2.

2.4.1.1. R&D expenditure

2.4.1.1.1. R&D Total

The first analysis seeks to explore whether the AIA had a significant impact on innovation by comparing the US to international control groups. The graph below was plotted to show the development of R&D expenditure for all companies in the US compared to all companies in Canada and the UK over time. It clearly shows an upward trend for the US since 1998, which was impacted only temporarily by events such as the 2008 Financial & Economic Crises. The other countries that are designated as control groups had experienced a less steep growth before 2003 and had a slower recovery after the crisis.

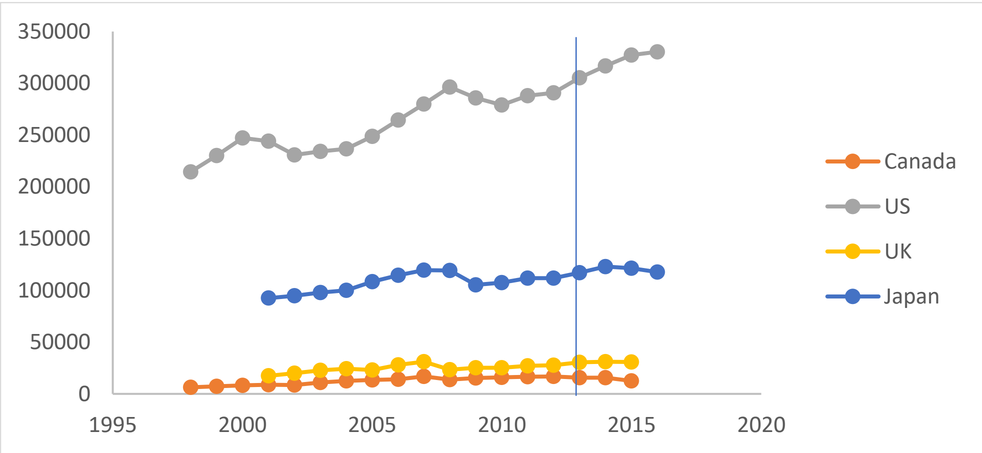

Figure 2. Development of R&D expenditure over time

Table 7 below shows the outcomes of the diff-in-diff analyses that were performed with the US as the treatment group and Canada, the UK and Japan as control groups.

Table 7: Output table for the diff-in-diff analysis based on total R&D expenditure

	Total R&D (US vs. Canada)	Total R&D (US vs. UK)	Total R&D (US vs. Japan)
year	2203.2	6228.5	14351.6
	(0.11)	(0.35)	(0.79)
country	224010.5***	225135.1***	130980.5***
	(19.96)	(20.14)	(10.88)
diff	107134.2***	83763.9**	94985.8***
	(4.12)	(3.35)	(3.73)
_cons	12359.6	24564.8**	105389.7***
	(1.56)	(3.11)	(11.96)
N	37	30	36
R^2	0.951	0.959	0.882

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

When considering the output table, the r-squared for the control groups is high which indicates a good fit of the model based on the OLS regression. Furthermore, all countries have a significantly different level of R&D expenditure of all companies compared to the US, which implies there is no distortion of the result. This is in line with the graphical representation, that doesn't show any overlap between the data of the US and the control groups. The most relevant output of this analysis is a significant effect at the 1% level for the difference in difference estimator based on all the control groups. In other words, this result indicates that the positive change in R&D expenditure in the US after 2013 was different or stronger than the change in R&D expenditure in the control groups.

As mentioned in the explanation of the research set-up, Canada has been deemed the most reliable control group due to its similarity to the US.[2] Canada showing a significant result, indicates a strong effect that only has seen a limited distortion by confounders, since both countries are exposed to similar external effects. It can be argued that US firms, due to having an easier and more direct access to capital markets for financing than Canadian firms, might have benefitted faster and more sustainably from the bull market. However, the impact of this confounding variable is mitigated by the fact that both countries are operating in the same economic free-trade zone. Furthermore, it also has been assessed whether there are other changes in the system supporting innovation in the US have occurred. The conclusion was that

[2] The dataset for Canada has a different number of observations compared to the dataset of the US, however literature is ambivalent on the impact of this, which is why it is not considered in the following.

the main and most significant event was the AIA, which indicates that the observed positive impact on R&D expenditure can be attributed to the AIA. Concerning the additional control group of Japan, there is a significant positive as well, and the parallel trend assumption is strong, which contributes additional support to the result that there is a significant positive effect caused by the AIA. Therefore, the null hypothesis "H1o: The AIA didn't have any significant impact on innovation in general" can be rejected, since a significant positive impact of the AIA on R&D expenditure is supported by the analysis of available data.

A potential follow-up question that can be assessed by future research is which specific aspect of the AIA contributed the most to this positive impact. This would then add additional insights for the overall research question of the best system of IP protection. Based on this analysis and the data available at this point, it can nevertheless be stated that the overall compendium of provisions introduced by the AIA had a positive impact on innovation, and as such can be considered beneficial for any system of IP protection.

2.4.1.1.2. R&D Small Enterprises

The second analysis is the first to focus on companies that have been segmented into groups, specifically small enterprises. This is to assess whether any significant impact can be found for the R&D expenditure of small enterprises in the US that has been triggered by the AIA, compared to unaffected control groups of small companies in the UK and Japan. Canada hasn't been considered as a control group in this analysis since the data is only available until 2013, i.e., there is only one data point in the post-treatment period, which would lead to an unreliable and inconclusive output. Figure 3 below shows the R&D trend for small companies, yielding a differentiated pattern for the US compared to the other control groups. Small companies in the US have experienced higher volatility than firms in other countries in their R&D expenditure in the years before the AIA has been introduced. The R&D expenditure had remained high until the crisis in 2008/2009 after which a significant downturn was observed, with 2013 being the first year in which the recovery period with observable growth has started. A possible explanation is that small companies have been affected more than bigger companies by the crisis since the availability of loans to finance their operations for this type of companies has been even tighter than for larger companies in the aftermath of the crisis.

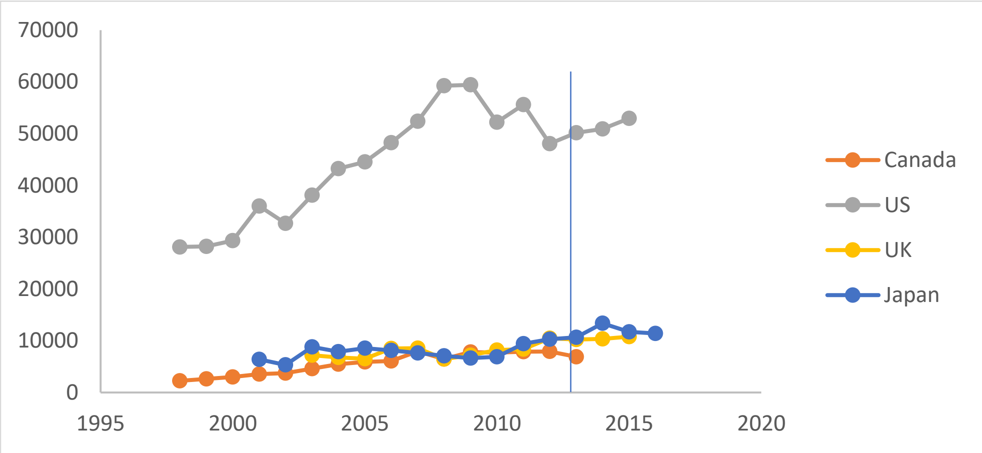

Figure 3: Development of R&D expenditure of small companies over time

The output Table 8 for the diff-in-diff analysis shows, similar to first analysis, that the levels of R&D expenditure in the control groups were found to be significantly different to levels of R&D expenditure in the control groups. Additionally, there has been a good fit of the model, judging on the values of r-squared. In the diff-in-diff estimator no significant effect was observed, implying that no significant impact by the AIA on the change in R&D for small companies in the US compared to the change in control groups of the UK and Japan was present. This is a highly relevant result, given the hypothesized impacts of the AIA in prior literature that predominantly predicted a negative impact on small companies' innovative abilities. These results should, however, be taken with caution due to the nature of the data for control groups which are geographically and economically distant from the US, a factor that could lead to a stronger influence of confounding variables.

