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Death squad or quality improvement? The impact of introducing post-grant review on U.S. patent quality

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Death squad or quality improvement? The impact of introducing post-grant review on U.S. patent quality

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Abstract

Increasing evidence indicates that a large share of granted patents are "undeserved" because they do not meet the criteria of novelty or non-obviousness. In recent decades, many jurisdictions introduced patent reforms to avoid weak patent applications and improve legal patent quality. In particular, the Leahy-Smith America Invents Act (AIA), enacted into law in 2011, introduced the post-grant validity challenge at the United States Patents and Trademarks Office (USPTO). This procedure allows any third party to question granted patents, possibly leading to patent revocation or scope reduction. This paper aims to provide evidence of the impact of such policy change on the legal quality of the patent system. To identify the policy effect we exploit the fact that the same invention is patented in different legislation and that not all of them have post-grant review procedures. In particular, we compare the same patent filed at the USPTO and the Canadian Intellectual Property Office (CIPO). In this setting, we apply standard Diff-in-Diff analysis to estimate the effect of the post-grant validity challenge on the patent scope. Our results indicate that the AIA reform contributed to a reduction of U.S. patent scope in the last decade, indeed increasing the legal quality of the patent system.

Keywords: patent opposition, patent quality, policy evaluation, patent scope

JEL classification: K41, L24, O31, O32, O33, O34

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On September 16, 2011, the America Invents Act (AIA) was enacted into law. The purpose of the AIA and this final rule is to establish a more efficient and streamlined patent system that will improve patent quality and limit unnecessary and counterproductive litigation costs.

U.S. Federal Register, Vol.77, No.157, August 14, 2012

1 Introduction

Patent quality is an essential aspect of the patent system that has received a lot of attention in the literature, both concerning its meaning or definition and its measurement (Van Pottelsberghe de la Potterie, 2011; Squicciarini et al., 2013; De Rassenfosse, Griffiths, et al., 2016; Harhoff, 2016; De Rassenfosse and Jaffe, 2018). Notwithstanding the multidimensional aspect of patent quality, particular concern regards the *legal quality* of patents; that is defined by the probability of a grant to survive a legal challenge (Higham et al., 2021). This dimension of quality has recently attracted attention because new evidence indicates that a large share of granted patent should be invalidated (Henkel and Zischka, 2019). Questionable validity is often due to an overly broad or vague scope of the claims (Marco et al., 2019), that may lead to "uncertain interpretation by courts and competitors" (Harhoff, 2016).

In the last decades, policymakers started to consider the introduction of administrative procedures to deal with patents of low legal quality. Scholars (Merges, 1999; Hall et al., 2004; Lemley, Lichtman, et al., 2005) and organizations (US Federal Trade Commission, 2003) supported the introduction in the U.S. of a post-grant review challenge, so to eliminate "unwarranted market power in the current stock of granted patents" (Graham and Harhoff, 2014). To achieve these goals, the Leahy-Smith American Invents Act (AIA), enacted into law in 2011, introduced three new proceedings for challenging the validity of an issued patent: Inter Partes Review (IPR), Post-Grant Review (PGR) and Covered business method review (CBM). The new law supporters hoped to make prosecuting patents more efficient, increase patent quality, reduce patent litigation, foster innovation and bring the U.S. patent system closer to those of other countries (De Corte et al., 2012). However, the very high rate of claim cancellation registered by the United States Patent Trial and Appeal Board (PTAB) in first instances[1] has attracted an enormous amount of attention and fierce criticisms. The former Chief Judge of the U.S. Court of Appeals for the Federal Circuit, described the PTAB as "acting as death squads, killing property rights"[2]. Recently, a bill willing to abolish both IPR and PGR entirely was proposed[3]. Furthermore, while the policymakers' intention might be straightforward, it has been argued that firms may strategically use these new procedures to harm competitors[4].

Against the backdrop of this discussion, this paper aims to empirically assess whether the introduction of the

[1]Love et al. (2019) documents that about 82% of instituted claims subject to a final written decision were cancelled.

[2]https://www.bloombergquint.com/technology/-death-squad-that-tossed-2-000-patents-challenged-at-high-court

[3]https://www.congress.gov/bill/115th-congress/house-bill/6264/text

[4]https://www.wsj.com/articles/hedge-fund-manager-kyle-bass-challenges-jazz-pharmaceuticals-patent-1428417408

post-grant review at the USPTO has improved the legal quality of patents. Specifically, we distinguish two main channels through which the AIA reform may enhance the U.S. patent legal quality. On one side, we test whether the existence of post-grant review creates the incentive for applicants to reduce the scope of claims and avoid overly broad patents since the first stage of the application procedure. On the other side, we assess the response of patent examiners to the new institutional setting, investigating whether the AIA has reduced their leniency in examining patent applications.

Very few works to date provide empirical evidence on the ways these challenging proceedings work in the U.S. patent system. Love et al. (2019) find a significant relationship between patent validity and some characteristics of a patent and its assignee, prosecutor, examiner, and prosecution history. For example, their results suggest that patents with more words per claim are significantly more likely to survive an inter partes review. On the contrary, patents obtained by small entities, patents assigned to examiners with higher allowance rates and patents with more backward citations are less likely to survive the challenge. Bar and Costello (2019) analyze the use of administrative validity challenges by defendants in patent infringement suits. Their findings suggest that cases where defendants use administrative challenges involve patents of particularly broad scope and high value than the litigated patents pool. By comparing patents challenged through different procedures before and after the AIA reform, Bar and Costello (2017) find no difference in patent scope in grants challenged after 2011. Examining the effect on welfare, the theoretical analysis by M. Schankerman and Schuett (2022) shows that the impact of introducing post-grant review challenges might be ambiguous, as firms' strategic effects may offset the positive impact of lowering litigation costs. However, their quantitative analysis indicates that the positive effect of lowering costs dominates, resulting in an increase in welfare of 0.8%.

In this paper we begin by underling the importance of providing high quality standards by patent offices and briefly discuss the mechanisms through which the recent established U.S. policy change may enhance the quality of the patent system. We then compare differences in outcomes across USPTO-CIPO patent twins, i.e. patent filed at both patent offices for the same underlying invention (Rassenfosse, Griffiths, et al., 2021). We proxy patent legal quality using novel measures of patent scope computed using patent claims data (Marco et al., 2019; Kuhn and Thompson, 2019; Bekkers et al., 2020) and assess whether the policy change affects the quality of the U.S. patent system, thus providing evidence on the effectiveness of administrative post-grant review procedures. To address endogeneity issues and isolate the effect of the policy change, our identification strategy applies a patent-level Difference-in-Difference estimation. We use the U.S. policy change as a natural experiment to understand its impact on patent quality. We choose Canadian patents as control group because of the geographic and economic proximity (Josh Lerner et al., 2015) and because most of the claims are written in English. Moreover, given the fact that the Canadian patent system switched to a first-to-file (FTF) regime in 1989 (Lo and Sutthiphisal, 2009; Abrams and Wagner, 2013), we can isolate the effect of the introduction of post-grant review proceedings from the other pillar of the AIA reform, namely the change in the patent priority rules.

Our empirical results suggest an increase in U.S. patent legal quality thanks to the introduction of post-grant challenge proceedings. In particular, firms react to the reform by drafting patent claims more carefully, thus reducing the scope of patents. This is particularly true in discrete industries, when the risk of a subsequent invalidity hit innovation that is valuable for the firm. Moreover, the AIA reform results in an increase in examiners' effort during the application procedure. However, the impact in time is not immediate and it is restricted to some specific examiners' art units.

This paper contributes to the broad literature on patent quality and the more specific literature on the possibility to improve it through administrative procedures of patent challenges. To the best of our knowledge, this study represents the first attempt to evaluate the impact of the AIA reform on U.S. patent quality. Moreover, the paper aids in understanding how applicants and examiners respond to patent office incentives, on which the empirical literature is still scant (Eckert and Langinier, 2014). In this way, our empirical analysis provides policy recommendations to help patent offices improve their grant procedures. Lastly, our study contributes also to the related literature about patent quality measurement, by employing a recently developed indicator of patent quality, constructed using patent claims data.

The rest of the paper is structured as follows. Section 2 discusses the concept of patent quality and provides the institutional background. Section 3 describes the importance of patent scope and how we measure it using claims' data. Section 4 discusses the data and the empirical strategy. In Section 5 we present our empirical analysis and main results. In Section 6 we discuss the validity of our main assumptions and provide robustness checks for our main findings. Finally, Section 7 offers concluding thoughts.

2 Legal quality, patent scope and post-grant review

The grant of a patent involves a trade off between providing an incentive for innovation and allowing monopolistic rights during the patent term. In the same vein, what seek to be obtained by patent applicants and patent offices may often diverge. On the one hand, applicants' attempt is usually to obtain the broadest patent right over the invention, namely to receive a grant with the largest scope. In fact, obtaining a grant with larger scope increases the probability of protecting variations of the core invention and blocks competitors' innovation activity. On the other hand, patent offices have recently understood the importance to issue patents that are of high quality. Uncertainty over the breadth of patent claims and subsequent high litigation costs have been largely identified as undeserved negative consequences of low quality patents. Particular concern regards patents with broad or vague claims. An excessive scope can be exploited for the purpose of rent seeking, particularly by non-practicing entities (NPEs) (Schwartz and Kesan, 2013). In specific industries, characterized by cumulative innovation, unclear patent claim language or too broad patents may hamper subsequent follow-on innovation (Merges and Nelson, 1990). Among different dimension of patent quality, in this paper we focus on patent *legal quality*, that is we refer to "low quality patents" as those that are "overly broad relative to the inventive contribution or (...) unduly vague or ambiguous" (Marco et al., 2019). In both cases, the patent system is found to be responsible of "either decisional errors in granting patents or systemic errors in legally authorizing such patents in the first instance"(Marco et al., 2019). During the application procedure, it is indeed the scope of the patent, defined by the structure and wording of its claims, together with its allowability, to be discussed by the patent office's examiner and the applicant. Once the patent is issued, if the applicant is not satisfied with the claims allowed, the negotiations among the two parts may even continue through a prosecution process, leaving space to different degree of uncertainty about the boundaries of the invention (Lemley and Shapiro, 2005). Recent studies have pointed out that a large share of granted patents should be entirely or partially invalidated because they do not meet the criteria of novelty or non-obviousness (Henkel and Zischka, 2019), suggesting widespread errors during the application procedure. Recently, Frakes and Wasserman (2022) suggest that having few time allocated for the examination is causing examiners to grant low quality patents. These "undeserved" monopolistic rights, which some scholars call "probabilistic patents" (Lemley and Shapiro, 2005), represent sources of uncertainty that might hamper the innovation process. In an attempt to solve these issues, several patent system around the world allow administrative procedure of post-grant review, to challenge the validity of newly granted patents.

The most notable example of post-grant validity challenge is the one available at the European Patent Office (EPO)[5]. The logic behind these procedures is to provide an error correction mechanism to the work of patent examiners, allowing the possibility to any third party to invalidate patents that have been mistakenly granted. The existence of these procedures may create the incentive for patent applicants to draft claims narrowly from the very beginning of the application procedure, fearing a subsequent patent challenge and the risk of invalidation. Moreover, an additional incentive may arise for patent examiners, who may reduce their leniency during the application procedure once aware of the possibility of future re-examinations. Applicants and examiners play a key role in affecting the overall quality of the patent system, however little is known about how they respond to patent office incentives (Eckert and Langinier, 2014)[6]

The United States Patent and Trademark Office (USPTO) recently introduced a variety of processes of post-grant validity challenge within the America Invents Act (AIA) of 2011. The principal and most diffused new procedure is the inter partes review (IPR), that may be filed by any party on grounds of obviousness or lack of novelty based on prior patents or printed publications, from nine months after patent grant. Given the speed of the procedure and the possibility for the patent owner to receive an estoppel provision that prevents challenger from rising invalidity arguments again in court, "IPR often operates as a one-time "up or down" vote on the validity of challenged claims" (Love et al., 2019). The post-grant review (PGR), that is much less utilized (Wallach and Darrow, 2016), must be filed instead within nine months of a patent grant and applies to patents with priorities after March 16, 2013. Differently from the IPR, this procedure may be used to challenge patents on any grounds that could render a patent invalid, therefore not only novelty and obviousness but also written description, enablement, etc. Finally, covered business method (CBM) patent reviews apply only to patents claiming a business method. The estimated cost of these procedures is $350,000, which compared to court litigation costs running into the millions, indicates cheaper procedures to challenge the validity of patents (M. Schankerman and Schuett, 2022).

