The causal effects of including standards-related documentation into patent prior art: evidence from an EPO policy change

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Abstract

It is crucial that patent offices grant patents only to those inventions that are novel and non-obvious. This paper investigates the effects of a policy change undertaken by the European Patent Office (EPO) in 2004, aimed at improving the quality of their patent granting process. The new policy involved the inclusion of documents shared in the context of setting technical standards into the prior art that EPO patent examiners consider for their search reports. As predicted, our empirical analysis finds a significant reduction in granting rates, but we did not observe an effect of the policy on patent scope.

JEL codes: O30, O34, O32, L15, C21

Keywords: quality of patent process, technological standards, policy evaluation, diff-in-diff-in-diff estimation, patent scope

1 Introduction

The prevailing view that patents help to achieve an optimum level of inventive activity and disclosure rests on the hypothesis that the static inefficiency, emerging from the temporary monopoly created by patents, is counterbalanced by the dynamic efficiency of introducing innovations into society (Nordhaus, 1969). However, this balance is achievable only if the patent system rewards just those inventions that truly deserve them, that is inventions that are novel and non-obvious (Farrell and Shapiro, 2008). Imposing enforceable legal rights by granting "weak" or "questionable" patents seriously harms the innovation process (Lemley and Shapiro, 2005). The phenomenon of weak patents is being increasingly recognized and investigated. Recent evidence suggests that highly significant shares of granted patents do not meet the patentability criteria of novelty and non-obviousness. For instance, Henkel and Zischka (2015) estimate that more than 75% of German patents would be partially or fully invalidated if challenged in court.

In searching for reasons of awarding patents to weak applications, scholars point their attention to a number of possible causes, including: the way in which patent offices are funded (Jaffe and Lerner, 2004) and the fee structures (Frakes and Wasserman, 2014b) in particular; the high levels of staff mobility and the related inexperience of examiners (Lemley and Sampat, 2012); the examiners' ignorance (Lei and Wright, 2017) and granting style (Frakes and Wasserman, 2016); and the insufficient time allowed for the patent examination process (Frakes and Wasserman, 2014a). While most of this work focuses on the US Patent and Trademark Office (USPTO), other patent offices likely suffer from the same problems, to at least some degree.

The uncertainty created by weak patents not only attracted attention of scholars, but also entered the agendas of patent offices and policy makers. In the US, the Federal Trade Commission (FTC, 2003) and the National Academies of Science (Merrill et al., 2004) have called for reforms to the patent system, and patent offices around the world are taking steps to address the quality of the patent granting process. For instance, at the European Patent Office (EPO), scrutinizing quality during both the pre-grant and the post-grant time frames, is an important part of the EPO Economic and Scientific Advisory Board's mandate (EPO, 2012) and the USPTO has appointed a Deputy Commissioner for Patent Quality in early 2015.

Arguably, the most promising area of intervention to reduce weak patents pertains to im-

proving the process through which patent examiners eventually come to ensure that the invention filed for a patent meets the criteria of novelty and inventive step. [1] The key step in such process is for examiners to investigate the state of the art at the time the patent was filed (or, if applicable, the date of the earliest patent filing for the same invention in another country: the 'priority date'). This state of the art – known as "prior art" – includes earlier patent applications as well as the body of so-called non-patent literature (NPL, encompassing scientific and other literature relevant for the invention at stake). However, the precise definition of what constitutes prior art differ across patent jurisdictions (Cotropia et al., 2013) and so does the practical assessment of prior art across patent offices around the world. For instance, there are different rules governing the applicant's duty to disclose relevant prior art to the patent office in the application document, and there are differences in the coverage of the databases that patent offices make available to their examiners in order to facilitate the prior art search.

Improving the quality of the patent granting process is not a simple task. Many proposed reforms call for more resources to ameliorate the granting procedure. Yet, the costs associated to broad reforms may be considerable, and this is even more a concern at a time when the number of patent applications is already steeply rising. Thus, it may be more efficient for patent offices to focus their efforts especially on technological areas where patents regularly result in legal disputes, with far-reaching consequences for firms, industry, and society, whereas it may be sensible to remain "rationally ignorant" about relatively less relevant patents (i.e. unused, not licensed or unlitigated patents, see Lemley, 2000). Technological areas dominated by technical standards represent outstanding cases where concerns about weak patents are at stake, not only because of the large number of disputes and the amounts of money involved in litigation (Bekkers et al., 2017), but also because of the policy debate on the societal impact of (mis)use of patents in this area (Kühn et al., 2013; EC, 2014, 2017).