Based on this analysis, the hypothesis "H1a: The AIA had a significant negative impact on innovation for individual inventors and small firms" can't be supported or rejected since there is no significant impact observable in the data. No implications can be made for whether the provisions in the AIA were beneficial to innovation on a small firm/individual inventor level. Further research shall be performed when additional data is available, thereby potential effects of the AIA might be more clearly observable, which could yield further insights on the actual effect of the AIA.

Table 8: Output table for diff-in-diff analysis based on R&D expenditure of small companies

	R&D small companies (US vs. UK)	R&D small companies (US vs. Japan)
year	2618.5	4013.8
	(0.68)	(0.75)
country	40438.8***	32764.5***
	(15.55)	(9.09)
diff	4231.9	10575.2
	(0.78)	(1.33)
_cons	7829.8***	7765.5**
	(4.26)	(2.89)
N	26	34
R^2	0.938	0.801

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

2.4.1.1.3. R&D Medium & Large Enterprises

The third analysis as well focuses on a specific group of enterprises, when comparing the R&D expenditure of medium & large enterprises in the US as a treatment group to the R&D expenditure of medium & large enterprises in Canada and the UK as control groups. Japan has been excluded as a control group due to the limited data available in the pre-treatment period, i.e., data is only available from 2011 on. Figure 4 below again shows that the United States has a steeper growth rate in R&D expenditure for medium and large firms than similar firms in the control groups, which experienced stagnant growth.

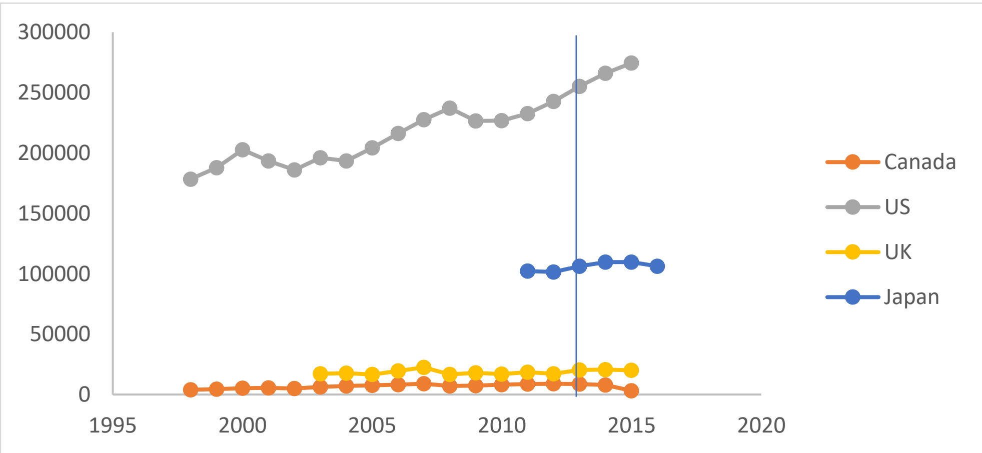

Figure 4: Development of R&D expenditure of medium & large companies over time

The output Table 9 below indicates that when comparing changes in the R&D expenditure of medium & large companies in the US, and the UK and Canada respectively, the difference-in-difference estimator yields a significant positive result. Therefore, the change in R&D expenditure of medium and large US companies following the introduction of the AIA was significant. Different growth trends in groups prior to the intervention could lead to a distorted result. Nevertheless, with Canada a solid control group is included, that is likely very little affected by confounders, giving an even higher significance to the result.

Thus, the results of the analysis support the alternative hypothesis "H1b: The AIA had a significant positive impact on innovation for medium and large firms", leading to two conclusions: Firstly, that the provisions of the AIA had a differential impact on firms of different sizes and secondly, that the provisions of the AIA were beneficial for medium & large companies with regards to innovation. This supports the line of argument in the literature that the provisions of the AIA have a beneficial effect for larger companies regarding innovation. The political implications of this are that measures to equal out the imbalance between companies of different sizes could lead to an even more beneficial impact of innovation.

Table 9: Output table for the diff-in-diff analysis based on R&D expenditure of medium & large companies

	R&D medium and large companies (US vs. UK)	R&D medium and large companies (US vs. Canada)
year	2223.6	1466.0
	(0.18)	(0.08)
country	193661.2***	185556.5***
	(22.72)	(19.98)
diff	70567.5***	83888.5**
	(3.98)	(3.10)
_cons	18121.4**	6829.5
	(3.01)	(1.04)
N	26	34
R^2	0.974	0.946

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

2.4.1.2. Patenting behavior

2.4.1.2.1. Applications

Having analyzed innovation by exploring R&D expenditure from various angles, the next analyses use patents as a proxy for innovation. Firstly, for the first analysis, patent applications under the Patent Cooperation Treaty (PCT) have been taken as a dependent variable, based on the country of the applicant. The PCT is an international treaty that has been ratified in 1970 and that harmonizes the system of patent applications world-wide, and that enables applicants to protect their invention internationally through one common application (WIPO 2018). The change in patent applications for the US and the control groups of Canada and the EU were compared to each other in a diff-in-diff analysis. The output table for the diff-in-diff regression shows that for the control group of Canada, a significant positive result can be observed. For the additional control group of Europe, no significant result was observed. Also, the r-squared indicates a comparatively good fit of the OLS regression model with the available data for Canada. The model for the EU control group has an r-squared of 33% which means that it explains only 33% of the variability of the data around its mean. As such more focus in the interpretation of the result shall lie on the control group of Canada, which additionally, due to its similarity to the US, opens fewer opportunities for confounding variables to distort the result.

Table 10: Output table for the diff-in-diff analysis based on patent applications

	Patent applications (US vs. Canada)	Patent applications (US vs. EU)
year	265.4	8048.5
	(0.10)	(2.00)
country	41824.4***	1317.9
	(26.56)	(0.55)
diff	12147.4**	4364.3
	(3.24)	(0.77)
_cons	2180.8	42687.2***
	(1.96)	(25.25)
N	34	34
R^2	0.970	0.325

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

For this analysis, the null hypothesis "H1o: The AIA didn't have any significant impact on innovation in general" can be rejected based on the available data. The positive impact of the AIA on all companies that have already been confirmed based on R&D expenditure can now be confirmed as well based on patent applications. This result again shows that one or several provisions of the AIA contributed to fostering innovation in the US.

2.4.1.2.2. Granted patents

The second analysis focuses on comparing the change in granted patents, based on data from the EPO for the EU and from the USPTO for the US. Canada wasn't included in this overview due to the lack of available data. The output table again shows a significant positive impact of the AIA on the change in granted patents for the US, as compared to the change in granted patents in the EU. This result further supports previous analysis in this thesis which observe a similar impact of the AIA on other measures of innovation. In the case of the EU, potential confounders should be assessed due to differences in economic systems and potential changes that have been effectuated on an EU-level in the IP protection system. A review of recent changes yielded the result that the most significant change in the EU has been the "Directive 2004/48/EC of the European Parliament and of the Council of 29 April 2004 on the enforcement of intellectual property rights ". This directive was however targeted at enforcement rather than at the issuing of patents which suggests that it had no confounding effect on this analysis.

Table 11: Output table for the diff-in-diff analysis based on granted patents

	Granted patents (US vs. EU)
year	5823.3
	(0.98)
country	66028.6^{***}
	(18.67)
diff	44802.9^{***}
	(5.32)
_cons	25141.3^{***}
	(10.05)
N	34
R^2	0.953

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This analysis offers further evidence to reject the null-hypothesis "H1o: The AIA didn't have any significant impact on innovation in general", thereby adding yet another proxy for innovation, that of granted patents, to the list of measures of innovation on which the AIA had a significant positive impact.