Before the AIA was enacted into law, interested parties wishing to challenge a U.S. patent after its grant had two options: (1) challenge the patent in federal court; or (2) request a "re-examination" of the patent by the USPTO. However, both ways were remarkably different from the new established procedures introduced with the AIA. Challenges through federal courts are usually initiated from a patent owner in response to a patent infringement and have very high costs for both litigants. Moreover, challengers must prove clearly and convincing

[5]For a detailed description see Harhoff and Reitzig (2004)

[6]The quality of the patent examination may also be driven by incentives coming from outside of the patent office. For instance, examiners may behave strategically in order to enhance their chances to move to the private sector (Eckert and Langinier, 2014). Recently, Tabakovic and Wollmann (2018) find that patent examiners are more lenient with firms that later hire them.

the invalidity of the patent since grants are presumed to be valid. The re-examination process instead can be requested by a patent owner or a third party on the only grounds of obviousness or lack of novelty. However, is not an adversarial proceeding in which advocates for each side introduce evidence and arguments in support of their position. The proceeding involves only the patent owner and the patent office. Excluding the third-party petitioner from participation makes this administrative tool appearing closer to a patent prosecution procedure than to patent litigation[7]. The statistics on the frequency of re-examination processes at USTPO also suggest that this proceeding was rarely employed at the USPTO before its replacement with the IPR after the AIA reform. Merges (1999) estimates that while the rate of EPO's post-grant procedure is 7%, only 0.3% of U.S. patents result in re-examination requests. In addition, in 1995, post-grant challenges at EPO result in much higher rates of patent revocation (34%) compared to re-examinations (12%) at USPTO. Similar re-examination processes are still available in those systems, for instance the Canadian Intellectual Property Office (CIPO), in which post-grant validity challenge is still not present.

The introduction of new procedures of post-grant challenges is not the only significant change resulting from the 2011 reform. In an attempt to close the gap between the U.S. patent system and those of other countries, the AIA converted the U.S. patent system from a first-to-invent (FTI) system to a first-to-file (FTF) system. In the old FTI system, the first inventor was entitled to patent protection, whereas in the new FTF system under the AIA, the first inventor to file a patent application is entitled to patent protection. While the latter system have been characterized the EPO since its foundation, many countries have switched from a FTI to a FTF application procedure in the last decades. For instance, a similar law change became effective in Canada in 1989 (Lo and Sutthiphisal, 2009; Abrams and Wagner, 2013).

3 Measuring legal quality using patent claims

The scope of a patent determines the boundaries of an invention for which a patent awards an exclusion right. Different proxies has been used in the literature to measure the breadth of patents. In the pioneering work by Lerner (1994), the empirical proxy for patent scope is the raw count of IPC classes assigned to a patent. The count of claims in the patent documents has been also largely utilized in the literature (Merges and Nelson, 1994; Lanjouw and M. A. Schankerman, 1997; Frakes and Wasserman, 2014). Historically, this latter measure relies on the total claim count rather than the count of independent claims only. However it has been recently demonstrated that the total claim count, without distinguishing among dependent and independent claims, tends to be an overestimated measure of the technological scope of a patent (Marco et al., 2019). Moreover, Novelli (2015) suggests that both total claim count and the number of patent classes represent different dimensions of patent scope. In particular, the total number of claims reflects the number of technological variations developed with respect to the initial core invention. The number of classes assigned to patents reflects instead the extent to which these variations are spread out in the technological space. We also note that, in our analysis, the total claim count may be a biased indicator of patent scope because of recent changes to the USPTO fee structure, occurred from the AIA reform on wards (Josh Lerner et al., 2015). In fact, the number of claims represents one of the criterion on which the fee

[7]For a detailed description of the differences between IPR and re-examination processes see Bar and Costello (2017) and Vishnubhakat et al. (2016).

schedule is based[8].

The recent availability of data regarding the text of claims has permitted the use of wording in the patent claims to directly assess the breadth of a patent (Okada et al., 2016). Marco et al. (2019) define and validate two claim-related metrics for patent scope based on independent claims. The first is the number of words used in the *shortest independent claim* and the second is the count of *independent* claims. The idea behind the first indicator is that the lower is the number of words in a claim, the minor are the details offered in the claim in describing the invention, the broader is the scope that the patent may potentially cover. On the contrary, a claim with more claim length should reflect more details and peculiarities of the related invention, suggesting a narrower scope. Using a similar approach, Kuhn and Thompson (2019) show that the breadth of a patent's scope can be proxied by the number of words in its *first claim*, with more words corresponding to less scope.

Among previous studies using the count of claim's words as a measure for patent scope, Bekkers et al. (2020) assess the impact of including standards-related documentation in patent prior art on patent scope changes during the patent prosecution process. By focusing on the leniency of examiners, Tabakovic and Wollmann (2018) suggest that in cases where the filing firm later hires the examiner, 11.5 to 13.9 fewer words are added from application to grant. Recently, Hegde, Herkenhoff, et al. (2022) find that, by accelerating patent public disclosure, patent scope decreased in the U.S. in the early 2000s.

In this paper we use a similar empirical setting in order to provide evidence of the effect of the AIA reform on U.S. patent legal quality. We claim that the introduction of post-grant validity challenges may affect the way in which applicants and examiners build patent claims; by providing incentives to reduce patent scope and the uncertainty that surrounds patents with an excessive breath. Measures of patent claim length indeed represent the best available proxies for our analysis.

4 Data and empirical framework

As mentioned above, the aim of this paper is to empirically investigate whether providing room to challenge the validity of newly granted patents spur applicants and examiners to reduce the scope of claims, lowering the uncertainty arising from overly broad or vague patents. The idea is that the introduction of post-grant challenges provides various incentives to build patent claims more carefully and restrict patent scope; avoiding future conflicts. Such incentives may result in an overall improvement of the legal quality of the patent system. In this section, we describe the data utilized, the way we construct our dependent variables to proxy patent quality and our empirical strategy.

4.1 Data

Our primary data source is the PATSTAT patent database (Spring 2021 edition). The initial sample includes all USPTO patents with an application date between January 1, 2004 and December 31, 2014[9]. From PATSTAT we

[8]For all the details see: https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule.

[9]We limit our analysis to this period because at the end of 2014 Canada ratifies the Patent Law Treaty, aimed at simplifying and harmonizing administrative practices with respect to the patent application process (see https://ised-isde.canada.ca/site/canadian-intellectual-property-office/en/patents/patent-branch/patent-notices-and-archived-web-content/archived-amendments-patent-act-questions-and-answers), introducing a possi-

can source information on patent families linking patent documents from different countries using the DOCDB family, defining all patents sharing the same set of priority documents, which ensure that they refer to the same invention[10]. Among the universe of the patents applied at the USPTO during the period we identify which ones are also filed at the CIPO and we found that among the census of U.S. patent applications between 2004 and 2014, 10.8% have a corresponding twin applied for at CIPO.

The starting dataset comprises all patent families with at least one patent filed at USPTO and CIPO. For a matter of completeness, we also include patent applications filed via the Patent Cooperation Treaty (PCT) route and having USPTO or CIPO as designated office. Within these patent families, 50.37% have only two single patent twins, directly qualifying twin-paired patents. The remaining families contain multiple applications to at least one of the two patent offices[11]. Multiple applications within a patent family to the same patent office usually includes re-issue patents, continuation patents, divisional and divisional-in-part (Hegde, Mowery, et al., 2009). Among multiple applications in the same legislation within the same patent family, we keep the earliest application at each patent offices. Among multiple patents filed at the same patent office in the same date, we take the average values of our outcome variables. As shown in Table 1, our initial dataset is composed

Table 1: Dataset composition

	Nr of families	Nr of patents
Initial dataset	341,846	683,692
among which:		
-outliers in the words' difference within the twin pair ($< 1^{st}$ and $> 99^{th}$ percentile)	6,834	13,668
Twins applications (final dataset used in Table 3)	335,012	670,024
of which:		
-PCT, USPTO as designated office		46,379
-PCT, CIPO as designated office		9,274
- not granted at *both* patent offices	230,983	461,966
Twins granted (final dataset used in Table 4)	104,029	208,058

Datasource: PATSTAT (Spring 2021 edition). Period of analysis: 2004-2014. Twins identified by the DOCDB family definition.

by 341,846 pairs of twins patents, corresponding to 683,692 patent applications. As discussed in the following section, we drop from our dataset all the observations that lay below the 1^{st} percentile and above the 99^{th} of the word count difference within the pair[12]. Our final dataset comprises 670,024 patent applications, corresponding to 335,012 families. Among U.S. patents, 46,379 applications have been filed via the PCT route and have USPTO as designated office. 9,274 applications instead have CIPO as designed office. The sample reduces once focusing on those applications that are granted at both patent offices, resulting in 208,058 patents granted and corresponding 104,029 families.

ble confounding factor to the analysis.

[10]For an extensive discussion on different patent family definitions see Martınez (2011)

[11]Specifically, 31.3% of the families have three applications, 10.2% have four applications and less than 9% have more than four applications

[12]We believe that these outliers represent cases in which information is mistakenly reported. In fact, for instance, the 99^{th} percentile corresponds to 235 words' difference between the two twins. In some cases, the two twins differ by more than 10,000 words. We also note that without trimming the data in this way, the final results of our analysis do not change.

4.2 Dependent variables: measuring patent scope

To evaluate the scope and legal quality of patents we follow extant literature and use claims' data. We retrieve claims' data using different data sources. The first one is the Patent Claims Research Dataset made available by Marco et al. (2019), providing claims' data of U.S. patent applications and patent grants. We supplement this dataset web-scraping data of Google patents to retrieve the claims of patents filed at CIPO and via PCT route. Finally, in those cases in which claim's text is not available in Google Patent, we use ORBIS-IP as an additional data source[13]. Following the approach by Marco et al. (2019), and for a matter of comparison, we exclude some claim language from the text of the claims obtained through Google Patent and ORBIS-IP[14]. As stressed above, we additionally drop all those twin pairs that are in the first and the last percentiles of the distribution of the difference in the words' counting within twin-pairs, in order to avoid outliers that are mistakenly reported in the above mentioned data sources.

Both dependent variables used in the analysis are measured using the count of words in the *first patent claim*. In both cases we follow the approach by Kuhn and Thompson (2019) instead of Marco et al. (2019) due to data availability. What differs in the two above mentioned approaches is that in the former the first claim is assumed to be the unique independent claim.

Our first dependent variable captures the breath of the patent at the application stage ($ScopeApplication$). It is computed as the number of words in the first claim (Kuhn and Thompson, 2019). Within twin pair, a greater number of words indicates that the claim is defined with greater precision and detail, thus suggesting an application with a narrower scope. This outcome variable allows us to test the impact of the AIA reform on the way in which applicants write the first claim. In fact, the introduction of post-grant challenges procedures may create the incentive to narrow the scope of patents since the first stage of the application procedure, to avoid subsequent patent challenges.