In this paper we examine the outcomes of an interesting policy change implemented in year 2004 by the EPO in the context of prior-art definition and examination in technological areas related to standards setting. Responding to the outcomes of several cases before its Board of Appeal, the EPO took the position that documents shared in the context of setting technological standards (e.g. technical contributions / submissions, meetings minutes, etc.) should also be considered part of prior art, whereas previously, the policy of the EPO and

[1] Other options include changes at the opposition or the litigation stages.

other patent offices was that such documents should not be considered by patent examiners when judging novelty and inventive step.[2] In addition, the EPO began to collaborate with major Standard Setting Organizations (SSOs) around the world to ensure that those documents were collected systematically and included in the EPO's internal search databases. This led to a significant increase in the repository of knowledge available to EPO examiners when searching for prior art.

Following this policy change, the EPO reportedly found the newly available documents shared in the context of standards setting to be of substantive practical value for its patent decision-making processes (see Willingmyre, 2012). Indeed, from our own communications with the EPO we learned that after the change, the use of standards-related documents and drafts was estimated to matter in roughly 30 percent to 40 percent of the examinations in technical fields that heavily rely on technical standards.

Despite these positive signals about the advantage brought by the EPO policy change, a full impact analysis has yet to be carried out. This paper aims to provide such an impact analysis, by addressing the effects of the policy on its two main goals of: (1) improving the ability of examiners to identify patent applications that are not worth a grant because prior art was already shared in the context of standards setting; and (2) where appropriate, improving the ability of examiners to define the scope of granted patents, such that they no longer include claims that cover prior art already shared in the context of standards setting (i.e. safeguarding the appropriate patent boundaries in Bessen and Meurer 2008's terminology).[3] The first goal relates to patents that should be rejected altogether, and the second to patents where some claims can be approved, while others cannot or must be modified to avoid clashing with standards-related prior art. Accordingly, our study focuses on two outcome variables: granting rates and changes to patent scope between initial filing and eventual grant.

Notwithstanding sustained efforts to improve cooperation and harmonization among major global patent offices – i.e. the so-called IP5, gathering, in addition to the USPTO and the EPO, also the Japanese (JPO), the Korean (KIPO) and the Chinese (SIPO) offices – the EPO decision

[2]Note that all patent offices already consider final, published standards as prior art, but those documents typically come much later in time and, thus, are much less likely to be published before patents relating to the standard are applied for.

[3]These were reasonably the two direct targets of the policy, as can be inferred from some available documentation (e.g. Karachalios 2010; Willingmyre 2012), although no official EPO document explicitly lists the policy targets.

to considering SSOs documentation as part of prior art remains an isolated action. In our study, we exploit this fact by comparing focal outcomes across patent twins, i.e. patent documents filed for the same underlying invention at the EPO and the USPTO. Our identification strategy is based on a quasi-experimental setting that exploits the essentially exogenous nature of EPO policy change, and we employ a patent-level Differences-in-Differences-in-Differences (DDD) approach to isolate the effect of the policy on average differences in outcomes across EPO-USPTO twins from other possible confounding factors.

This study contributes to the broad stream of literature on the working of the patent system and the need to improve the quality of the patent granting process (Jaffe and Lerner 2004; Bessen and Meurer 2008) as well as to the more specific literature examining how improving prior art determination (see, e.g., Lampe 2012; Lemley and Sampat 2012) and availability (Choudhury and Khanna 2015) could affect patent system effectiveness. Our analysis also offers recommendations to help patent offices to improve their procedures based on the insights from a specific policy change.

The remainder of the paper is organized as follows. Section 2 reviews the role of prior art in patent granting procedures. Section 3 discusses why improving the quality of the patent granting process is especially important in technical areas related to standards, and provides more detailed information on the EPO policy change we are examining. Section 4 presents the experimental design and the related identification strategy. Section 5 describes the data, the definition of the treatment and control groups, and the main variables. Sections 6 and 7 present the main findings and a series of robustness checks. We conclude in Section 8.