2.4.2. Results for BRDIS data (R&D funds to sales ratio)

2.4.2.1. Small, medium & large and total of all companies

The following analyses have been performed using BRDIS data. The survey point that has been taken as a direct variable is the R&D funds to sales ratio. The graph below shoes the development over time of the R&D expenditure to sales ratio for small, medium & large and the total of all companies. Using this ratio instead of total R&D funds or expenditure has the advantage that when sales go up due to a good economic situation, and R&D expenditure also rises, the ratio remains constant. However, this connection could also distort the result, when sales go down, but R&D expenditure remains constant, this could lead to a higher ratio even though R&D expenditure hasn't changed. This relation should be considered when interpreting the results. Using the ITSA single-group approach, each of the aforementioned groups have been analyzed separately.

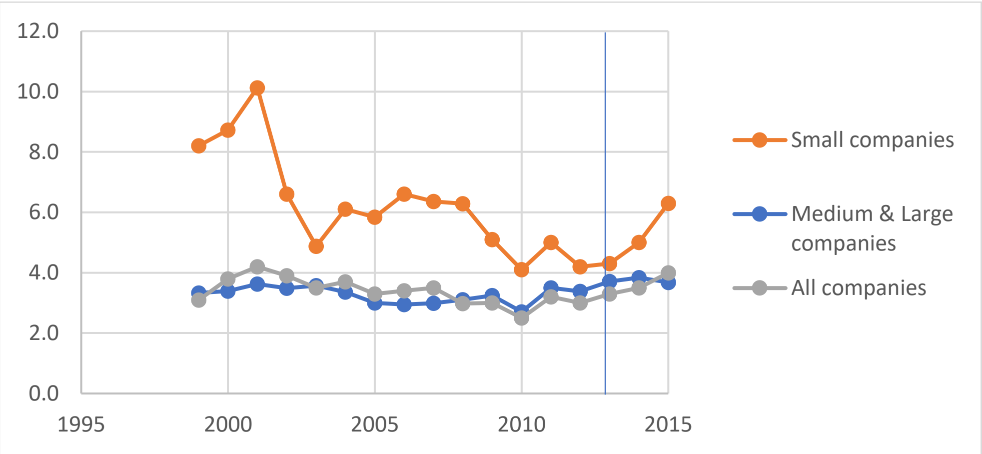

Figure 5. Development of R&D funds to sales ratio over time

What becomes clear is that small companies have been experiencing a downwards trend in their R&D to sales ratio before the AIA, which is statistically significant as per the output table below. However, even though an early upwards trend after the treatment can be observed, it is not statistically significant. Future analyses when additional observations are available could yield an insight on whether this trend is sustainable and possibly also significant. This result for small companies is however in line with the results of prior analysis based on OECD data, which don't find a significant result either. The additional evidence produced by this analysis again doesn't allow to reject or support the alternative hypothesis "H1a: The AIA had a significant negative impact on innovation for individual inventors and small firms".

For medium & large companies, however, there was a significant positive impact in 2013, yet there wasn't any impact on the trend in the following years after the AIA until 2015. This may be rooted in the fact that companies were optimistic in their spending in the year when the AIA was introduced, however, retracted their optimism in the aftermath. Nevertheless, the outcome for medium & large companies supports the result of prior analysis on this group of companies, which observed a significant positive impact as well. Also, in these cases there is support for the hypothesis "H1b: The AIA had a significant positive impact on innovation for medium and large firms.".

The analysis of the total of all companies, suggests that even though there was no significant effect in the year of treatment, there was a significant positive impact in the years after the treatment. This suggests that overall, the AIA had a positive effect on this measure of innovation, even though no particular group of companies experienced a significant longer-term effect. The outcome of this analysis leads to again rejecting the null- hypothesis, "H1o: The AIA didn't have any significant impact on innovation in general". This is in line with all proxies for innovation that have been assessed during earlier analysis. They have also found a significant positive impact of the AIA on innovation in general, thereby presenting strong evidence that the defined goal of the AIA, to foster innovation, has effectively been achieved.

Table 12: Output table for the ITSA based on the R&D to sales ratio

	R&D/sales (small companies)	R&D/sales (medium & large)	R&D/sales (all companies)
_t	-0.325**	-0.0255	-0.0716*
	(-3.94)	(-1.30)	(-2.33)
_x2013	0.365	0.667**	0.425
	(0.32)	(3.33)	(1.95)
_x_t2013	1.326	0.0255	0.422***
	(1.81)	(0.77)	(8.30)
var2	0	0	0
	(.)	(.)	(.)
_cons	8.400***	3.423***	3.829***
	(13.14)	(30.82)	(14.89)
N	17	17	17
R^2	0.649		

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

2.4.2.2. Exposed vs non-exposed companies

For the last analysis that is based on the R&D funds to sales ratio, two groups of industries were defined: industries in which companies are more exposed to litigation and industries in which they are less exposed to litigation. Industries have been assigned to groups according to litigation statistics, which ranked industries according to the number of litigated patents (Clarivate Analytics 2017). The most exposed industries are, based on the classification, Computing and Control, Communications, Mechanical – Buildings, construction and vehicles and Pharmaceuticals as well as Polymers and Plastics (Clarivate Analytics 2017). The average R&D to sales ratio was taken for both the more exposed and the less exposed group which constitute the basis for this analysis. Prior literature, e.g. by Mezzanotti (2016) focused on differences in exposure between firms and how a legal decision, more specifically, the 2006 Supreme Court decision "eBay vs. MercExchange" that prevents the grating of permanent injunctions almost automatically after a patent infringement, impacted them. He concluded that more exposed firms are showing a stronger positive reaction to the decision in terms of innovative activity than less exposed firms. This thesis contributes to the literature by examining another case where both more exposed and less exposed industries/companies could have been impacted differently.

What becomes clear from the chart below is that exposed industries have experienced stronger volatility over the past years than less exposed companies in their R&D to sales ratio. Less exposed industries have kept, after a spike in the early 2000s, the ratio on a relatively stable level. This may be due to the fact that exposed industries have a high sensitivity to changes in the external environment, an explanation that Mezzanotti (2016) also put forward in his paper. However, the direction of this trend for exposed companies isn't clear yet, as they have seen both a spike in the R&D to sales ratio of approximately two percentage points in 2014 and a sharp decrease in 2015 by three percentage points.

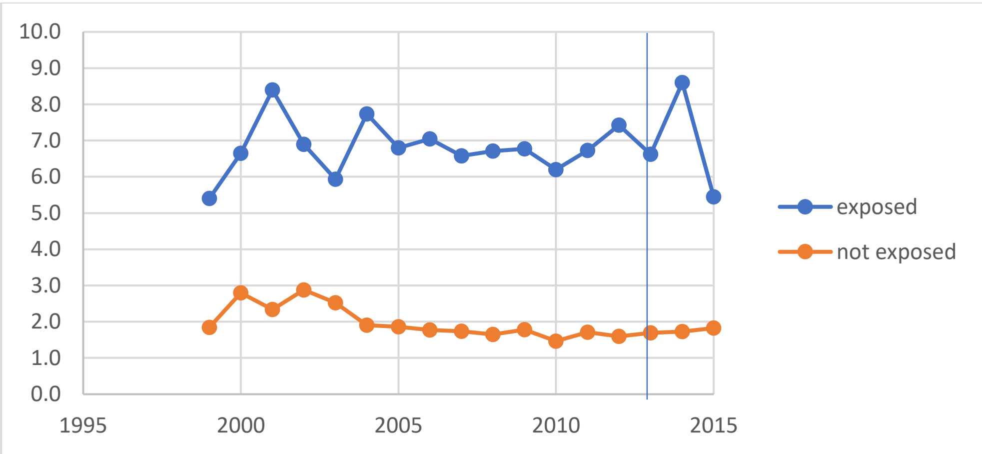

Figure 6: Development of R&D funds to sales ratio for more and less exposed industries over time

The output table of the interrupted time series design suggests that companies that are more exposed to litigation experienced no significant impact by the AIA. Companies that are less exposed saw a significant positive impact in the annual trend after the AIA came into force. The explanation for this case is that due to changes that protect companies in general from harmful litigation and by facilitating procedures, also companies that are in industries that haven't seen a high R&D expenditure to sales ratio in the past are more inclined to invest a greater share of their sales into R&D. Confounding factors can be largely disregarded in the interpretation of this analysis since in the ITSA methodology it is assumed that any confounder would be detectable since the impact of the treatment would be stronger than the confounder. Based on this analysis, further implications for the null-hypothesis "H2o: The introduction of new patent enforcement procedures didn't have a significant impact on litigation and as a consequence innovation" can be derived. It can be partially rejected with regards to less exposed industries since the analysis shows a significant positive impact on innovation for them.