A second dependent variable is used to test the impact of the AIA reform on the examiners' leniency during the application procedure. Following the approach by Bekkers et al. (2020), this variable measures changes to patent scope between filing and granting ($\Delta Scope$). In particular, we compare the text of the first claim in the patent application with the text of the first claim in the granted patent, by computing the number of words in both claims:

$$\Delta Scope = \frac{\mid ScopeGrant - ScopeApplication \mid}{ScopeApplication} \tag{1}$$

A greater $\Delta Scope$ suggests that the examiner has increased his/her effort in reducing the scope of patents during the application procedure (Tabakovic and Wollmann, 2018). By definition, the examiner can never increase the scope of the initial application. Therefore, any change in the number of words between application and grant indicates a reduction of scope. We may compute this variable for a sub-sample of patents filed during the period of analysis, since not all applications received a grant at both patent offices (see Table 1). Among the robustness checks in Section 6, we show that the results do not change once computing the variable as in equation 1 without

[13] These cases represent 3% of the patents in our dataset.

[14] We follow the cleaning description presented in the methodology appendix provided by Marco et al. (2019); that can be found at: https://www.uspto.gov/ip-policy/economic-research/research-datasets/patent-claims-research-dataset

the absolute value.

In Section 4, we perform an additional robustness check and exclude from our analysis all patents examined by the biotechnology art unit of the patent office, because of the widespread use of Markush language[15]. In these cases, it happens that lists or words are used to increase the breath of a patent, "reversing the normal relationship between claim length and scope"(Kuhn and Thompson, 2019). We find that the results do not change.

4.3 Identification strategy and empirical model

Our identification strategy relies on the firms' widespread practice to fill applications of worthy inventions in multiple patent offices around the world in order to obtain patent protection in multiple countries (Rassenfosse, Griffiths, et al., 2021). This implies that we can observe the outcome of interest, in this case patent scope, for a given patent in countries with different legal settings to build reliable counterfactuals. Recent contributions have exploited the existence of "twin patents" to evaluate patent differences for the same underlying invention (Bekkers et al., 2020; Rassenfosse and Raiteri, 2020; Hegde, Herkenhoff, et al., 2022; Frakes and Wasserman, 2022). In this paper we compare the scope of U.S. patents that were subject to the AIA policy change in 2011 with the scope of the applications filed for the same invention at a different patent office, where post-grant validity challenges has not been introduced in the patent system. In particular, we select applications filed at CIPO to build counterfactuals. This patent office is the best candidate for several reasons. First, the vast majority of patent claims filed at CIPO are written in English, allowing us to perform patent scope analysis on the basis of the text in the patent claims. Second, before the introduction of the three above mentioned post-grant challenges procedures, the two patent systems shared a very similar re-examination processes, allowing us to isolate the effect of the reinforcement of challenges options following the policy change. Third, as stated above, the second major change of the AIA reform, the switch from a FTI to a FTF system, had been implemented in Canada in 1989, leaving the introduction of the challenging procedures as the solely major difference in the two countries' patent systems after the policy change. Fourth, the Canadian patent system, among other candidates, is the one with the closest geographic and economic proximity with the U.S. patent system. Previous contributions in the literature indeed exploit these similarities to build counterfactual using patent data. Lo and Sutthiphisal (2009) and Abrams and Wagner (2013) use the Canadian change in the patent priority rules (from FTF to FTI patent regime) as a natural experiment in order to understand its relative impact on individual inventors and R&D efforts. Similar setting and natural experiments can be found in Josh Lerner et al. (2015)[16].

In order to select the pre- and post-policy period, we rely on Josh Lerner et al. (2015), providing the key dates of the legislative history of the AIA and showing that "in each step of the legislation the AIA passed with an overwhelming majority". This latter evidence suggests that even at the time of the first legislative step applicants likely react by changing patenting behaviours[17]. Therefore, we use February 3rd, 2011 as the date

[15]The number of patents assigned to the Biotechnology art unit is 150,206, corresponding to 75,103 patent families.

[16]In providing evidence on the impact of the switch from FTF to FTI patent regime, Josh Lerner et al. (2015) argues that Canada "serves as a fitting "case study" for the AIA because of Canada's numerous similarities with the United States, including close geographic proximity, a similar initial patent system, and a relatively common innovative environment".

[17]The same is not necessarily true for patent examiners. For this reason, we test the validity of our results by defining the pre-post AIA reform using the date in which the IPR procedure becomes effective.

of the exogenous shock, corresponding to the date in which the AIA is firstly reported by the Senate Judiciary Committee[18]. In Section 6 we check for the validity of this choice, ruling out any anticipation effects or spurious factors.

Following previous contributions (Bekkers et al., 2020; Hegde, Herkenhoff, et al., 2022), our "twin-patents approach" is built using the DOCDB family definition. The treatment group consists of all patents filed at the USPTO after the policy change; whereas, the control group is the corresponding CIPO patent application. For each DOCDB family, we select pairs of twins composed by only one patent filed at each patent office, based on the application with the earliest date of filing. In Section 6 we show that the results do not change once including all patents in the DOCDB family, without focusing of single pairs of twins. In Table 11 we provide an additional exercise to validate our twin-patents approach based on a text-similarity algorithm.

We frame the identification of the U.S. policy effect according to the following patent-level Diff-in-Diff regression:

$$Y_i = \beta_0 + \beta_1 US_i + \beta_2 POST_i + \delta_1 US_i \times POST_i + bPCT_i + Month_{FE} + Family_{FE} + \epsilon_i \tag{2}$$

For each patent i, our dependent variable Y is either the patent scope at the application ($ScopeApplication$) or the patent scope change between application and grant ($\Delta Scope$). The dummy US_i equals 1 for a patent filed at USPTO (or with USPTO as designated office) and zero for the twin filed at CIPO (or with CIPO as designated office). The dummy $POST_i$ equals 1 if the patent was filed after the policy change and zero otherwise. The coefficient δ_1 of the interaction $POST \times US$ indeed yields an estimate of the effect of the introduction of post-grant validity challenges in the AIA reform. We control for patents applied through the PCT routes (PCT) at both patent offices once using $ScopeApplication$ as dependent variable. We also include application month fixed effects ($Month_{FE}$) to control for variations in the business cycle. Moreover, we control for unobservable characteristics, such as sector- and patent- specific features by adding patent family fixed effects ($Family_{FE}$). In Section 6 we explore alternative specifications with different fixed effects. In the regression analysis, the standard error is clustered by DOCDB patent family.

Our identification strategy rests on the assumption that applicants and examiners at CIPO are not indirectly affected by the AIA reform in the way they draft claims of Canadian twins. In theory, this assumption is credible because of the incentive mechanism discussed in Section 2. Indeed, during the application procedure, applicants attempt to obtain the broadest patent right over the invention, in order to receive a monopolistic right able to cover more variations of the core invention. For this reason, narrowing the claims of the CIPO twin as an indirect effect of the AIA reform is not reasonable in terms of economic incentive for applicants. Moreover, we believe that the assumption is particularly plausible with respect to the behaviour of CIPO examiners, that have no reason to react to a policy change occurring in an other patent system. In Section 6 we provide evidence to support this reasoning. We show that in most of the cases, the applications at the two patent offices are done in the same date, but carried out by different patent attorneys, that are well aware of the patent office's specific legal setting. The use of different attorneys may justify differences in claim's text among twins because of the peculiar institutional features of the patent system in each country. More or less stringent legal settings may influence the

[18]Josh Lerner et al. (2015) (pp 48) report six different dates corresponding to different stages of the reform implementation, ranging from February 3rd, 2011 to September 16th, 2011, date in which the AIA is signed into law.

way in which patent claims are written and the resulting legal quality of patents. The same timing of the two procedures suggest instead that we can interpret our results as a lower bound of the impact of the AIA reform. In other words, we believe that our identification strategy provides conservative estimates, as it identifies the effects of introducing port-grant review at USPTO for identical inventions that are, often simultaneously, filed also at CIPO.

5 Empirical analysis

In this section we present some descriptive evidence[19] and the results of our Diff-in-Diff regressions.

We start by showing in Table 2 the average values of our outcome variables in the pre- and post-policy period. The figures suggest a reduction in *ScopeApplication* at both patent offices. The drop is particularly high at USPTO compared to CIPO. With respect to $\Delta Scope$, we observe an increase in the number of words' changes in U.S. twins. On the contrary, the latter variable decreased on average for twins filed at CIPO.

Table 2: Average outcomes by patent office, pre- vs. post-policy change

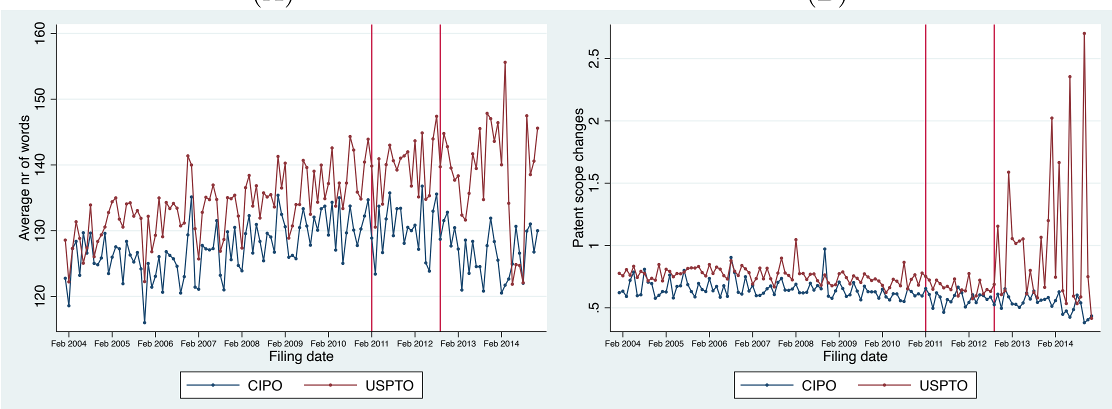
	ScopeApplication		$\Delta Scope$	
	Pre-policy	Post-policy	Pre-policy	Post-policy
USPTO	133.7	139.4	0.76	0.79
CIPO	127.4	128.2	0.65	0.57

A graphical analysis of the average inter-temporal trends of our dependent variables over the period 2004-2014 is shown in Figure 1. In Panel A, we observe an increase in the monthly average number of words in USPTO twins from February 2011. The same trend is not displayed in the corresponding CIPO twins.

In Panel B, we observe that the rise of $\Delta Scope$ is clearly postponed to September 2012. Interestingly, this coincides with the post-grant challenge procedures becoming effective (16th of September 2012).

Figure 1: Monthly average outcome variables over time at USPTO and CIPO (2004-2014)

(A) (B)

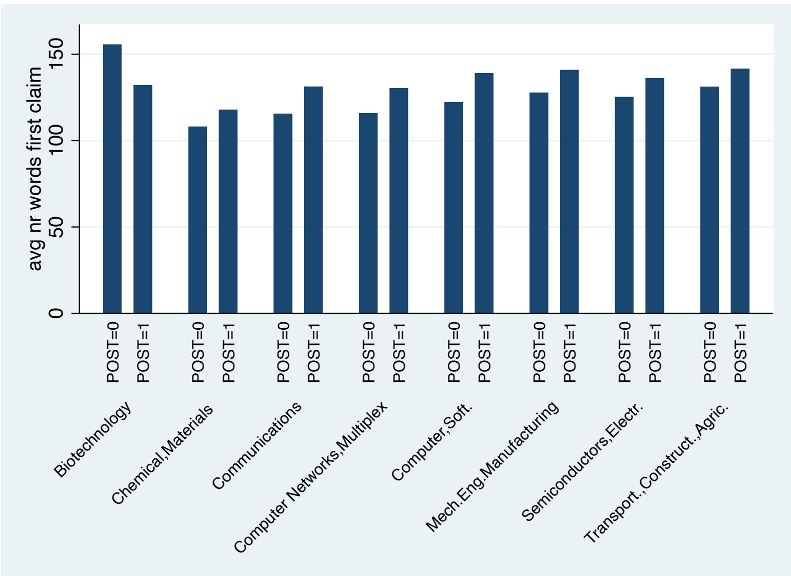


Panel A plots the trend over time of the outcome variable *ScopeApplication* and Panel B plots the trend over time of the outcome variable $\Delta Scope$ in the period 2004-2014, distinguishing USPTO and CIPO patents.