2 The role of prior art in determining novelty and inventive step

The identification of relevant prior art is a key step during the patent prosecution/ patent granting procedure, because novelty and non-obviousness (i.e. the presence of an 'inventive step') are fundamental requirements for the legal monopoly that patents create. Patent examiners are required in their search reports to disclose whatever prior art they believe to be relevant in order to assess a patent application. An important question, then, is what exactly

constitutes prior art. While the precise definition of prior art differs to some degree across legislations, the World Intellectual Property Organization (WIPO) handbook on intellectual property rights (IPR) defines it as follows: "*Prior art is, in general, all the knowledge that existed prior to the relevant filing or priority date of a patent application, whether it existed by way of written or oral disclosure.*" (WIPO, 2004). Here, the disclosure element refers to whether the relevant knowledge is in the 'public domain' as explained by the EPO in Article 54(2) of the European Patent Convention: "*The state of the art shall be held to comprise everything made available to the public by means of a written or oral description, by use, or any other way, before the date of filing of the European Patent Application.*" (EPO, 2016).

Important to note is that in this context, *'public'* does not mean a relevant piece of previous knowledge is available *for free.* For instance, academic journals usually demand a (sometimes steep) subscription fee, yet the content of the articles published in such journals is considered to be in the public domain, and, thus, counts as prior art. Decision T0050/02 of the EPO Technical Board of Appeal ruled exactly in this direction: "*A document is made available to the public [...] if all interested parties have an opportunity of gaining knowledge of the content of the document for their own purposes, even if they do not have a right to disseminate it to third parties, provided these third parties would be able to obtain knowledge of the content of the document by purchasing it for themselves.*"(EPO, 2004). In contrast, information shared in a confidential setting (e.g., where the participants sign agreements not to disclose information) generally does not qualify as prior art.

A seemingly more technical, yet crucial issue related to the determination of prior art pertains to the documentation available to patent examiners when searching for prior art. In fact, although a certain piece of information may meet the definition of prior art, it will not affect the examination process if the examiner does not find it. Given the need for effective, efficient, and conclusive searches for prior art, patent offices provide their examiners with extensive, well-structured databases. These include – rather obviously – all already existing patent applications, but also a large body of NPL documents. The USPTO makes NPL available to the examiners in its STIC (Scientific and Technical Information) database which ensure access to an extensive number of electronic books, periodicals, conference proceedings, dissertations, and more (USPTO, 2016). In the case of the EPO, its EPOQUE database contain a total

of 12 million NPL documents including commercial and non-commercial publications such as journals, conference material, books, academic dissertations, technical reports and monographs (EPO, 2003). Certainly, prior art as understood in patent law is not restricted to what is made available in patent offices' internal databases, and patent examiners may also search elsewhere.[4] However, such search is often difficult and not very effective, and a major issue is that the precise dating of documents (essential for proper prior art assessment) is not easily guaranteed.[5]

Despite the crucial role of prior art in determining patentability and therefore patent validity (Lemley and Shapiro, 2005; Allison and Lemley, 1998; Lemley and Sampat, 2012), little academic research has been devoted to understanding its role in the patent examination process. Exceptions are Choudhury and Khanna (2015), who, in a setting similar to ours, found that providing to examiners new prior-art about traditional Indian medical knowledge reduces filing and granting in the area of herbal patents. There is also some indirect evidence provided by recent works on strategic citations by assignees. Langinier and Marcoul (2016) conducted a theoretical investigation of the examination procedure where applicants strategically cover up relevant prior art, and Lampe (2012) found that applicants withhold between 21 percent and 33 percent of relevant known prior art in the form of patents.