Table 13: Output table for the ITSA based on the categorization into more exposed and less exposed companies

	R&D/sales (more exposed)	R&D/sales (less exposed)
_t	0.0143	-0.0754*
	(0.23)	(-2.66)
_x2013	0.536	0.256
	(0.48)	(1.74)
_x_t2013	-0.564	0.125**
	(-0.82)	(4.00)
year	0	0
	(.)	(.)
_cons	6.714***	2.483***
	(11.59)	(9.32)
N	17	17
R^2		

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

2.5. Summary of Results and Implications for the Research Question

This summary section now offers the chance to revisit the results of the analyses, by summing them up based on the assessed hypotheses and by discussing the implications for the main research question. Moreover, the outcomes shall be embedded in prior literature, and briefly, implications for policy makers are suggested.

For the analyses based on OECD data, hypothesis H1o could be rejected in all analyses since the AIA was demonstrated to have a significant positive impact on innovation, regardless of the used dependent variable (R&D expenditure, patent applications or patent grants). The outcome of the research thus indicates that the AIA reached its goal of fostering innovation in general. Results for assessed sub-groups are however mixed: for small companies, no significant impact was found, however for medium & large companies there was a significant positive impact on innovation observed. This suggests on the one hand that further analyses would need to be performed to determine the impact of the AIA on small companies. On the other hand, it suggests that medium & large companies benefitted from the AIA, which was a hypothesized impact of it that has been discussed broadly in literature. Therefore, these results add an empirical assessment that confirms the theoretical considerations.

Table 14. Summary of the outcome of the analyses based on OECD data

Proxy for innovation	Analyses performed	Tested Hypotheses	Result
R&D expenditure	Total (All Enterprises)	H1o: The AIA didn't have any significant impact on innovation in general.	Rejected
	Small Enterprises	H1a: The AIA had a significant negative impact on innovation for individual inventors and small firms.	Result not significant
	Medium & Large Enterprises	H1b: The AIA had a significant positive impact on innovation for medium and large firms.	Accepted
Patents	Applications	H1o: The AIA didn't have any significant impact on innovation in general.	Rejected
	Grants	H1o: The AIA didn't have any significant impact on innovation in general.	Rejected

Regarding the analyses based on BRDIS data and the R&D funds to sales ratio as a dependent variable, hypothesis H1o could be rejected in the analysis, since also in this data set there was a significant positive impact caused by the AIA. Again, as in the analysis based on OECD data, the result for small companies wasn't found to be significant. For medium & large companies, a significant positive effect could be observed. Finally, only for companies that are operating in industries that are less exposed to litigation, a significant impact was observed. This contradicts the result of Mezzanotti (2016), who found a stronger reaction to a US Supreme Court decision on more exposed companies. The result is however in line with the suggestion in the literature that the AIA was more aimed at the issuance of patents rather than at the litigation side (Scott Morton and Shapiro 2015). Future analyses based on additional data could yield further interesting insights into this field and move the analyses from a short-term to a more medium/long-term perspective.

Table 15. Summary of outcomes based on BRDIS data

Proxy for innovation	Analyses performed	Tested Hypotheses	Result
R&D funds to sales ratio	Total of all industries	H1o: The AIA didn't have any significant impact on innovation in general.	Rejected
	Small companies	H1a: The AIA had a significant negative impact on innovation for individual inventors and small firms.	Result not significant
	Medium & Large companies	H1b: The AIA had a significant positive impact on innovation for medium and large firms.	Accepted
	More and less exposed industries	H2o: The introduction of new patent enforcement procedures didn't have a significant impact on litigation and as a consequence innovation.	Partially rejected for less exposed industries

What do these results mean now for the research question? The new features that were added to the US system of IP protection by the AIA had a positive impact on innovation in general. In particular, medium & large companies experienced a boost by the AIA. However, it is not clear from the analysis of what the impact on small companies has been. The question of whether this measure has been effective is now dependent on the objectives of policy makers. If policy makers aim specifically at increasing innovation in the small companies, other and additional measures than the ones included in the AIA might lead to a better result. However, if medium & large companies are targeted, the measures included in the AIA can be deemed successful for encouraging innovation. The initial research question however, targets innovation in a society and small companies are very important contributors to this process. Therefore, also these companies should be supported. To sum up, the AIA has laid an important cornerstone for an ideal system of IP protection, to achieve a broad dispersion of innovation in a society, more extensive special provisions for small companies should be introduced additionally.

3. Indirect Impact on Innovation

3.1. Introduction to NPEs and Literature Review

In the following, it will be assessed, whether the AIA had an indirect impact on innovation, which will be explored by performing an event study. The underlying hypotheses of this analysis are:

H3o: The AIA didn't have any significant impact on the business operations of PAEs.

H3a: The AIA had a significant negative impact on business operations of PAEs.

The event study is specifically targeted at exploring whether the introduction of the AIA had any significant impact on the values of Non-Performing Entities (NPEs). These firms are also known as Patent Assertion Entities (PAEs) or patent trolls, and the names are used interchangeably in the following. They are defined as entities which primarily acquire patents and generate revenue by enforcing them against accused infringers. These firms are specialized in patent litigation and don't have any other business operations such as selling, distributing or producing products or providing services. Even though they claim of themselves to be defending the rights of patent owners for the purpose of maintaining a reliable system, they have been subject to criticism. Barack Obama said for example: "They don't actually produce anything themselves, they're just trying to essentially leverage and hijack somebody else's idea and see if they can extort some money out of them." (Investopedia 2018a). As such, curbing the activities of such companies has been seen as one of the goals of the AIA.

How does this now relate to the initial question of the impact of the AIA on innovation? As mentioned before, companies that are subject to (NPE) litigation likely experience a decline in R&D investment, as Mezzanotti (2016) discussed in depth. If the AIA is triggering a decrease in NPE litigation, as a consequence companies would be more likely to undertake R&D investment and would be in turn also more likely to file and be granted patents. Prior research on the impact of the AIA on these entities was drawn up by Feldman et al. (2013) and Cotropia, Kesan, and Schwartz (2014). Feldman et al. (2013) concluded that the AIA had some initial success in curbing the activities of NPEs, based on a decline in the number of defendants sued by them. However, the overall level of claims by NPEs in 2012 was higher than in 2008. The paper by Cotropia, Kesan and Schwartz (2014) yields the result that there has been an increase in the raw number of patent lawsuits from 2010 to 2012 filed by NPEs. This development is however related to the changes triggered by the AIA, more specifically in the joinder rules. Based on these rules it is now prohibited to include multiple, unrelated defendants in a single lawsuit based on commonly-asserted patents. After the AIA has come into force, patent holders need to file separate lawsuits against each unrelated defendant. Taking into account these changes, there is nearly no change in PAE litigation, when the count is based on the total number of patent litigants.