[19]Complete descriptive statistics and correlations of all the variables are reported in Table 12 and Table 13 of Appendix A

We show in Figure 2 and Figure 3 how our proxy of scope, measured by the number of words in the first claim, differs across examiners' art units[20]. We first note that the number of words in the first claim is the highest in the biotechnology artunit. In Figure 2, we display patent scope distinguishing the pre-post policy change. Apart from patents examined by the biotechnology art unit, the scope of patents has decreased in the second period compared to the first one. In Figure 3, we focus on U.S. twins and compare the scope of applications that have been challenged (C) through any of the procedures introduced by the AIA and applications that have not been challenged (NC). Information related to challenged U.S. patents via IPR, PGR or CBM after the policy change is available in PATSTAT. Interestingly, the figure shows that challenged patents have a broader scope compared to non challenged patents. This is true, on average, across art units. The only exception is Computer, Networks and Multiplex, in which the two groups on average coincide in terms of number of words. This early evidence suggests that firms are usually challenging broader patents, likely because they are not able to design around them, and aim to invalidate them to gain freedom to operate in their subsequent follow-on innovation (Gaessler et al., 2021). A remarkable example is the very recent IPR procedure filed by Moderna against the Canadian firm Arbutus Biopharma, regarding a mRNA technology. Experts in the field have argued that this administrative case shows that "Moderna is moderately fearful that it will not be able to design around Arbutus' patents, which is why it has tried to preemptively invalidate them"[21]. However, previous findings have also stressed how the incentive to use post-grant review mechanisms may be reduced in industries characterized by complex technologies and high density of patent thickets (Gaessler et al., 2021; Martinelli et al., 2022). This may explain why in Computer, Networks and Multiplex we found no difference between challenged and not challenged patents.

Figure 2: Number of words in the first claim across art units and pre-post policy change



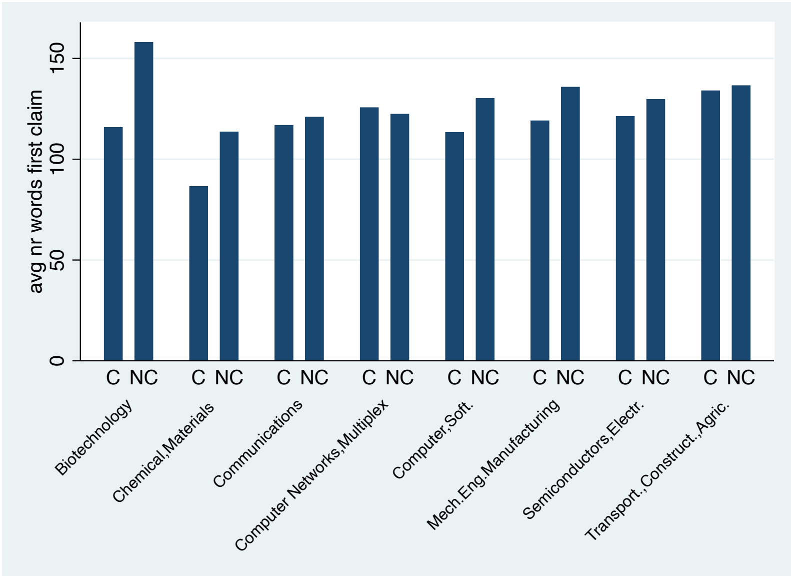
Our own elaboration on twins filed at USPTO and CIPO between 2004 and 2014

In Table 3 and 4 we display the results of our Diff-in-Diff regression for both outcome variables. Treated

[20]The art unit corresponds to the specific technology center of the patent office to which the application is assigned during the application procedure.

[21]See https://www.markmanadvisors.com/blog/2018/12/17/does-moderna-therapeutics-pipeline-depend-upon-its-patent-dispute-with-arbutus-biopharma-over-mrna-delivery

Figure 3: Number of words in the first claim across art units and challenged-not challenged patents



Our own elaboration on twins filed at USPTO between 2010 and 2014

patents are patents filed at the USPTO (dummy $U.S. = 1$) and examined after the policy change (dummy $POST = 1$). By including the DOCDB family fixed effect, we directly compare the outcomes of the twins in each pair. In Columns 1 of Table 3 we show the estimates of a specification that includes the main variables, their interactions and month-year fixed effects. In Column 2 we add the PCT route dummy. In Column 3 we add DOCDB-family fixed effects. Finally, in the last column we exclude all the patents examined by the Biotechnology art unit, because the use of the Markush language does not guarantee that the differences in the number of words in the claims correctly measures differences in the scope of patents (Kuhn and Thompson, 2019; Marco et al., 2019). The results in Table 3 suggest an increase in the number of words in U.S. patent application due to the AIA reform. The interaction coefficient shows that the U.S. policy change causes patent claims to have 4.03 words more compare to the control group of Canadian patents. This evidence indicates an overall reduction of patent scope due to the introduction of post-grant validity challenges. Table 4 displays the result of the Diff-in-Diff analysis using the patent scope changes as dependent variable. We note that the PCT route regards the application procedure and the definition of prior art, but does not characterize patents once they are granted in any receiving patent office. For this reason, we do not include PCT applications in this additional analysis in which we focus on patents that are granted[22]. In the third column we exclude patents assigned to the Biotechnology art unit. Finally, in the last column, we perform the regression analysis by changing the way in which we define the pre-post policy change. In line with the trends observed in Figures 1, we use the date in which the post-grant procedures becomes effective (16th September 2012). In all the specifications, the interaction term $POST \times US$ displays a positive and significant coefficient, indicating that the policy change increases the effort

[22]The reason for the drop in the number of observations in this additional analysis is twofold: 1) we can compute the outcome variable only for patents that result in final grant at *both* patent offices, 2) the web scraping from Google Patent for twins granted at CIPO results in some missing observations (around 1.5% of the observations).

of examiners in reducing the scope of patents during the application procedure. As shown in the last column, the impact is particularly relevant from September 2012 on wards, date in which the most diffused post-grant procedure (inter partes review) becomes effective in the U.S..

Introducing post-grant validity challenges improves the legal quality of patents by creating the incentive for both applicants and examiners of narrowing the first claim of the application, thus reducing overly broad patents.

Table 3: Policy impact on the scope of patent applications (*ScopeApplication*)

	1	2	3	Exclusion of biotechnology art unit
POST	4.416	4.795	1.254	-1.069
	(5.698)	(5.702)	(4.325)	(2.578)
U.S.	6.326***	4.605***	4.452***	1.527***
	(0.136)	(0.149)	(0.133)	(0.124)
POST x U.S.	5.007***	4.658***	4.033***	4.354***
	(0.324)	(0.320)	(0.318)	(0.313)
PCT		16.44***	20.53***	19.55***
		(0.873)	(0.467)	(0.487)
Observations	670,024	670,024	670,024	519,818
R-squared	0.002	0.003	0.943	0.915
Month FE	YES	YES	YES	YES
Family FE	NO	NO	YES	YES

OLS estimates of Equation 2.
Robust standard errors in parentheses, clustered by patent family.
Legend: *** p<0.01, ** p<0.05, * p<0.1

Table 4: Policy impact on the patent scope change ($\Delta scope$)

	1	2	Exclusion of biotechnology art unit	Policy change: IPR becoming effective
POST	-0.00142	-0.139**	-0.155**	-0.151
	(0.093)	(0.062)	(0.062)	(0.130)
U.S.	0.110***	0.111***	0.125***	0.107***
	(0.007)	(0.009)	(0.006)	(0.008)
POST x U.S.	0.117***	0.136***	0.144***	0.400***
	(0.037)	(0.040)	(0.044)	(0.101)
Observations	208,058	208,058	176,264	208,058
R-squared	0.002	0.577	0.568	0.577
Month FE	YES	YES	YES	YES
Family FE	NO	YES	YES	YES

OLS estimates of Equation 2.
Robust standard errors in parentheses, clustered by patent family.
Legend: *** p<0.01, ** p<0.05, * p<0.1

5.1 Validity of the parallel trend assumption

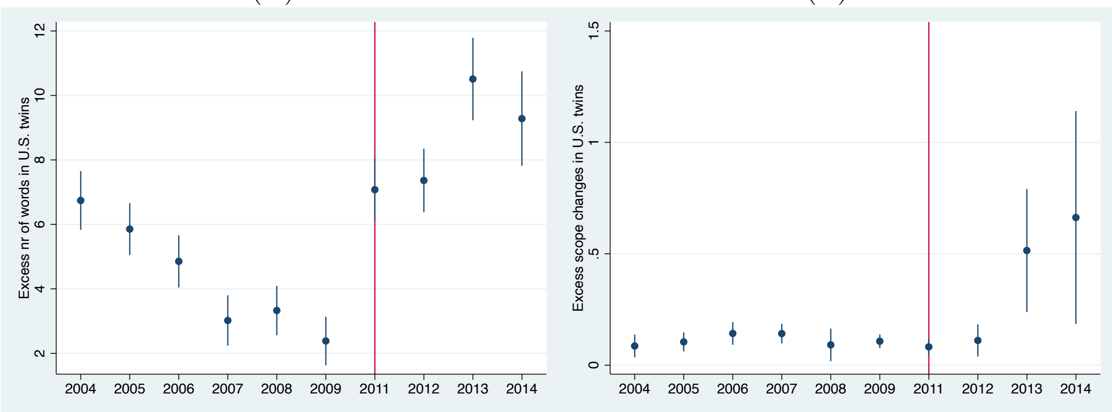
A key assumption required for the difference-in-differences approach is that the treated and control group have a parallel trend in the absence of the treatment. To provide support for this assumption, we extend our baseline model to estimate the year-specific differences between U.S. and CIPO twins over time, using the following specification:

$$Y_i = \beta_0 + \delta_1 US_i \times Year_i + bPCT_i + Year_{FE} + Family_{FE} + \epsilon_i \quad (3)$$

where 2011 is the baseline omitted period[23]. Figure 4 provides a graphical illustration of the estimated coefficients and their 95 percent confidence intervals. The results show that the increase in *ScopeApplication* and $\Delta Scope$ did not start before 2011 and is particularly relevant after 2012. This evidence support the common-trends assumption.

Figure 4: Impact of the AIA reform on patent scope, 2004-2014

(A) (B)



Panel A plots the yearly excess number of words of USPTO patents relative to CIPO (*ScopeApplication*). Panel B plots the yearly excess in scope changes of USPTO patents relative to CIPO ($\Delta Scope$). The blue lines represent 95 percent confidence bands calculated from standard errors clustered on the DOCDB family.

5.2 Heterogeneity across examiners' art unit and various degrees of patent thicktes

The preceding results show that the introduction of post-grant procedures to challenge the validity of issued patents improves the legal quality of patents, on average. However, the impact on both applicants and examiners' incentive may differ across technologies. To test heterogeneous effects of the AIA reform on U.S. patents' scope we perform our regression analysis (Equation 2) using split samples across art units. The findings are displayed in Table 5 and Table 6. Once using *ScopeApplication* as dependent variable, the coefficient $POST \times U.S.$ is positive and significant across all art unit, with the exception of Computer networks multiplex cable. In terms of magnitudes, some heterogeneity may be observed. By normalizing the coefficient by the average number of words in the first claim in each art unit (Table 15), we observe the largest impact in patents assigned to the Mechanical engineering manufacturing products art unit (5.92%). On the contrary, a much lower effect (1.47%) was found for applications examined by the Semiconductors electrical optical components art unit.