3 Standards development and prior art at the European Patent Office

In many technical fields, standardization is a key alignment mechanism, allowing the rate and direction of technological progress to be negotiated among participating stakeholders (Schmidt and Werle 1998; Farrell and Saloner 1988). Standards shape what future technologies will look like, particularly the case in areas where the market requires interoperability, such as in telecommunications, IT and media, and future technologies such as e-health, smart grids, smart cities, etc. Implementing a technical standard in a product or service may require the use of patented technologies. Such patents are known as standard-essential patents (SEPs) and,

[4] A humorous example is a 1949 Donald Duck story being used as prior art against a patent on a method of raising a sunken ship, see `http://www.iusmentis.com/patents/priorart/donaldduck/`

[5] This is also why the Internet is not well suited to search for prior art.

by their very nature, represent significant value to their owners. However, financial and legal uncertainties regarding access to and pricing of such essential patents may jeopardize the diffusion and success of standards (Lemley 2002; Lemley and Shapiro 2013). For this reason, many SSOs have adopted IPR policies that require participants to disclose essential patents during the development of a new standard, and request them to commit to licensing these patents on fair, reasonable and non-discriminatory (FRAND) conditions (Lemley 2002; Bekkers and Updegrove 2013). Despite such policies governing the licensing of essential patents, there continue to be levels of disputes and litigation. The likelihood of litigation is four time higher for standard essential patents compared to patents with otherwise similar characteristics (Bekkers et al., 2017). There is ongoing debate – in industry, and among policy makers, antitrust/competition authorities and academics – on the societal impact of (mis)use of patents in technological areas related to standards (EC 2014; Kühn et al. 2013; EC 2017).

If patents offices want to focus on improving the quality of the patent granting process in specific areas, those domains relating to technical standards would be splendid candidates. As an EPO official explained in 2010:"*This is terrain for strategic patenting, patent thickets, and many patent applications of incremental nature, which prompted the EPO attempts to raise the bar.*" (Karachalios, 2010). There are also indications that in court cases, SEPs are more often found invalid than are other patents.[6]

The creation of a standard is a collaborative process. Participants discuss ideas at work group meetings and share written technological contributions, thus working together in a consensus-based way towards a final standard. For a complex interoperability standard, this process can involve hundreds of participants, span a decade, and include many meetings. For instance, the 3GPP work group developing the 3G, 4G and 5G telecommunications standards involved total over 1,300 meetings between January 1999 and October 2017.[7]

The information exchanged among the participants during and between meetings usually covers the state of the art in a given field, as well as many innovative ideas the participants are developing. New ideas can come also from participants' shared thinking. Yet, before the EPO

[6]An investigation that identified 380 alleged and declared SEPs that were asserted in United States district courts or the United States International Trade Commission between January 1, 2005 and June 30, 2014 showed that only about 25% of the challenged patents were both valid and infringed. In the ICT domain, the percentage of these cases was 33%. These numbers are considerably higher for non-SEP patents (RPX, 2014).

[7]See `http://www.3gpp.org/3gpp-calendar`

policy change that we examine in this paper, that body of information was not considered by patent examiners when determining the prior art relevant to assess the patentability of a patent applications. This not only allowed companies to file for a patent on ideas that they had already disclosed to industry partners at SSO meetings; it also created the real risk that companies would file for a patent on ideas that *other* participants shared in the standards-setting context, or based on combinations of such ideas.[8] In fact, the literature makes reference to cases of purported "stealing of ideas" in standards-setting processes (Granstrand, 1999, p.204).

Already in the 1990s, some EPO examiners with extensive industry experience became aware that many innovations in the area of mobile telecommunications had already been shared in SSO meetings before being applied for as a patent. Yet, even when they (incidentally) had access to such information, they were not supposed to consider this in their determination of prior art, which made them feel uncomfortable.[9] Then, in the late 1990s, some interesting developments took place at the EPO. In November 1996, a third party opposed a patent granted by the EPO in March 1994 (patent number EP0249181).[10] The opponent argued that the patent in question was not novel, and cited the preliminary documents and the minutes of a meeting of a standard-developing work group (ISO/TC22/SC3/WG9, which was developing a plug for an electrical connection between a truck and a trailer). Furthermore, the opponent argued that these documents were available to all relevant stakeholders and should be therefore considered to be publicly accessible. While the opponent lost their initial case, it later applied to the EPO Technical Board of Appeal (Case T 202/97) which in 1999 ruled that a proposal sent to a SSO work group in preparation for a meeting is not usually protected by a confidentiality obligation and, therefore, is public. In other words, the EPO acknowledged that information shared in the standards-setting context could be considered prior art.[11] In the ensuing years,

[8]Following the USPTO's recent abandonment of its "first to invent" system, all most important patent offices around the world now work under a "first to file" system which assigns patents to the entity that files, not to the real inventor.