To sum up, no reduction in PAE litigation could be observed following the AIA from an ex-post perspective. However, a different, more general trend is observable that hasn't been captured by prior research, namely a shift from claims placed in trials to other, newly introduced procedures of contestation. Figure 1 and Table 2 are depicting the development of claims related to patents. What becomes clear is that the new procedures (IPR and PGR) that are handled by the PTAB have become increasingly popular since the introduction of the AIA in 2012. This is reflected in the figures for claims directed at the PTAB rising. Disadvantages arising for NPEs from the shift to the PTAB are that there are lower legal fees associated with the proceedings. This indirectly doesn't play into the hands of the NPEs, since the perspective of having to pay exorbitant legal fees used to encourage defendants to opt for settlements rather than speculate on the outcome of a trial. The trend has been confirmed in 2017 when it was estimated that plaintiffs and defendants avoided at least 2.31 billion USD in deadweight losses only from legal fees (Landau 2017). What can be seen is furthermore that trials before the US District Courts have been declining, however, trials before the Federal Circuit has increased. This is based on the fact that the Federal Circuit is now the only legal recourse against decisions of the USPTO, as discussed before in section 1.3.2. Cases before the International Trade Commission have remained stable at a low level. The underlying data was selected for the period from 2008 to 2018 and was drawn on 13 June 2018 from Docket Navigator.

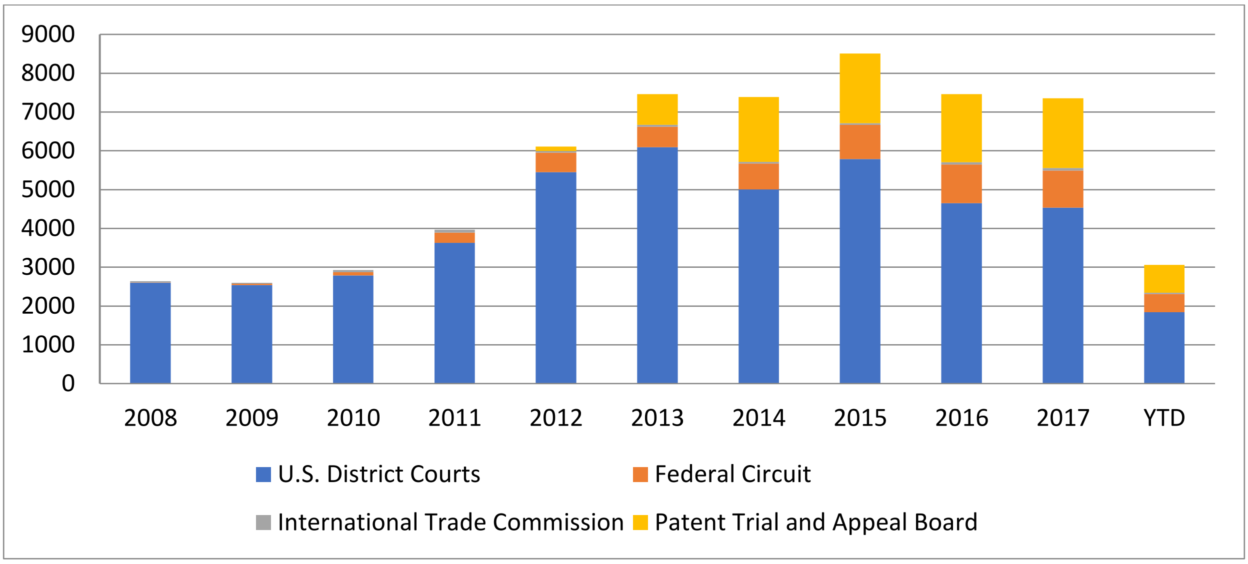

Figure 7. IP-related cases by year (Source: DocketNavigator)

Conducting an event study yields the result whether the hypotheses that are stated at the beginning of this section can be supported by data. The event study complements prior research by pursuing a broader approach to measuring the actual impact of the AIA on NPEs which is to focus on market-related measures and an ex-ante perspective. The goal is to firstly compare the result of this assessment to the outcomes of prior ex-post research and secondly to have a broader view of the outcomes of the impacts of the AIA. This broader view is mainly rooted in the fact that prior research discusses the level of claims quantitatively rather than qualitatively. The event study is however based on the assumption that all available information is included in the share price, also meaning qualitative criteria. A caveat pertaining to this assessment is that the sample is limited to public NPEs due to the nature of the analysis which is based on share price data and market returns. Consequently, private NPEs, some of which are among the largest companies of this kind, are excluded from the analysis.

Table 16: *Patent litigation statistic of claims filed, split by addressed bodies from 2008 to June 2018*

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	YTD	2018 est
U.S. District Courts	2594	2544	2786	3628	5452	6093	5008	5786	4653	4536	1839	4233
Change		*-2%*	*10%*	*30%*	*50%*	*12%*	*-18%*	*16%*	*-20%*	*-3%*	*-59%*	*-7%*
Federal Circuit	13	26	84	264	500	526	665	884	994	955	473	1089
Change		*100%*	*223%*	*214%*	*89%*	*5%*	*26%*	*33%*	*12%*	*-4%*	*-50%*	*14%*
International Trade Commission	36	30	56	71	45	47	37	38	55	64	27	62
Change		-17%	87%	27%	-37%	4%	-21%	3%	45%	16%	-58%	-3%
Patent Trial and Appeal Board	0	0	0	0	111	792	1677	1798	1758	1799	720	1657
Change		-	-	-	-	614%	112%	7%	-2%	2%	-60%	-8%
Total	2 643,00	2 600,81	2 929,19	3 965,71	6 109,03	7 458,21	7 386,87	8 506,51	7 460,38	7 354,10	3 057,32	7 041,04

Note. Data from *DocketNavigator*

3.2. Event Study

3.2.1. Methodology & Theoretical Background

3.2.1.1. Efficient Market Hypothesis

The general purpose of an event study is to assess the impact of a specific event on a firm's value (MacKinlay 1997). In this case, it is targeted at assessing the impact of the introduction of a change in the law, i.e. the America Invents Act (AIA) on the share prices of NPEs.

Historically the event study methodology was used to test market efficiency as in the Efficient Market Hypothesis (EMH) that was devised by Fama (1970). Generally, the EMH states that when investors are seeking profits they include every available piece of information in their trading decisions. This leads to the share prices reflecting all relevant information. The random-walk assumption then implies that the flow of information is unpredictable, which leads to the future direction of share prices being unpredictable. Therefore, a market where traders are not able to generate systematic excess gains is an efficient market. The EMH is commonly split up into three forms: the weak, the semi-strong and the strong form: The weak form states that current prices contain information that is derived from past prices. The semi-strong form states that, in addition to information from past prices, share prices incorporate all publicly available information. The strong form of the EMH states that any information, regardless of it being public and private, is reflected in share prices. Whereas there has been empirical support for the weak and the semi-strong form, the strong form is difficult to validate, due to the nature of the information being insider information. The form that is tested in this thesis for market efficiency is the semi-strong form of the EMH. It would be supported and, consequently the market would be efficient if the market reaction shows an irregular price adjustment in response to new information. For the reaction to be significant, the market reaction has to be quick and full, which means that the adjustment needs to start as soon as the information is available, or shortly afterwards (Kliger and Gurevich 2014).

3.2.1.2. Event Study methodology

The methodology which is used in this thesis to calculate the impact of the event follows the research methodology that MacKinlay (1997) introduced. Firstly, the notation will be described. In order to index return in event time, τ is used. The event date is defined as $\tau = 0$ the event window is represented by $\tau = T_2$ to $\tau = T_3$. The estimation window is set from $\tau = T_0 + 1$ to $\tau = T_1$. The length of the estimation window is $L_1 = T_1 - T_0$, the length of the event window is $L_2 = T_3 - T_2$. Depending on the design that is chosen, T_1 and T_2 can also be the same date and don't necessarily need to be separated by a few days in between.