With respect to the applicant's incentive to react to the policy change, Table 5 suggests the presence of a peculiar mechanism occurring in high-tech fields. Previous studies on post-grant challenges, focusing on the EPO procedures, have found that the use of such administrative procedures may differ across fields characterized by

[23] We average our dependent variables over the year to reduce the noise in the monthly estimates.

different concentration of patent thickets (Harhoff, Graevenitz, et al., 2016; Gaessler et al., 2021). If the density of patent thickets is high, inventions are spread across many patents. In such fields, succeed in invalidating a patent during an administrative procedure does not guarantee freedom to operate in subsequent follow-on innovation, reducing the incentive of using this kind of procedure. We therefore test whether a similar mechanism is present in our data as well. To proxy the density of patent thickets we use the measure developed by Graevenitz et al. (2011). This indicator measures the frequency by which a patent applicant simultaneously "blocks" and "is blocked" by other firms in a specific field. Following the approach by Martinelli et al. (2022), fields are defined by the concordance table developed by Van Looy et al. (2014), identifying 27 distinct sectors. We construct a dummy variable ($HighThickets_j$) which is equal to one whether the field is characterized by high density of patent thickets[24]. In the last column of Table 5 we show the results of an additional analysis, based on the following specification:

$$
\begin{aligned}
Y_{i,j} = \beta_0 + \beta_1 US_i + \beta_2 POST_i + \delta_1 US_i \times POST_i + \\
\delta_2 US_i \times POST_i \times HighThickets_j + bPCT_i + Month_{FE} + Family_{FE} + \epsilon_{i,j}
\end{aligned}
\tag{4}
$$

In this case, the coefficient of interest is the triple interaction $US_i \times POST_i \times HighThickets_j$ which estimates the differential impact of the AIA reform in fields characterized by high density of patent thicktes. The coefficient of the interaction $US_i \times POST_i$ is positive and significant, meaning that legal quality improves in fields characterized by low values of patent thickets. On the contrary, applicants' incentive to reduce the scope of patents is not present in technological fields characterized by high density of patent thickets, where we instead find that the scope reduces.

Turning to the policy impact on the patent scope change (Table 6), we find a positive and significant impact of the AIA reform only in two out of eight art units, namely in Semiconductors Electrical Components and Transportation, Construction and Agriculture. Once we postpone the date of the shock to the time in which the procedure of IPR becomes effective, we find a positive and significant coefficient also for the Chemical and materials art unit. This evidence suggests not only a much higher degree of heterogeneity across art units once focusing on the examiners' incentive, but also confirms that the process of adaptation of the examiners to the new incentive mechanism is much slower than that of applicants. Heterogeneous impact of the AIA reform across art units may reflect different degrees of specialization of the examiners and various degrees of stringency of the examination across art units. Righi and Simcoe (2019) find that examiners' specialization is less pronounced in computers and software compared to other art units. This may explain why the AIA reform has no impact in these art units. Moreover, the incentive to reduce the scope of applications, provided by the introduction of post-grant review, might fail in cases of high turnover of examiners. Tabakovic and Wollmann (2018)'s evidence indicates that patent examiners are more lenient while examining patents of firms that later hire them. In our analysis, the existence of post-grant review may spur examiners to more carefully examine an application only if

[24] In Table 15 we show the distribution of patent thickets across art unit. Not surprisingly, the number of triads is particularly high in complex fields such as Compute software information security, Computer networks multiplex cable, Communications and Semiconductors Eletrical Optical Components. In the other art units, the average number of triads is around eight times less.

Table 5: Policy impact on the scope of patent applications ($ScopeApplication$) across art units and high-low patent thickets

	Biotech.	Chemical and materials	Computer software information security	Computer networks multiplex cable	Communi-cations	Semi-conductors Electrical Optical Components	Transport. Construct. Agriculture	Mechanical Engineering Manufacturing Products	High-Low patent thicktes
POST	16.28	-8.531**	0.0834	3.805	7.116*	-8.232	-2.032	5.735	0.272
	(34.874)	(3.628)	(2.916)	(11.562)	(4.155)	(8.427)	(3.205)	(7.629)	(4.344)
U.S.	12.78***	2.856***	3.795***	2.267***	1.635***	0.753**	1.589***	-0.511**	4.185***
	(0.385)	(0.242)	(0.743)	(0.530)	(0.400)	(0.306)	(0.260)	(0.259)	(0.192)
POST x U.S.	6.021***	1.852***	4.600***	1.077	4.202***	1.899**	3.240***	7.830***	7.753***
	(0.945)	(0.589)	(1.748)	(0.954)	(1.202)	(0.748)	(0.612)	(0.656)	(0.480)
PCT	23.79***	20.55***	4.853***	9.174***	7.899***	11.90***	14.80***	23.98***	20.29***
	(1.238)	(1.280)	(1.773)	(1.816)	(1.573)	(1.284)	(1.335)	(0.829)	(0.465)
High Thickets									-0.0517
								(0.344)	
POST x High thickets									2.066***
									(0.695)
U.S. x High thickets									0.561**
									(0.285)
POST x U.S. x High thickets									-8.265***
									(0.626)
Observations	150,206	122,174	16,696	25,030	30,992	62,598	96,408	153,098	670,024
R-squared	0.959	0.909	0.906	0.916	0.909	0.919	0.919	0.891	0.943
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Family FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

OLS estimates of Equation 2 (columns 1-8) and Equation 4 (column 9).
Robust standard errors in parentheses, clustered by patent family.
Legend: *** p<0.01, ** p<0.05, * p<0.1

Table 6: Policy impact on the patent scope change ($\Delta scope$) across art units

	Biotech.	Chemical and materials	Computer software information security	Computer networks multiplex cable	Commun-ications	Semi-conductors Electrical Optical Components	Transport. Construct. Agriculture	Mechanical Engineering Manufacturing Products	High-Low patent thickets
POST	-0.213	0.0846	-0.0288	-0.137	-0.184	-0.0349	-0.277*	-0.233*	-0.0639
	(0.658)	(0.192)	(0.165)	(0.140)	(0.228)	(0.093)	(0.145)	(0.124)	(0.072)
U.S.	0.0545	0.127***	0.0993***	0.252***	0.0979***	-0.00131	0.0978***	0.197***	0.122***
	(0.033)	(0.015)	(0.021)	(0.017)	(0.012)	(0.014)	(0.020)	(0.009)	(0.010)
POST x U.S.	0.0466	0.185	0.221	-0.0531	0.210	0.197**	0.200*	0.0704	0.109**
	(0.071)	(0.113)	(0.242)	(0.098)	(0.162)	(0.086)	(0.105)	(0.080)	(0.054)
High Thickets									0.0331
									(0.030)
POST x High thickets									-0.140*
									(0.077)
U.S. x High thickets									-0.0234
									(0.015)
POST x U.S. x High thickets									0.0570
									(0.079)
Observations	31,794	40,564	5,484	9,964	12,064	25,346	38,044	44,656	208,058
R-squared	0.607	0.555	0.674	0.673	0.595	0.579	0.545	0.593	0.577
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Family FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

OLS estimates of Equation 2 (columns 1-8) and Equation 4 (column 9).
Robust standard errors in parentheses, clustered by patent family.
Legend: *** p<0.01, ** p<0.05, * p<0.1

he or she is remaining at the patent office for a sufficient period of time. Only in these cases, the examiner fears future re-examinations and subsequent negative consequences for his/her future career.

Finally, the presence of patent thickets does not affect the work of patent examiners (column 9, Table 6). This latter result is not surprising, since the above mentioned diverging mechanisms occurring in fields characterized by thickets regards the behaviour of patent applicants but do not interest the work of patent examiners.

5.3 Heterogeneity across patent value

Our results indicate an improvement in the legal quality as a response to the introduction of post-grant validity challenges. Across art unit, the positive impact of the reform is mainly driven by the applicant's incentive to reduce the scope from the initial filing of the application. In this section we test whether applicants' drafting strategies may diverge depending on the underlying value of the application. In order to disentangle more valuable patents at the time of filing, we use PCT applications (Frietsch and Schmoch, 2010) and the DOCDB family size. PCT filings are used by applicants seeking international protection for their invention. The PCT route allows applicants to file other national applications within 30 months from the priority application, postponing the cost of national applications and delaying the decision of whether to file national applications and in which countries (Dechezleprêtre et al., 2017). The indicator of family size instead is computed as the number of jurisdictions in which the patent is filed within the DODDB family. The idea behind these measures of patent value is that a patent should be more valuable if, at the time of filing, the applicant faces an higher cost to acquire a larger market scope, seeking protection of the invention in other countries. In this case, we frame our regression analysis as follows:

$$\begin{aligned} Y_i = \beta_0 + \beta_1 US_i + \beta_2 POST_i + \delta_1 US_i \times POST_i + \\ \delta_2 US_i \times POST_i \times PatentValue_i + Month_{FE} + Family_{FE} + \epsilon_i \end{aligned} \tag{5}$$

with $PatentValue$ computed either as a dummy equal to one whether the application is filed via the PCT route or as the logarithm of the size of the patent family. Since the latter variable does not vary within the same family, in the latter specification we do not include family fixed effects but a set of alternative fixed effects.

The results are displayed in Table 7. The effect of introducing post-grant challenges on the applicant's incentive to narrow the scope of the application is greater for high-value patents. Applicants react to the policy change by improving the legal quality of those patents that are particularly valuable, while caring less for low-value applications. An alternative interpretation may be that applicants expect patent challenges to occur more likely against patents of higher value.

6 Robustness checks

6.1 Validity of the twins-approach and the underlying assumptions

The main assumption of our empirical analysis is that the twin pairs that we identified using the DOCDB definition are equivalent with respect to the underlying invention, but differ in terms of claims' text as a response to different legal settings of the two patent offices. Moreover, our identification strategy rests on the assumption that the U.S. patent reform does not indirectly affect the way in which claims of the corresponding twin at CIPO are written. Corroborating these assumptions means providing support to our choice in terms of reliable counterfactual but

Table 7: Policy impact on the scope of patent applications (*ScopeApplication*) across patents with different value

	1	2	3	4
POST	2.567	6.680	9.821	15.76***
	(4.307)	(6.011)	(5.994)	(5.955)
U.S.	4.554***	2.573***	2.367***	2.500***
	(0.131)	(0.437)	(0.444)	(0.441)
POST x U.S.	0.269	2.235**	2.343**	2.191**
	(0.290)	(1.032)	(1.042)	(1.039)
PCT	2.633***	17.58***	17.79***	15.64***
	(0.439)	(0.783)	(0.636)	(0.839)
POST x PCT	4.189***			
	(0.763)			
U.S. x PCT	14.09***			
	(0.786)			
POST x U.S. x PCT	18.87***			
	(1.596)			
log(family size)		7.747***	9.407***	11.13***
		(0.510)	(0.534)	(0.529)
POST x log(family size)		-1.515*	-3.069***	-6.802***
		(0.886)	(0.912)	(0.898)
U.S. x log(family size)		1.046***	1.122***	1.149***
		(0.229)	(0.232)	(0.233)
POST x U.S. x log(family size)		0.923*	0.885*	1.056**
		(0.530)	(0.535)	(0.534)
Observations	670,024	656,653	669,256	668,742
R-squared	0.943	0.101	0.113	0.061
Month FE	YES	YES	YES	YES
Family FE	YES	NO	NO	NO
Artunit FE	NO	YES	NO	NO
Examiner FE	NO	NO	YES	NO
IPC 4dgt FE	NO	NO	NO	YES

OLS estimates of Equation 5.
Robust standard errors in parentheses, clustered by patent family.
Legend: *** p<0.01, ** p<0.05, * p<0.1

also confirmation of the mechanisms being in place. In Table 8 we provide evidence that the twins in our sample are filed in either the same exact date or very closed in time at the two patent offices. In this way, we rule out the

Table 8: Difference in days in the twins' filing dates

	Nr. Obs.	25th percentile	Median	75th percentile	95th percentile	Mean	Min	Max	Std.Dev.
Difference between filing dates, nr days	341,846	0	0	115	365	95	0	3,542	174.774

possibility that one of the twins may be subject to modifications and amendments in time, differentiating from the other. Not only the twins refer to the same DOCDB family and underlying invention, but they very likely coincide in terms of content, since they are filed at the same time at the two patent offices. However, the parties responsible for the applications at the two patent office, namely the attorneys, are usually different entities[25]. In

[25]In most of the cases, the party involved in the application, with which the patent office is meant to correspond, is a "law firm or the legal department of a commercial enterprise" (Miller, 2020). Recent findings by Rassenfosse, Jensen, et al. (2021) suggest that patent attorney firms have a surprisingly large role in the patent system.

our sample, only in 0.38% of the cases the two applications are filed by the same attorney at both patent offices[26]. This may explain the variability of the claims' texts among the twins. In our sample, in most of the cases, the country of origin of these entities coincides with the one of the corresponding patent office (Rassenfosse, Jensen, et al., 2021). Applications are therefore filed by legal parties that are well aware of the specific legal settings of each national patent office. Using this knowledge, patent attorneys may slightly adapt the claims' text in order to both fulfill the specific requirements of each legal system but also to obtain the broadest scope possible inside the institutional boundaries. As stated in Section 2, applicants' attempt is usually to obtain a grant with the largest scope, in order to increase the probability of protecting future variations of the core invention and block competitors' follow-on innovation. With this respect, we believe that changes in the legal setting of one patent system do not affect the way in which the text is written in the other patent office. Rephrasing, adding or removing words to the claims is occurring at each patent office independently, as a response to specific legal settings and requirements of each patent office.