[9]Source: discussions with EPO staff.

[10]Unlike most other patent offices, the EPO has an opposition procedure, allowing any member of the public to challenge a grant decision. These oppositions mostly happens when third parties have access to prior art that was not found by the examiner during the granting process.

[11]The Court's decision of February 10, 1999 offers the following summary "*Mit einer Tagesordnung an Mitglieder einer internationalen Normenausschußarbeitsgruppe versandter Normungsvorschlag zur Vorbereitung einer Normen-Sitzung unterliegt gewöhnlich nicht der Geheimhaltung und gilt daher als der Öffentlichkeit zugänglich.*" (Translated: A proposal for a standard, sent along with the draft agenda to members of an international standards body, is

several other rulings by the same Technical Board of Appeal provided further guidance on when SSO-related documentation constitutes prior art, and when it does not (including cases T 0050/02, T 0273/02 and T 0738/04). Together, these cases established the general principle that, absent specific reasons,[12] preliminary and other documents produced within open SSOs need to be considered as publicly available, and therefore part of the prior art.[13]

Recognizing that the outcome of these appeal cases could improve the quality of the European patent granting process, the EPO realized that additional steps were necessary for their wider impact. The first step taken by the EPO was to ensure itself systematic access to preliminary standardization documents that met the requirements for prior art. This was achieved by becoming member of several SSOs, and signing specific memoranda of understanding with the European Telecommunications Standards Institute (ETSI) and the Institute of Electrical and Electronics Engineers (IEEE), and a High Level Technical Agreement with the International Telecommunication Union (ITU) (Willingmyre, 2012). These agreements gave the EPO access to a large repository of relevant documents such as: (i) standards documents finalized after discussions, agreements and voting; (ii) preliminary drafts of standards which were the basis for discussion and voting within the SSOs; (iii) documents related to the initial drafting of standards, but later replaced by the published versions; and (iv) other relevant contributions to work groups meetings, predominantly first disclosures of new technical information made shortly before or during a meeting.

The EPO's second action involved a substantial process of preparation, harmonization, classification, proper date checking, bibliographical information collection, and technical document formatting and/or language translation, aimed ultimately at including standards-related documents into the EPO NPL-databases and infrastructure, eventually making them readily

generally not subject to confidentiality and should therefore be considered as publicly available.)

[12]Specific reasons to depart from this general principle include cases where (1) there is an explicit confidentiality obligation regarding the document, or there is uncertainty whether such an obligation exists (case T 0273/02); and (2) there is uncertainty over the actual date of publication of the document, for instance because of a missing front page (Case T 0738/04).

[13]Here we refer specifically to SSOs where membership is open to any interested party. There are many more dimensions and interpretations of what an "open SSO" comprises (see Krechmer, 1998; Andersen, 2008; Wijkström and McDaniels, 2013). Note that in some private standards consortia, standards – even final ones – are not publicly published, and are available only to consortia members subject to a non-disclosure agreement (examples are CD-ROM, DVD and Blu-ray disc). Thus, these standards – final versions or preliminary documents – never enter the public domain.

available for prior art searches by EPO examiners.

After several years of preparation, the ETSI-NPL database – arguably the most important part of EPO's planned standards-related NPL infrastructure – was fully launched at the EPO in 2004. Since then, patent examiners have been able to access and consider standards-related NPL in their examination work. The ITU and IEEE databases were completed in 2006 and 2008, respectively.

4 Empirical framework and working hypotheses

As we mentioned in the introduction, the EPO policy change had two objectives. First, to improve the ability of examiners to identify patent applications not worthy of being granted because of prior art already shared in the context of standards setting. Second, where appropriate, to improve the ability of examiners to better define the scope of granted patents, intervening on claims that cover up prior art already shared in the context of standards setting. In this section we describe the empirical strategy designed to identify the effects of the policy on these outcomes, and offer a brief discussion of the effects we expect to observe if the policy proves successful.