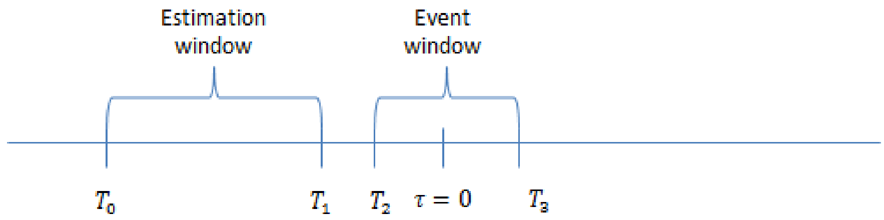

Figure 8. Graphical Illustration of the Notation

To assess the impact of an event on share prices, it is necessary to calculate the so-called Abnormal Return. This is the actual ex-post Actual Return of the security, minus the projected Normal Return over a predefined event window. In other words, the Abnormal Return is compared to a hypothetical situation where the event didn't take place – and as such includes portions of return which are unexpected. Formally, the abnormal return for an individual security in the event period is defined as:

$$AR_{i\tau} = R_{i\tau} - E\ (R_{i\tau}|X_\tau) \qquad (5)$$

where

$AR_{i\tau}$	=	abnormal return
$R_{i\tau}$	=	actual return
$E\ (R_{i\tau}\|X_\tau)$	=	normal return
X_τ	=	conditioning information for the return model

Actual return

Not the absolute share prices are used in this analysis, but rather the actual daily return for a stock and a market portfolio. This is calculated by employing the standard arithmetic model of returns, which compares the percentage difference between two day's closing stock prices.

$$Daily\ Return = \frac{Stock\ Price_{Today} - Stock\ Price_{\ yesterday}}{Stock\ Price_{yesterday}} \qquad (6)$$

The next step is to model the so-called normal return, which is the hypothetical return that would have been achieved if the event hadn't taken place. There are two broad categories of models to choose from, which have been widely used in event studies: statistical and economic models. Commonly used statistical models are the Market Model (single-factor benchmark), the Multi-Factors Model (multi-factor benchmark) and the Constant Mean Return Model. The most commonly used economic model is the Capital Asset Pricing Model (CAPM). In the following, the Market Model will be briefly presented, which was employed in this event study to model normal returns.

Market Model

The model is the "*market model* where X_τ [the variable which contains conditioning information, see equation (1)] is the market return." (MacKinlay 1997) It assumes a linear relation between the return of a given security *i* and the return of a market portfolio. The market model reduces the variance of abnormal return, by excluding variation in the market returns, however minimal this effect may be, which as a consequence increases the ability to detect events (MacKinlay 1997). Specifically, it was decided to employ the single-factor benchmark, which is based on the single factor model of returns devised by Sharpe in 1963. The rationale for not including additional factors is that they wouldn't increase the explanatory power. Therefore, the model's linear specification is stated as:

$$R_{i\tau} = \propto_i + \beta_i R_{mt} + \varepsilon_{it} \qquad (7)$$

$$E(\varepsilon_{it}) = 0 \qquad (8)$$

$$var(\varepsilon_{it}) = \sigma_\varepsilon^2 \qquad (9)$$

where

$R_{i\tau}$	=	normal period τ returns on stock i
R_{mt}	=	period- τ returns on the market portfolio m
$\propto_i$	=	y-intercept (model's parameter)
β_i	=	slope (model's parameter)
ε_{it}	=	zero mean disturbance term

$E(\varepsilon_{it})$	=	expectation
$var(\varepsilon_{it})$	=	variance

A linear regression with the market return as the independent variable and the stock return as the dependent variable is conducted to estimate the model's parameters, by drawing on stock prices during the estimation window. The outcome are estimates for the parameters $\propto_i$ and β_i , designating the intercept and the slope respectively, and they are specific to each stock, reflecting its behavior relative to the market (Kliger and Gurevich 2014). Intercept and slope are calculated in the following way:

$$\beta_i = \frac{\sum_{\tau=T_0+1}^{T_1}(R_{i\tau} - \mu_i)(R_{m\tau} - \mu_m)}{\sum_{\tau=T_0+1}^{T_1}(R_{m\tau} - \mu_m)^2} \qquad (10)$$

$$\alpha_i = \mu_i - \beta_i\mu_m \qquad (11)$$

where

$R_{i\tau}$	=	normal period τ returns on stock i
R_{mt}	=	period- τ returns on the market portfolio m
μ_i	=	mean return for security i
μ_m	=	mean return for market portfolio m
β_i	=	slope specific to a stock
$\propto_i$	=	intercept specific to a stock

The mean return for the security i during the event period τ is calculated as follows:

$$\mu_i = \frac{1}{L_1}\sum_{\tau=T_0+1}^{T_1} R_{i\tau} \qquad (12)$$

where

L_1	=	length of the estimation window
$R_{i\tau}$	=	normal period τ returns on stock i

The mean return for the market portfolio m in event period τ is calculated in a similar manner:

$$\mu_m = \frac{1}{L_1}\sum_{\tau=T_0+1}^{T_1} R_{m\tau} \qquad (13)$$

where

L_1	=	length of the estimation window
R_{mt}	=	period- τ returns on the market portfolio m

Consequently, the parameters that were calculated need to be applied to estimate the normal returns in the event window.

Aggregation of abnormal returns

Since there is more than one security in the sample and more than one day in the event window, the results need to be aggregated both over time and over the company sample. The cumulative abnormal returns for a single security in a sample over the event window (CAR) have to be calculated, by aggregating it over time (MacKinlay 1997). The first step in this process is to calculate the abnormal returns for a stock for each point of time during the event window. When plugging in the equation for the Normal Returns estimation (3) in the initial equation (1), the abnormal return of a stock can thus be estimated by the following equation:

$$AR_{i\tau} = R_{i\tau} - (\propto_i + \beta_i R_{m\tau}) \qquad (14)$$

where

$AR_{i\tau}$	=	abnormal return for a single security at a point of time during the event window
$R_{i\tau}$	=	actual period-τ returns on stock i
$\propto_i$	=	y-intercept (model's parameter)
β_i	=	slope (model's parameter)
R_{mt}	=	period-τ returns on the market portfolio

Consequently, the returns for a single security over time need to be aggregated, which results in the Cumulative Abnormal Return (CAR). In other words, the CAR is calculated by summing up all Abnormal Returns in each event window for an individual security (Kliger and Gurevich 2014).

$$CAR_i(\tau_2, \tau_3) = \sum_{\tau=\tau_2}^{\tau_3} AR_{i\tau} \qquad (15)$$

$$\sigma_i^2(\tau_2, \tau_3) = (\tau_3 - \tau_2) * \sigma_{\varepsilon_1}^2 \qquad (16)$$

where

$CAR_i(\tau_2, \tau_3)$	=	cumulative abnormal return from $\tau_2$to τ_3 where $T_2 < \tau_2 \leq \tau_3 < T_3$
$AR_{i\tau}$	=	estimated abnormal return at period τ
$\sigma_i^2(\tau_2, \tau_3)$	=	variance of CAR_i
$\sigma_{\varepsilon_1}^2$	=	variance of $AR_{i\tau}$

In this analysis, not a single security is assessed but rather the trend over time of the shares of all NPEs in the sample. Therefore, a cumulative measure needs to be introduced, which is called the CAAR (cumulative average abnormal return). To calculate it, firstly the AAR (average abnormal return) needs to be determined by building the sum of observations whose returns are hypothesized to move in the same direction and dividing it through the number of observations. The CAAR for a sample is then the sum of all AARs over a period (Kliger and Gurevich 2014).