We provide evidence supporting our assumption by presenting here the results of two additional exercises, using a triple interaction regression analysis. Our first exercise estimates AIA's effects in our twin analysis for priority and non-priority U.S. patents[27]. Our prior is that if the U.S. twin is the first application it should be affected more by the AIA reform relative to those cases in which the first application is filed at CIPO. To implement this triple difference analysis, we augment Equation (1) with an indicator whether the patent is a priority in the U.S. or not:

$$\begin{aligned} Y_i = \beta_0 + \beta_1 US_i + \beta_2 POST_i + \delta_1 US_i \times POST_i + \\ \delta_2 US_i \times POST_i \times Priority_i + bPCT_i + Month_{FE} + Family_{FE} + \epsilon_i \end{aligned} \tag{6}$$

As shown in Table 9 we find a positive and significant coefficient of the interaction $POST \times U.S. \times Priority$ for both outcome variables. Applicants' incentive to reduce patent scope is found for those patents filed first in the U.S. and than at CIPO. In the same way, examiners put more effort in applications with U.S. priority. On the contrary, the positive impact of the reform is not found in non-priority patents, using both outcome variables. The results shown suggest that the positive impact of the AIA reform on U.S. legal quality is entirely driven by U.S. priority patents. We believe that this finding stresses the importance of patent office's specific legal setting on the ways claims are written.

Our second exercise consists in assessing the impact of the AIA reform distinguishing patents filed by either local or non-local applicants[28]. We expect local U.S. applicants to be more sensible to their own legal setting compared to foreigners. In this case, we use the following regression specification:

Particularly so at USPTO, the quality of the attorney is a better predictor of grant probability than invention quality.

[26]To retrieve the information about the patent attorney we use the Patent Examination Research Dataset (PatEx) for U.S. twins and the "Patent researcher datasets" for Canadian twins (available at: https://www.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/h$_w r04810.html$.

[27]Our measure of priority is a dummy equal to 1 whether the patent is, within each single twin pair, the first application. We note here that using this definition, priority patents are not necessarily the first application worldwide.

[28]The information about the country of origin of the patent's applicant is retrieved from table tls206-person in PATSTAT.

Table 9: Policy impact on patent scope across patents with priority and non-priority in the U.S.

	ScopeApplication	$\Delta Scope$
POST	4.846	0.0233
	(4.347)	(0.063)
U.S.	-1.110***	0.157***
	(0.386)	(0.035)
POST x U.S.	-6.091***	-0.340***
	(0.681)	(0.065)
Priority	-3.090***	-0.0127
	(0.289)	(0.018)
Post x Priority	-4.532***	-0.265***
	(0.533)	(0.062)
U.S. x Priority	7.191***	-0.0468
	(0.527)	(0.041)
POST x U.S. x Priority	11.29***	0.599***
	(0.976)	(0.118)
PCT	18.92***	
	(0.470)	
Observations	670,024	208,058
R-squared	0.943	0.577
Month FE	YES	YES
Family FE	YES	YES

OLS estimates of Equation 5.
Robust standard errors in parentheses family.
clustered by patent family.
Legend: *** p<0.01, ** p<0.05, * p<0.1

$$Y_i = \beta_0 + \beta_1 US_i + \beta_2 POST_i + \delta_1 US_i \times POST_i + \delta_2 US_i \times POST_i \times Local_i + bPCT_i + Month_{FE} + Family_{FE} + \epsilon_i \quad (7)$$

Table 10: Policy impact on patent scope across patents with local and non-local applicants

	ScopeApplication	$\Delta Scope$
POST	-0.681	-0.106*
	(4.405)	(0.061)
U.S.	0.765***	0.131***
	(0.158)	(0.011)
POST x U.S.	-5.726***	0.271***
	(0.272)	(0.070)
Local	-6.362***	0.0387*
	(0.404)	(0.020)
POST x Local	-0.916	0.188***
	(0.601)	(0.062)
U.S. x Local	13.77***	-0.0747***
	(0.511)	(0.027)
POST x U.S. x Local	21.55***	-0.504***
	(0.928)	(0.127)
PCT	14.57***	
	(0.537)	
Observations	614,536	205,938
R-squared	0.942	0.577
Month FE	YES	YES
Family FE	YES	YES

OLS estimates of Equation 6.
Robust standard errors in parentheses,
clustered by patent family.
Legend: *** p<0.01, ** p<0.05, * p<0.1

The results displayed in Table 10 suggest that the incentive to reduce patent scope bites local applicants only. On the contrary, examiners increase their effort during the application procedure only while dealing with patents filed by foreign applicants. While the AIA reform generates an incentive to narrow the scope of patents only for local U.S. applicants, examiners balance this discrepancy by improving their effort during the application procedures of patents filed by non-local applicants.

As an additional exercise, we use a text-based similarity algorithm[29] on a sample of ten randomly selected pairs of twins to check whether they differ in the ways they are written (Table 11). We conduct this exercise on both the text of the patent's abstract and patent's first claim. The findings suggest that, in the same DOCDB patent family, both abstracts' and claims' text are very similar but do not often coincide. This is particularly true for the text of the claims, that legally defines the scope of patents. We interpret this result as an additional evidence of the fact that applicants and attorneys have different degrees of freedom in defining the scope of patents depending on the specific legal setting of the patent office. In Appendix A we show some examples of twin pairs

Table 11: Assessing the closeness of patents in the same family using a text-similarity algorithm

	Text-similarity score	
	First claim	Abstract
Average	0.84	0.84
Median	0.93	0.98

Based on 10 random pairs of USPTO-CIPO twins in our sample. Text similarity score obtained from the *Max Planck Logic Mill.*

in our sample. While the text of the abstracts does not change in the cases reported, the word count of the first claims differs, due to a better characterization of the invention.

As an additional robustness test to ensure the validity of our twins-approach we replicate our analysis by keeping all the patents in each DOCDB family, without focusing on single pairs of twins. The results are shown in Table 18 of Appendix E.

6.2 Alternative fixed effects

To test the robustness of our results, we run the regression analysis based on Equation 1 for both outcome variables using a set of alternative specifications with a variety of different fixed effects. In particular, we separately include: i) patent examiner fixed effects, ii) IPC class at four digit fixed effects, iii) patent office's art unit fixed effects iv) applicant fixed effects and v) attorney's fixed effects. Across this wide range of specifications, we find very similar results (see Table 16 and 17 in Appendix C)

6.3 Placebo AIA date

As describe in Section 4.3, in our analysis we select the pre- and post-policy period using the date of the first legislative step of the AIA reform (February 3rd, 2011). To rule out spurious effects driving the results, we use an earlier fictitious date (3rd February 2007). The findings are displayed in Table 19 and 20. We find that the coefficient δ_1 is not significant using *ScopeApplication* as outcome variable, suggesting that our results are not

[29]We employ the Max Planck Logic Mill available at https://app.logic-mill.net/app/lm/similarity/. We thank Dietmar Harhoff, Ghosh Mainak and Sebastian Erhardt for making these data available to us.

biased by spurious trends. Once using $\Delta Scope$ as dependent variable, the coefficient is significant but close to zero. As an additional exercise, we exclude the year before February 3rd, 2011 to deal with potential anticipation effects (Table 19 and Table 20). Also in this case, we find very similar results to those presented in Table 3 and Table 4. In the same tables, we also displayed the results once setting the date of the policy change as either the date in which the AIA is signed into law (16th of September 2011) or as the date in which the most common procedure of post-grant review becomes effective (16th of September 2012)[30]. As expected, we find higher coefficients of $POST \times US$ compared to the main results.

6.4 Other robustness checks

As an additional robustness check, we use alternative regression models to compare the results with our main OLS estimates. Given the nature of our dependent variable, we use a count model. We find that the results are robust once using the Poisson model (see Appendix F).

Finally, to test the sensitivity of our results once using $\Delta Scope$ as outcome variable, we run our analysis using the latter variable computed as in Equation 1 without the absolute value (see Appendix F). Once again, the results are very closed to those of the main analysis.

7 Conclusions

The impact of introducing procedures of post-grant review on the quality of patents is an empirical question that this paper addresses. These administrative procedures aim to provide an error correction mechanism to the work of patent offices, allowing any third party to challenge the validity of newly granted patents. Since overly broad or vague claims often characterize questionable patents (i.e. patents that might be invalid), we test whether post-grant review incentivizes drafting claims narrowly, reducing the scope of patents and enhancing their legal quality.

We exploit the AIA reform enacted into U.S. law in 2011 as a natural experiment to estimate the effect of introducing post-grant review. We use a patent-level Diff-in-Diff analysis and a twin-patents approach to build counterfactuals. Following recent literature (Kuhn and Thompson, 2019; Marco et al., 2019), we proxy patents legal quality using patent scope measured as the number of words in the first patent claim.

We distinguish two main channels through which the AIA may enhance the U.S. patent legal quality. On one side, applicants may react to the policy change by filling out narrower (in scope) applications to reduce the risk of invalidation and costly challenges. Conversely, a post-grant review may prompt examiners' efforts to improve their examination of applications. Many requests for re-examinations may cause negative consequences for examiners' future careers, thus providing an incentive mechanism to reduce leniency while examining applications.

Our findings suggest a rise in patent legal quality due to the introduction of post-grant challenge proceedings. Both applicants and examiners react to the AIA reform by narrowing patent claims and reducing the scope of patents. Applicants particularly respond to the policy change for valuable inventions filed in discrete technologies.

[30] In the case of $\Delta Scope$ as outcome variable, this latter exercise is presented also in Table 4, as we believe that the examiners react to the policy change from this date on wards (see also Figure 1 for a graphical representation of the trend over time).

Examiners respond slower to the new incentive mechanism, improving their effort only in specific art units of the patent office. Moreover, the disciplinary effect of post-grant review bites local U.S. applicants only because they are more aware of the national legal settings. On the contrary, examiners reduce their leniency in applications filed by foreigners.

This paper studies the effectiveness of post-grant review on a specific dimension of patent quality, namely the legal quality of claims. While this could be seen as a limit, our choice derives from recent evidence suggesting that patent quality indicators are "consistently inconsistent" (Higham et al., 2021). It follows that the selection of the metric to proxy patent quality should be appropriate to the research question and "consider the norms and legal strategies involved in patent drafting" (Higham et al., 2021). As suggested by Marco et al. (2019), we think that measures of patent claim length represent the most suited available proxies to test the effectiveness of post-grant review introduction.

Although we can not generalize our findings to other patent quality notions, our study has relevant implications for policy. We indicate that post-grant review incentivizes applicants and examiners to narrowly draft patent claims, suggesting feasible ways of improving the patent system. Since "patent scope is at the front and center of debates surrounding patent quality in legal and public policy communities" (Marco et al., 2019), we would therefore recommend other patent offices to consider the introduction of similar administrative procedures.