4.1 Identification strategy and empirical model

Several features of the policy change provide support that it can be considered as exogenous, opening up the possibility to build a quasi-natural experiment comparing patent outcomes before and after the implementation of the policy. In fact: (1) there is a clear point in time when the policy came into force, since before 2004 patent examiners simply did not have ready access to standards-related NPL documentation; (2) the policy change was not and could not be anticipated by examiners, since, even if they knew about the new EPO's view on prior art, they could not change their "granting propensity" and examination routines until the new standards-related NPL documentation was made available to them; and (3) the EPO policy change was not anticipated by applicants, since there had been no previous trend toward rejecting patents on the grounds of standards-related confidential NPL.[14]

[14]We can ignore the appeal cases in the previous section as negligible compared to the very large number of patent applications related to standards.

In addition to exploiting the exogenous nature of the EPO policy change, we take advantage of a specific feature of the functioning of patent systems which allows a very peculiar identification of counterfactual outcomes, i.e. that the same invention can be filed for at multiple patent offices around the world, in order to obtain patent protection in multiple countries. This implies that we can observe the outcomes of interest (granting decision and changes in scope between initial filing and eventual grant) for a given patent application related to a given invention filed at the EPO – i.e. where the policy change took place – and compare them with the outcomes of the application filed for the same invention at a different patent office, where standards-related NPL documentation was not provided to examiners.

In our analysis, we choose the USPTO as the counterfactual patent office. This office does not make documents shared in the context of setting technological standards systematically available to its examiners. Moreover, were a USPTO examiner to be somehow able to be in the possession of such information, or see a reference to it (e.g. in an already published search report of an EPO examiner or other sources), it is unclear whether such information could be considered by the examiner in the determination of a patent application patentability, given the conditions for patentability in the United States defined in 35 US Code Par. 102 and the lack of a clear, legal precedent for the use of such information (whereas such a clear, legal precedent exists at the EPO).[15]

Based on these considerations, in our study we use a "twin-patents approach" that compares the outcomes for a patent filed for a given invention at the EPO against the outcomes for the patent application filed for the same invention at the USPTO. In this approach, the treatment group clearly consists of all applications involving an invention related to standards setting, applied for a patent at the EPO in the period after the EPO examiners were given full access

[15]The conditions for patentability set in 35 US Code 102 stipulate that an invention cannot be patented if it has been already patented, described in a printed publication, or is in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention [etc.] (see `https://mpep.uspto.gov/RDMS/MPEP/current#/current/al_d1fbe1_234ed_52.html`). Prior to the enactment on September 16, 2012 of the America Invents Act (AIA), on September 16, 2012, Code 102 stipulated that an invention could not be patented if (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the patent applicant; or (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the US [etc.] (see `https://mpep.uspto.gov/RDMS/MPEP/current#/current/d0e302383.html`. See also Willingmyre (2012).

to the standards-related NPL search database. Instead, the definition of the relevant control group is subject to flexibility allowed for by the availability of twin-patents across the EPO and the USPTO. At minimum, one could just take the corresponding USPTO twin of each treated EPO patent application, thus limiting the comparison of outcomes only across twin-applications applied in areas related to standards and only in the years after the EPO policy change occurred. According to this strategy, the effects of the EPO policy change would be correctly identified assuming that there are no other factors than the policy change itself were influencing the outcomes across the two patent offices in those technological areas in the post-policy years. However, and notwithstanding the exogeneity of the EPO policy change, a number of technology-specific and patent-office-specific unobserved confounding factors might make this assumption hardly tenable. For instance, patent offices work within different legal and procedural frameworks (e.g., different notions of prior art and inventive-step), and technologies may have evolve differently in the two offices.

To control for patent office-specific and technological area-specific unobserved confounding factors, thus rendering the underlying parallel trends assumption more convincing, we implement a different definition of control group, by including in the analysis: (i) the EPO-USPTO twins filed not only in standards-related areas, but also in areas unrelated to standardization; and (ii) the EPO-USPTO twins filed for a patent (in all technological areas) both before and after the EPO policy was implemented.