3.2.2. Introduction of specific hypothesis and companies in the sample

The event study design mandates that a null- hypothesis in a specific form is defined. Since the hypotheses that have been defined following the literature review are generic and broad, a more targeted hypothesis for this study is formulated:

H0: The AIA didn't have any significant impact on the values of NPEs.

It will be used for the purpose of conducting this event study only, and in the results-section linked back to the actual hypotheses that are the subjects of examination in this chapter. The specific hypothesis will be tested on a list of public NPEs, that was compiled by drawing on IPE Check-ups and Patently-o (Crouch et al. 2014; ipcheckups 2012). It was then updated with the most recent developments. This means that companies which changed ticker symbols and where no historical share price is available, or which haven't been active at the time of the event study, have been removed. This yields a final list of the following entities, with their respective ticker symbols in brackets, that are considered in the event study:

Acacia Research Group (ACTG), Asure Software Inc. (ASUR), Opti Inc. (OPTI), Rambus Inc. (RMBS), VirnetX Holding Corp. (VHC), Document Security Systems Inc. (DSS), Worlds Inc. (WDDD), Democrasoft Inc. (DEMO), Pendrell Corporation (PCOA), Parkervision Inc. (PRKR), Xperi Corporation (XPER), Interdigital (IDCC), Spherix (SPEX).

3.2.3. News review

To be able to determine the event dates and the respective event windows, a news review needs to be undertaken. This will give guidance on when information first became public that contained enough relevant content to cause a potential reaction in values of companies. A review of the news regarding the process of passing into law of the AIA has been conducted by employing the Factiva database. This yields the result that Reuters firstly reported on the patent reform being on the Senate Judiciary Committee's agenda on 11 January 2011. On 20 January there was again news by Reuters and other news agencies that the bill would be introduced to the Senate floor on 25 January 2011 by a bipartisan group of senators. Even though the bill had bipartisan support, the news stated it wasn't clear that it also would get passed by Congress, since a similar act had failed the year before (Gills 2011). On 3 February 2011, it cleared the Senate Judiciary Committee. However, it still wasn't clear whether it would succeed in the full Senate and Congress even though it had powerful supporters on both sides since it was opposed by conservatives (Smith 2011). After discussions in the full Senate began on 28 February 2011, the AIA was passed by Senate on 8 March 2011 with a vote of 95 to 5. It then went on to the House of Representatives, where it also received support from powerful leaders. As such it was passed on 23 June 2011 by 304 to 117 votes. On 8 September 2011, Senate approved the version of the Act as devised by the House. Consequently, it was signed into law by the then president of the US, Barack Obama, on 16 September 2011 and became effective in stages. It became fully effective for patent applications filed on or after 16 March 2013 (Petersen 2014). These developments are summed up in the following table.

Table 17: *Overview of news connected to the passing into law of the AIA*

Date	News
11 January 2011	First reports that the patent reform is on the Senate Judiciary Committee's agenda
20 January 2011	News that the bill would be introduced to the Senate floor on 25 January 2011 by a bipartisan group of senators
25 January 2011	The bill is introduced to the Senate floor with strong bipartisan support.
3 February 2011	The bill cleared the Senate Judiciary Committee
28 February 2011	Discussions in the full Senate begin.
8 March 2011	The bill passes in the Senate.
23 June 2011	The bill passes in the House of Representatives.

8 September 2011	Senate approves the version of the Act as devised by the House (single bill).
16 September 2011	President Barack Obama signs the AIA into law.
16 March 2013	The bill becomes fully effective for applications filed on or after 16 March 2013.

Note. Data from Factiva

3.2.4. Definition of event dates, event window and estimation window

The first event date is defined as "the exact calendar date when it was reasonably clear that the AIA would get strong support in the Senate, to have good chances to pass." As such 20 January 2011, when it was clear that the bill would be introduced on the Senate Floor with strong bipartisan support is defined as the first event date. However, given that a similar proposal had failed two years earlier, two additional event dates are considered which represent reaching different steps in the legislative process. As such, the dates where the bill was approved in Senate and House of Representatives are taken as event dates. The second event date is defined as "the date the Senate passed the legislation" which is 8 March 2011. The third event date is defined as "the date the House of Representatives passed the legislation", which is 23 June 2011.

In a next step, an event window needs to be set to capture all reactions in connection with the event. To fulfill this purpose, the event window is usually larger than the period of interest, thus capturing information which becomes available to the market before or after the actual announcement date. This is consistent with the Efficient Market Hypothesis (MacKinlay 1997). As far as the exact length of the event window is concerned, there is, however, a trade-off. The downside is that a longer event window might make the results more vulnerable to the influence of potential other events. The upside is that only a longer event window might lead to observing the effects of an event. To limit the influence of potential other events, a thorough review of news announcements was conducted for each company and, if relevant, is pointed out in the analysis of results. A meta-review of 400 event studies concluded that event windows typically range in their length between 1 and 11 days and center symmetrically around the event day (Holler 2012).

- The event window for the first event is set to start from 11 January 2011 (T=-9), to take into account the uncertainty in the market of whether the legislation would be passed and to capture any speculations before the event. It ends on 3 February 2011 (T=+9) when it was cleared in the Judiciary Committee, and from which date on the Senate paused until 28 February.

- The event window for the second event is starting on 28 February 2011 (T=-6), when the bill was beginning to be debated in the full Senate. It ends on 16 March 2011 (T=+6).
- For the third event, the event window was defined to start on 16 June 2011 (T=-5) and ends after the event on 30 June 2011 (T=+5), to capture delayed reactions in the market.

Research has been carried out to find the optimal length of an estimation window to reach valid results. Holler (2012) reviewed 400 event studies and finds that estimation windows range between 30 and 750 days. There have also been studies that assess the sensitivity of results, which conclude that the event study results are not sensitive to variations in event window lengths when the window lengths exceed 100 days (Armitage 1995). Therefore, for the events, the estimation windows have been defined as follows:

- For the first event date the estimation window is defined from T=-10 to T=-160, i.e. from 8 June 2010 to 10 January 2011.
- For the second and the third event dates, the estimation windows are also defined from T=-10 to T=-160, since there are no interferences with potential other events.

The estimation windows have been checked for potential events that could lead to a distortion in share prices, however no such event has been found.

3.2.5. Results and Interpretation

The event study analysis has been carried out in Stata, following the procedure described by Princeton University Library (2008). First, historical share price data for each of the companies has been drawn from Yahoo Finance, from 1 January 2008 until 31 December 2011. Historical data has been drawn as well for the relevant market index, which is the index S&P 500 that is based on the market capitalization of 500 large companies, which have common stock listed on the NYSE or NASDAQ (Investopedia 2018b). In a next step, data has been treated and brought into a format that Stata can process. Then, the event study was performed by relying on the procedure described by Princeton University Library, which indirectly performs each of the steps that were defined in the methodology section in Stata. The detailed process as described by Princeton University Library, including the used commands have been attached in the appendix.

The results of the event study are interpreted on different levels: Firstly, results are analyzed by the abnormal returns for each company, as the cumulative abnormal return (CAR) for each event window is assessed. Secondly, based on all the firms in the sample, the cumulative average abnormal returns (CAAR) are analyzed. This is to gain an understanding of the bigger picture of all the firms' reactions in the sample and their changes in value. For the interpretation of results a test statistic which tests whether each of the CARs is statistically different from zero has been calculated in Stata, based on the following, simplified formula. If the absolute value generated by this test is larger than 1.96, the average abnormal return is significantly different from zero at the 5% level.

$$test = \frac{\frac{CAR}{N}}{\frac{AR\_SD}{\sqrt{N}}} \qquad (17)$$

where

CAR	Cumulative abnormal return
N	number of days in the event window
AR_SD	abnormal return standard deviation

The detailed results are attached in the appendix. For the first event window, companies predominantly show no significant reaction to the event. Only three companies out of the 13 companies in the sample show a significant reaction in their CARs. However, they are ambivalent. While DEMO experiences a CAR of 473%, DSS sees a negative CAR of -17% and OPTI a positive CAR of 60%. Due to the limited sample and especially, the ambivalent results, a condition that Kliger and Gurevich (2015) stated, shouldn't be present in order to calculate a reliable CAAR, the results are only analyzed on a company level. Therefore, only implications for single companies for each event can be presented based on the output. Nevertheless, the lack of significant reactions carries important implications, since it demonstrates that markets didn't see the first event, i.e., the initial presentation of the AIA, as carrying enough relevant information to generate a significant impact for the NPE's values. A specific cause could be that the final content of the AIA wasn't fully known at this early stage. With the content unknown, no assumptions could be taken by the market on whether the AIA is beneficial for NPEs.