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Appendix

A Examples of twins pairs in our sample

Figure 5: DOCDB Family ID 8565412

Sensing arrangement

Abstract

The invention relates to an arrangement for sensing ambient conditions in electric equipment. These conditions may include verification of the user, the location of the equipment and various properties of the environment. The invention is preferably applied in mobile terminals. One idea of the invention is to provide a sensor arrangement with a substrate (**663**) that forms at least part of a sensor, and also serves as a substrate for other sensors (**695-698**). The substrate is preferably flexible so that it can be formed in a shape which is follows the shape of the device cover. The invention also describes a way to create two- or three-dimensional electrode structures that can be used to optimize the performance of the sensor. When the surface structure is designed to follow the shape of a finger, a very small pressure is required when sliding the finger along the sensor surface. This way the use of the sensor is ergonomic and the measurement is made very reliable.

Images (12)

Classifications

G06K9/00 Methods or arrangements for recognising patterns

View 8 more classifications

Claims (30) Hide Dependent

1. A sensor arrangement comprising at least one sensor, at least one integrated signal processing circuit for the measurement of signals from the at least one sensor, and interconnecting wiring between the at least one sensor and the integrated circuit, characterized in that the arrangement comprises a substrate, said substrate forming at least part of said interconnecting wiring and said substrate is further arranged to serve as a functional part of at least one said sensor.

US20050030724A1
United States

Download PDF Find Prior Art Similar

Inventor: Tapani Ryhanen, Kari Hjelt
Current Assignee : Nokia Technologies Oy

Worldwide applications

2003 FI 2004 JP DE US CN KR AU CA EP WO 2010 US JP

Application US10/763,805 events

2003-01-22 • Priority to FI20030101
2004-01-22 • Application filed by Nokia Oyj
2005-02-10 • Publication of US20050030724A1
2010-10-12 • Application granted
2010-10-12 • Publication of US7813534B2
Status • Active
2029-05-08 • Adjusted expiration

Show all events

Info: Patent citations (48), Cited by (128), Legal events, Similar documents, Priority and Related Applications
External links: USPTO, USPTO PatentCenter, USPTO Assignment, Espacenet, Global Dossier, Discuss

Improved sensing arrangement

Abstract

The invention relates to an arrangement for sensing ambient conditions in electric equipment. These conditions may include verification of the user, the location of the equipment and various properties of the environment. The invention is preferably applied in mobile terminals. One idea of the invention is to provide a sensor arrangement with a substrate (663) that forms at least part of a sensor, and also serves as a substrate for other sensors (695-698).
The substrate is preferably flexible so that it can be formed in a shape which is follows the shape of the device cover. The invention also describes a way to create two- or three-dimensional electrode structures that can be used to optimize the performance of the sensor. When the surface structure is designed to follow the shape of a finger, a very small pressure is required when sliding the finger along the sensor surface. This way the use of the sensor is ergonomic and the measurement is made very reliable.

Classifications

G06K9/00 Methods or arrangements for recognising patterns

View 8 more classifications

Claims (14) Hide Dependent

1. A sensor arrangement comprising at least one sensor (322, 622, b9b), at least one integrated signal processing circuit (380, 680) for the measurement of signals from the at least one sensor, and interconnecting wiring (323, 324) between the at least one sensor and the integrated circuit, wherein the arrangement comprises a substrate, said substrate forming at least part of said interconnecting wiring and said substrate is further arranged to serve as a functional part of at least one said sensor, characterized in that said substrate comprises means for forming a sensor together with a sensor part, wherein said substrate and said sensor part are galvanically separated, and wherein said substrate and said sensor part comprise means for transferring energy and measurement information inductively between said substrate and said sensor part.

CA2513908A1
Canada

Download PDF Find Prior Art Similar

Other languages: French
Inventor: Tapani Ryhaenen, Kari Hjelt
Current Assignee : Nokia Oyj

Worldwide applications

2003 FI 2004 JP DE US CN KR AU CA EP WO 2010 US JP

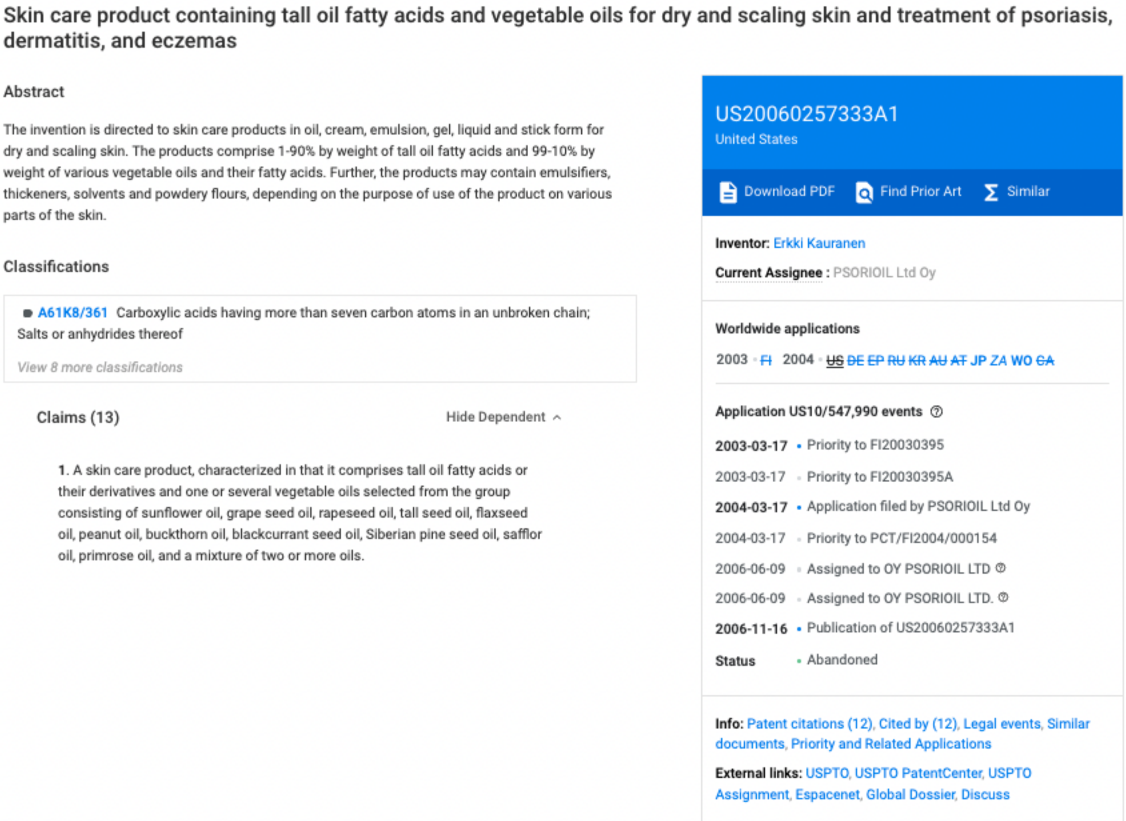
Application CA002513908A events

2003-01-22 • Priority to FI20030101
2003-01-22 Priority to FI20030101A
2004-01-22 • Application filed by Nokia Corporation, Tapani Ryhaenen, Kari Hjelt
2004-01-22 Priority to PCT/FI2004/000031
2004-08-05 • Publication of CA2513908A1
Status • Abandoned

Info: Patent citations (48), Cited by (128), Legal events, Similar documents, Priority and Related Applications
External links: Espacenet, Global Dossier, CIPO, Discuss

Source: Google Patent

Figure 6: DOCDB Family ID 8565819



Skin care product containing tall oil fatty acids and vegetable oils for dry and scaling skin and treatment of psoriasis, dermatitis, and eczemas

Abstract

The invention is directed to skin care products in oil, cream, emulsion, gel, liquid and stick form for dry and scaling skin. The products comprise 1-90% by weight of tall oil fatty acids and 99-10% by weight of various vegetable oils and their fatty acids. Further, the products may contain emulsifiers, thickeners, solvents and powdery flours, depending on the purpose of use of the product on various parts of the skin.

Classifications

- A61K8/361 Carboxylic acids having more than seven carbon atoms in an unbroken chain; Salts or anhydrides thereof

View 8 more classifications

Claims (13)

Hide Dependent

1. A skin care product, characterized in that it comprises tall oil fatty acids or their derivatives and one or several vegetable oils selected from the group consisting of sunflower oil, grape seed oil, rapeseed oil, tall seed oil, flaxseed oil, peanut oil, buckthorn oil, blackcurrant seed oil, Siberian pine seed oil, safflor oil, primrose oil, and a mixture of two or more oils.

US20060257333A1
United States

Download PDF | Find Prior Art | Similar

Inventor: Erkki Kauranen

Current Assignee : PSORIOIL Ltd Oy

Worldwide applications

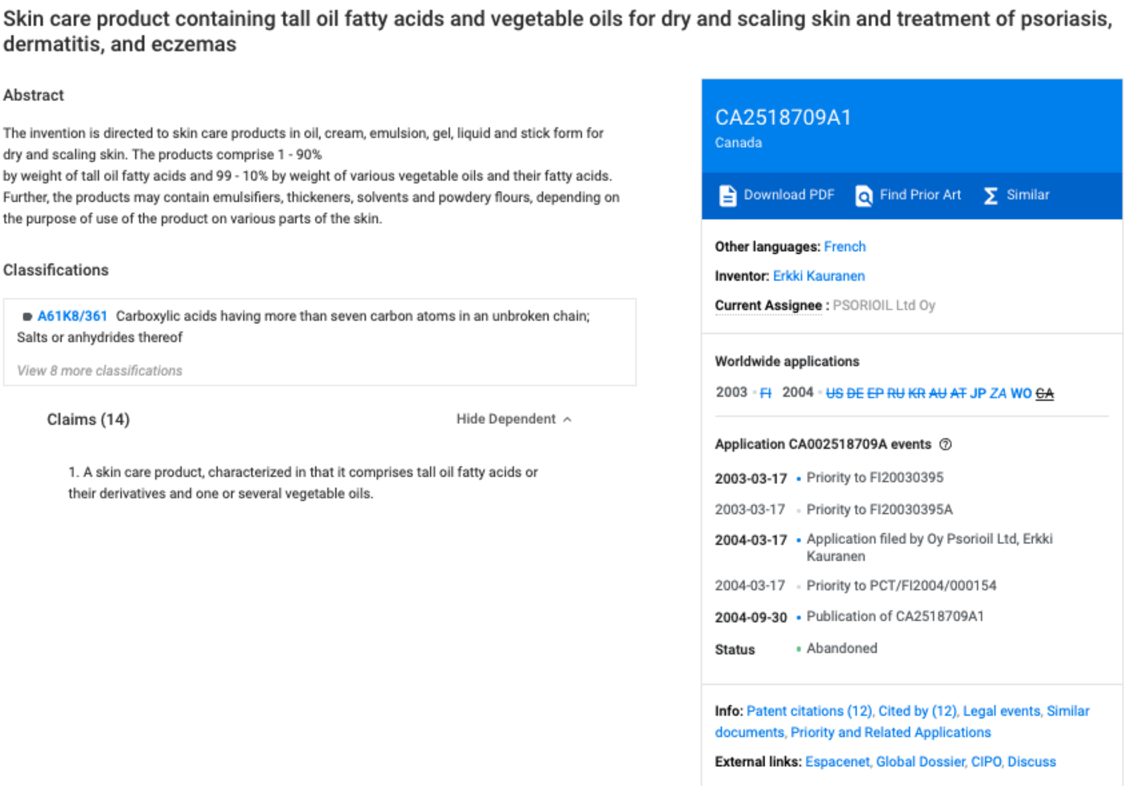
2003 · FI 2004 · US DE EP RU KR AU AT JP ZA WO CA

Application US10/547,990 events

2003-03-17	Priority to FI20030395
2003-03-17	Priority to FI20030395A
2004-03-17	Application filed by PSORIOIL Ltd Oy
2004-03-17	Priority to PCT/FI2004/000154
2006-06-09	Assigned to OY PSORIOIL LTD
2006-06-09	Assigned to OY PSORIOIL LTD.
2006-11-16	Publication of US20060257333A1
Status	Abandoned

Info: Patent citations (12), Cited by (12), Legal events, Similar documents, Priority and Related Applications

External links: USPTO, USPTO PatentCenter, USPTO Assignment, Espacenet, Global Dossier, Discuss



Skin care product containing tall oil fatty acids and vegetable oils for dry and scaling skin and treatment of psoriasis, dermatitis, and eczemas

Abstract

The invention is directed to skin care products in oil, cream, emulsion, gel, liquid and stick form for dry and scaling skin. The products comprise 1 - 90%
by weight of tall oil fatty acids and 99 - 10% by weight of various vegetable oils and their fatty acids. Further, the products may contain emulsifiers, thickeners, solvents and powdery flours, depending on the purpose of use of the product on various parts of the skin.