Eventually, after taking all the EPO-USPTO twin patents observed in diverse technological areas over time, we frame the identification of the EPO policy effects according to the following patent-level Diff-in-Diff-in-Diff (DDD) regression:

$$\begin{aligned} Y_i &= \beta_0 + \beta_1 EPO_i + \beta_2 POST\_POL_i + \beta_3 STD_i + \\ &+ \delta_1 EPO_i \times POST\_POL_i + \delta_2 EPO_i \times STD_i + \delta_3 STD_i \times POST\_POL_i + \\ &+ \gamma_0 EPO_i \times STD_i \times POST\_POL_i + \alpha_t + \mathbf{bX_i} + u_i \ . \end{aligned} \tag{1}$$

For each patent i, the dependent variable Y is alternatively one of the two outcomes of interest (receiving a grant, and changes in patent scope between application and grant). On the right hand side, the dummy EPO_i equals 1 for patents filed at the EPO, and zero for

the twin-application filed at the USPTO; the dummy $POST\_POL_i$ equals 1 if the patent can be considered as under examination for prior art in the period after the EPO policy change, and zero otherwise; the dummy STD_i equals 1 if the patent is in a technological area where standards are relevant, and zero otherwise. Thus, the coefficient γ_0 yields an estimates of the causal effect of the EPO policy change, capturing the difference in average outcomes for the group of patents subject to the policy (i.e., filed at EPO in areas related to standardization after the standards-related NPL became available to EPO examiners).

To ease identification, Equation (1) also includes a full set of year fixed-effects (α_t), allowing for time trends in the dependent variables. We include also a set of patent-level variables ($\mathbf{X_i}$) to control for patent-specific characteristics otherwise unobserved, but possibly relevant for determining differences across twins in the outcomes of the examination process, over and above the EPO policy change. These patent-level controls measure: (i) whether the patent application is a priority document; (ii) whether one of the assignees of the patent is local ; and (iii) the number of claims reported in the patent.

The empirical definitions of outcome and control variables appearing in Equation (1), and the details on the construction of the treatment and control groups, are presented in Section 5. Before that, we here below discuss the effects of the policy we theoretically expect to observe.

4.2 Expected policy effects

What can we say a-priori about the effects of the policy on the outcome variables of interest, if the policy achieved its objectives? In terms of granting probabilities, we expect that more applications not worthy of a patent grant are identified and rejected by EPO examiners. Thus, controlling for other factors, after the policy change we should observe a decrease in granting rate at the EPO in standards-related areas vis-à-vis the counter-factual USPTO twins. This effect will show up as a negative estimated coefficient on the three-way interaction γ_0, meaning a negative difference in average granting rates across treated EPO patents and controls.

Regarding the impact on changes to patent scope between the initial filing and eventual granting, the policy change provided EPO examiners a more extended basis of knowledge to base their judgment of the appropriate extent of legal protection that should be assigned to a given patent application for an invention in standards-related areas. As a result of this improved

knowledge and extended definition of prior art, we expect EPO examiners of standards-related applications to more frequently inform patent applicants that the claims in their application do not meet the patentability criteria, vis-à-vis USPTO examiners and compared to the pre-policy period. In response to that, we expect applicants to be "forced" to make more substantive changes to patent scope in their EPO applications than in their USPTO applications, in an attempt to retain the possibility that a patent is granted. We thus predict that standards-related EPO applications undergo more substantive reductions in scope in the process from initial filing to application to the final grant, compared to counter-factual USPTO twins (controlling for other factors). This would imply an estimated positive coefficient on the three-way interaction in the empirical model taking scope changes as the dependent variable.

5 Sample design and main variables

This section presents the data and details the steps taken to identify twin patents and to construct the treatment and control groups. We also discuss the empirical definition of the outcome variables and patent-level controls.

5.1 Data sources and initial sample

The primary data source for this study is the PATSTAT patent database (October 2015 edition), published and maintained by the EPO. PATSTAT builds on EPO and other patent offices' internal databases. It is one of the most comprehensive and widely used data sources for studying patent empirics, encompassing over 100 million patent records and over 200 million legal status records from 90 patent authorities around the world.[16]. From PATSTAT we can source information on patent families linking patent documents from different countries, allowing us to implement our "twin-patent" approach, and we can access a number of variables which we exploit to distinguish between treated and control patents, and to define outcome and control variables.