For the second event date, there was a significant result for one out of the 13 companies in the sample, namely for IDCC, which experienced a negative CAR of -20%. Similar to the first event, this result also indicates that the event wasn't deemed as carrying enough relevant information by the market, to trigger a significant reaction in the stock prices of NPEs. This may be rooted in the fact that already at an earlier stage, the effects of the AIA had become clear to the market and have already been considered in the share price.

For the third and last event date, none of the CARs of the companies was found to be significant. This reaction is most likely due to the fact, that even before this last event, where the AIA had been finally passed, it was reasonably clear to the market, that the AIA would likely be passed. As such the information might already have been taken into consideration by the markets at an earlier date.

3.3. Summary and Implications for the Research Question

To sum up, the event study has shown that the market showed no significant reaction to the passing of the AIA. This implies that the specifically defined null-hypothesis "H0: The AIA didn't have any significant impact on the values of NPEs." is accepted. For the more general null-hypothesis "H3o: The AIA didn't have any significant impact on the business operations of PAEs" this means that it can be accepted as well, and for the alternative hypothesis "H3a: The AIA had a significant negative impact on business operations of PAEs" no support was found. This indicates that the market didn't assume that the AIA was an effective measure to curb the operations of NPEs or impact their returns. This result is also in line with prior research that assessed the ex-post effect of the AIA and found no change in the number of lawsuits filed by NPEs. These results further imply that the AIA didn't reach the aim that was defined by lawmakers, who saw it as an important step to protect "genuine" companies and to support their innovative abilities. Further research could focus on singling out the demonstrated shift of claims from the court system to the PTAB system, and on how this shift affects the revenues and operations of NPEs.

4. Overall Conclusion

Having assessed two possible ways – directly and indirectly - in which the AIA can impact innovation, the conclusion is that the AIA has reached its goal of fostering innovation on an overall level. This thesis as such presents the first empirical assessment of the AIA and thereby adds to prior literature. This result holds true when defining innovation based on R&D expenditure, R&D funds to sales ratio as well as patents. The implication is that the provisions and contents of the AIA can be deemed to be an important cornerstone for any system of IP protection that aims to foster innovation in the future, which is one possible response to the initial research question of: "What are the characteristics of a system of IP protection that foster innovation?".

Also, with regards to whether the AIA supported or curbed the activities of different groups of companies, the analyses produced valuable results. The provisions of the AIA were found to have no significant impact on innovation in small companies. This result is surprising, since the consensus in previous literature was that the AIA is likely to have a negative impact on small companies. Moreover, the AIA was found to have a significant positive impact on medium & large companies. This supports previous literature which assumed that the new first-to-file system is more beneficial for this group of companies than other groups. This is a finding that should alert policy makers when they aim to focus their effort on promoting innovation of small companies. For yet another group, an unexpected result was produced, by showing that for companies that are less exposed to litigation, the AIA caused a significant positive impact on innovation. Prior studies have stipulated that more exposed companies have had stronger reactions to similar events. This is an interesting observation that would require further exploration. The final-take away for policy makers is that different changes than the ones included in the AIA would need to be introduced to trigger an observable decrease in the business activities of NPEs. This is supported both by ex-post literature assessing NPE- based cases of litigation quantitatively as well as by my ex-ante analysis that assessed both qualitative and quantitative factors.

An avenue for future research can explore the medium- and long-term impact of the AIA on innovation, by reperforming the analyses when additional observations become available. Assessing the impact of the shift of claims towards PTAB-based procedures in more depth could additionally yield valuable insights.

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Appendix

Appendix 1: Stata code for preparing data

```
sort company_id
by company_id: gen eventcount=_N
by company_id: keep if _n==1
sort company_id
keep company_id eventcount
save eventcount

use All companies_close_market return_treated, clear
sort company_id
merge company_id using eventcount
tab _merge
keep if _merge==3
drop _merge
expand eventcount
drop eventcount
sort company_id date
by company_id date: gen set=_n
sort company_id set
save stockdata2

use eventdates, clear
sort company_id event_date
by company_id: gen set=_n
sort company_id set
save eventdates 2

use stockdata2, clear
merge company_id set using eventdates2
tab _merge

list company_id if _merge==2
keep if _merge==3
drop _merge

egen group_id = group(company_id set)
```

Appendix 2: Stata code for performing the event study

```
sort company_id date
by company_id: gen datenum=_n
by company_id: gen target=datenum if date==event_date
egen td=min(target), by(company_id)
drop target
gen dif=datenum-td


by company_id: gen event_window=1 if dif>=-2 & dif<=2
egen count_event_obs=count(event_window), by(company_id)
by company_id: gen estimation_window=1 if dif<-30 & dif>=-60
egen count_est_obs=count(estimation_window), by(company_id)
replace event_window=0 if event_window==.
replace estimation_window=0 if estimation_window==.


forvalues i=1(1)39 {
l id group_id if id==`i' & dif==0
reg ret market_return if id==`i' & estimation_window==1
predict p if id==`i'
replace predicted_return = p if id==`i' & event_window==1
drop p
}

sort id date
gen abnormal_return=ret-predicted_return if event_window==1
by id: egen cumulative_abnormal_return = sum(abnormal_return)

sort id date
by id: egen ar_sd = sd(abnormal_return)
gen test =(1/sqrt(number of days in event window)) * (
cumulative_abnormal_return /ar_sd)
list company_id cumulative_abnormal_return test if dif==0
```

Appendix 3: CARs for each company for each event

Event No.	Company	CAR	TEST
1	ACTG	-6%	-0.4515243
2	ACTG	8%	0.3971701
3	ACTG	8%	0.6780245
1	ASUR	-6%	-0.748237
2	ASUR	-3%	-0.2648887
3	ASUR	-11%	-1.116784
1	DEMO	473%	3.507107
2	DEMO	-173%	-0.7473019
3	DEMO	115%	0.8960736
1	DSS	-17%	-2.379089
2	DSS	-8%	-1.347379
3	DSS	1%	0.0856043
1	IDCC	7%	0.6490666
2	IDCC	-20%	-2.459847
3	IDCC	14%	2.116975
1	OPTI	60%	10.46468
2	OPTI	6%	1.382179
3	OPTI	-89%	-0.7543367
1	PCOA	-4%	-0.1948084
2	PCOA	16%	0.3413159
3	PCOA	-7%	-0.2551633
1	PRKR	33%	1.075475
2	PRKR	12%	0.6732538
3	PRKR	-30%	-1.711037
1	RMBS	3%	0.72904
2	RMBS	-9%	-1.322892
3	RMBS	8%	1.423568
1	SPEX	-25%	-0.6762048
2	SPEX	-14%	-0.7040964
3	SPEX	-13%	-0.7310938
1	VHC	-20%	-1.518499
2	VHC	-9%	-0.7475502
3	VHC	4%	0.4397052
1	WDDD	-8%	-0.176048
2	WDDD	-38%	-0.9378703
3	WDDD	-16%	-0.7997476
1	XPER	-20%	-1.088644
2	XPER	-6%	-0.7366897
3	XPER	9%	1.338297