Classifications

- A61K8/361 Carboxylic acids having more than seven carbon atoms in an unbroken chain; Salts or anhydrides thereof

View 8 more classifications

Claims (14)

Hide Dependent

1. A skin care product, characterized in that it comprises tall oil fatty acids or their derivatives and one or several vegetable oils.

CA2518709A1
Canada

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Other languages: French

Inventor: Erkki Kauranen

Current Assignee : PSORIOIL Ltd Oy

Worldwide applications

2003 · FI 2004 · US DE EP RU KR AU AT JP ZA WO CA

Application CA002518709A events

2003-03-17	Priority to FI20030395
2003-03-17	Priority to FI20030395A
2004-03-17	Application filed by Oy Psorioil Ltd, Erkki Kauranen
2004-03-17	Priority to PCT/FI2004/000154
2004-09-30	Publication of CA2518709A1
Status	Abandoned

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Source: Google Patent

B Descriptives

Table 12: Dependent and independent variables in the regression analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
ScopeApplication	670,024	131.55	147.06	1	11,520
$\Delta Scope$	208,058	0.69	2.42	0	332
U.S.	670,024	0.5	0.5	0	1
POST	670,024	0.31	0.46	0	1
month-year	670,024	590.01	36.41	528	659
PCT	670,024	0.08	.28	0	1
High thickets	670,024	0.5	0.5	0	1
Priority	670,024	0.8	0.4	0	1
Local	642,238	0.30	0.46	0	1

Table 13: Correlation coefficients - *ScopeApplication*

	Scope Application	U.S.	POST	month-year	PCT	High Thickets	Priority	Local
Scope Application	1							
U.S.	0,032	1						
POST	0,007	0,017	1					
month-year	0,011	0,027	0,816	1				
PCT	0,035	0,219	0,015	0,011	1			
High Thickets	0,036	0,016	-0,067	-0,061	-0,003	1		
Priority	0,030	0,272	0,026	0,023	0,117	-0,028	1	
Local	0,013	0,481	-0,004	-0,010	0,460	0,023	0,215	1

Table 14: Correlation coefficients - $\Delta Scope$

	Delta Scope	U.S.	POST	month-year	High Thickets	Priority	Local
Delta Scope	1						
U.S.	0,029	1					
POST	-0,006	-0,021	1				
month-year	-0,008	-0,025	0,753	1			
High Thickets	-0,007	0,016	-0,006	-0,005	1		
Priority	0,009	0,329	-0,021	-0,024	-0,028	1	
Local	0,014	0,450	-0,036	-0,046	0,032	0,242	1

Table 15: Descriptives across art units

	Biotechnology	Chemical and materials	Computer software information security	Computer networks multiplex cable	Communi-cations	Semiconductors Electrical Optical Components	Transportation Construction Agriculture	Mechanical Engineering Manufacturing Products
Avg. nr words first claim	149.25	111.14	128.12	121.1	119.56	128.68	134.83	132.23
Density patent thickets	7,799.28	6,421.51	35,658.37	40,474.2	33,926.63	23,602.88	8,416.89	7,435.29

C Alternative fixed effects

We provide here the regression results of alternative specifications of Equation 1 with a variety of fixed effects for both outcome variables (Table 16 and Table 17). In Column 1 we include fixed effects at the art unit level[31]. In Column 2 the fixed effects are at the four digit IPC level. In Column 3 we add fixed effects based on the name of the examiner in charge of the application procedure at the patent office[32]. In Column 4 we instead include fixed effects at the attorney level[33]. Attorneys are parties involved in the application procedure, with which the patent office is meant to correspond. It is usually a law firm or the legal department of a firm. This information is not available for PCT patents. Finally, in the last column, we add applicants' fixed effects[34]. Our main results are confirmed.

Table 16: Policy impact on the on the scope of patent applications (*ScopeApplication*)

	Art unit FE	IPC 4dgt FE	Examiner FE	Attorney FE	Applicant FE
POST	3.770	2.316	3.961	3.804	6.084
	(5.819)	(5.760)	(5.788)	(5.341)	(8.102)
U.S.	4.723***	4.892***	4.740***	-6.511***	6.273***
	(0.138)	(0.148)	(0.138)	(1.887)	(0.321)
POST x U.S.	4.218***	4.389***	4.212***	5.351***	3.445***
	(0.316)	(0.319)	(0.320)	(0.461)	(0.622)
PCT	16.71***	14.83***	16.54***		17.16***
	(0.777)	(0.836)	(0.630)		(0.933)
Observations	657,238	669,160	670,024	603,703	940,927
R-squared	0.101	0.060	0.111	0.059	0.501
Month FE	YES	YES	YES	YES	YES

OLS estimates of Equation 2 with alternative fixed effects specifications.
Robust standard errors in parentheses, clustered by patent family.
Legend: *** p<0.01, ** p<0.05, * p<0.1

Table 17: Policy impact on the patent scope change ($\Delta scope$)

	Art unit FE	IPC 4dgt FE	Examiner FE	Attorney FE	Applicant FE
POST	-0.0168	0.00120	0.00616	0.00837	-0.133
	(0.096)	(0.095)	(0.104)	(0.096)	(0.121)
U.S.	0.110***	0.110***	0.108***	0.0508	0.111***
	(0.007)	(0.007)	(0.008)	(0.053)	(0.010)
POST x U.S.	0.119***	0.118***	0.122***	0.118***	0.102***
	(0.037)	(0.037)	(0.038)	(0.041)	(0.040)
Observations	207,922	207,984	208,058	203,770	299,468
R-squared	0.011	0.010	0.071	0.032	0.180
Month FE	YES	YES	YES	YES	YES

OLS estimates of Equation 2 with alternative fixed effects specifications.
Robust standard errors in parentheses, clustered by patent family.
Legend: *** p<0.01, ** p<0.05, * p<0.1

[31] The art unit corresponds to the specific technology center of the patent office to which the application is assigned during the application procedure (Frakes and Wasserman, 2022). This information is available for USPTO twins only, we therefore assume that the CIPO twin is assigned to the same art unit. For more information see: https://www.uspto.gov/patents/contact-patents/patent-technology-centers-management

[32] This information is available for USPTO twins only, we therefore impute the same patent examiner to the CIPO twin in order to perform our regression analysis.

[33] Information about the art unit, examiner and attorney of USPTO twins is available in the Patent Examination Research Dataset (PatEx). For more details see: https://www.uspto.gov/ip-policy/economic-research/research-datasets/patent-examination-research-dataset-public-pair. For CIPO twins we instead rely on the dataset available here: https://www.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/h$_w r01933.html$.

[34] Since it is often the case that for each application there is more than one applicant, the number of observations is in this case higher compared to the other specifications.

D Representativeness of twins pairs

In Table 18 we test whether our results are robust by using a broader definition of patent twins. Instead of keeping only the earlier application in each family at each patent office, we perform our analysis on all the applications (or grants) in the family, resulting in a higher number of observations. Also in this case, once we use $\Delta Scope$ we have less observations, because not all applications in the family are granted in the period of analysis at both patent offices. Moreover, also in this case we do not include patents via the PCT route in assessing the impact on patent scope changes during the application procedure. The results of this additional exercise are similar to those of the main analysis.

Table 18: Policy impact on patent scope

	ScopeApplication	$\Delta Scope$
POST	2.715	-0.153**
	(4.428)	(0.064)
U.S.	-0.117	0.0753***
	(0.173)	(0.013)
POST x U.S.	4.851***	0.135***
	(0.376)	(0.039)
PCT	60.03***	
	(1.027)	
Observations	784,033	250,984
R-squared	0.738	0.537
Month FE	YES	YES
Family FE	YES	YES
Art unit FE	NO	NO

OLS estimates of Equation 2
Robust standard errors in parentheses,
clustered by patent family
*** p<0.01, ** p<0.05, * p<0.1

E Placebo AIA date and additional tests for anticipation effects and policy effective dates

Table 19: Policy impact on the on the scope of patent applications (*ScopeApplication*)

	AIA signed into law	IPR becoming effective	Exclusion year before policy	Fictitious date 3rd Feb 2007
POST	-2.485*	-4.121**	5.454	2.296
	(1.323)	(1.744)	(16.214)	(4.066)
U.S.	4.623***	4.869***	4.444***	5.566***
	(0.128)	(0.122)	(0.144)	(0.214)
POST x U.S.	4.257***	5.056***	4.252***	0.190
	(0.353)	(0.453)	(0.325)	(0.277)
PCT	20.51***	20.49***	20.37***	20.62***
	(0.467)	(0.466)	(0.492)	(0.469)
Observations	670,024	670,024	593,688	670,024
R-squared	0.943	0.943	0.943	0.943
Month FE	YES	YES	YES	YES
Family FE	YES	YES	YES	YES

OLS estimates of Equation 2, alternative ways to define 'POST'
Robust standard errors in parentheses, clustered by patent family
Legend: *** p<0.01, ** p<0.05, * p<0.1

Table 20: Policy impact on the patent scope change ($\Delta Scope$)

	AIA signed into law	IPR becoming effective	Exclusion year before policy	Fictitious date 3rd Feb 2007
POST	-0.0669	-0.151	-0.228*	0.00955
	(0.071)	(0.130)	(0.129)	(0.087)
U.S.	0.110***	0.107***	0.113***	0.112***
	(0.009)	(0.008)	(0.011)	(0.013)
POST x U.S.	0.193***	0.400***	0.142***	0.0468**
	(0.054)	(0.101)	(0.041)	(0.019)
Observations	208,058	208,058	178,290	208,058
R-squared	0.577	0.577	0.572	0.577
Month FE	YES	YES	YES	YES
Family FE	YES	YES	YES	YES

OLS estimates of Equation 2, alternative ways to define 'POST'
Robust standard errors in parentheses, clustered by patent family
Legend: *** p<0.01, ** p<0.05, * p<0.1

F Additional robustness checks

Count models may be appropriate in our analysis once we use the $\Delta Scope$ as dependent variable. In fact, we observe some zero values of our dependent variable (even if these values occur only for 10% of our observations). This is not the case once using *ScopeApplication* as dependent variable. In Table 21 we test the robustness of our results using a Poisson model.

Table 21: Policy impact on patent scope using a Poisson model

	ScopeApplication	$\Delta Scope$
POST	0.0117	-0.211**
	(0.033)	(0.101)
U.S.	0.0327***	0.159***
	(0.001)	(0.012)
POST x U.S.	0.0298***	0.217***
	(0.002)	(0.051)
PCT	0.149***	
	(0.003)	
Observations	670,024	200,532
Month FE	YES	YES
Family FE	YES	YES
Robust standard errors in parentheses, clustered by patent family		
Legend: *** p<0.01, ** p<0.05, * p<0.1		

In Table 22 we test the sensitivity of our results once using $\Delta Scope$ computed using an alternative proxy based on Equation 1 without including the absolute value.

Table 22: Policy impact on patent scope changes using an alternative proxy for $\Delta Scope$

	Alternative proxy for $\Delta Scope$
POST	-0.0902
	(0.065)
U.S.	0.112***
	(0.009)
POST x U.S.	0.0897**
	(0.040)
Observations	208,058
R-squared	0.579
Month FE	YES
Family FE	YES
Robust standard errors in parentheses, clustered by patent family	
Legend: *** p<0.01, ** p<0.05, * p<0.1	