The initial sample for the analysis includes all EPO and all USPTO patents recorded in PATSTAT with an application date between January 1, 2001 and December 31, 2011. For

[16]For further information see `https://www.epo.org/searching-for-patents/business/patstat.html#tab3`

our analysis, we need to access EPO and USPTO patent application as well as patent grant documents. However, USPTO patent applications are available only since March 2000, because the USPTO did not publish those documents before that date. By choosing January 1, 2001 as the start date of our data, i.e. 9 months after the USPTO began to publish application files, we net out potential initial slack in the availability of USPTO applications.

The end date of December 31, 2011 is based on the need to determine in a reliable way whether a patent is granted, rejected, pending, or withdrawn, taking into account well known truncation issues. In fact, the time between patent application and eventual grant can span several years (Hall et al., 2001). By including patent applications filed up to December 31, 2011, we can exploit at least four more years of PATSTAT data to observe if a grant manifest for the most recent application in the data, and an even longer time period is available for older patent applications.

5.2 Identification of standards-related vs. other technological areas

Our construction of the treatment and control groups starts with providing a criterion to distinguish patents that are standards-related and, thus, potentially affected by the EPO policy change. Our strategy is to identify those International Patent Classification (IPC) subclasses covering technologies where standardization is a prominent phenomenon. We do that by observing which IPC subclasses have a high rate of occurrence of SEPs.

We exploit a recent, publicly available database (the dSEP database, see Bekkers et al., 2017) which compiles disclosed SEPs from the 14 largest global standard setting bodies, allowing us identify the most frequent IPC subclasses in these kinds of patents. The distribution of SEPs by IPC subclasses is heavily skewed: the five top ranked subclasses in terms of number of disclosed SEPs (see upper panel in Table 1) cover 63 percent of all disclosed SEPs. We take these five subclasses as identifiers of standards-related patents: a given patent enters our focal set (i.e. STD=1 in Equation 1) if it is classified in *at least one* of these five IPC subclasses. The number of EPO applications in each class (last column in Table 1) shows that these subclasses are quite large, presumably because they are dominated by telecommunications and other technology areas that are cumulative in nature and, thus, involve many patents.[17]

[17]See Bekkers and Martinelli (2012) for a similar selection.

Table 1: Standards-related and non standards-related IPC subclasses

Set	IPC subclass	No. of SEPs	Short technical topic of subclass	Number of EPO applications between 2002 and 2011
Standards-related (STD=1)	H04L	3717	Transmission of digital information, e.g. telegraphic communication	120097
	H04W	3452	Wireless communication networks	61284
	H04B	1509	Transmission systems used in telecommunications	61527
	G06F	782	Electric digital data processing	149192
	H04M	489	Telephonic communication	36760
Non standards-related (STD=0)	C23C	5	Coating metallic material	29916
	H01M	5	Processes or means for the direct conversion of chemical energy into electrical energy	33620
	C08G	4	Macromolecular compounds obtained otherwise than by reactions only involving carbon-to-carbon unsaturated bonds	52618
	A01N	1	Preservation of bodies of humans or animals or plants or parts thereof biocides	37022
	A61F	1	Filters implantable into blood vessels; prostheses; etc.	52564
	E21B	1	Earth or rock drilling	16965
	A61M	0	Devices for introducing media into, or onto, the body	52564
	B01J	0	Chemical or physical processes, e.g. catalysis, colloid chemistry; their relevant apparatus	63213
	B65D	0	Containers for storage or transport of articles or materials,	55730
	C08F	0	Macromolecular compounds obtained by reactions only involving carbon-to-carbon unsaturated bonds	46708
	C08K	0	Use of inorganic or non-macromolecular organic substances as compounding ingredients	39193
	C09D	0	Coating compositions, e.g. paints, varnishes or lacquers;	38633
	F16H	0	Gearing	26974

Source: Own calculations based on the dSEP database developed in Bekkers et al. (2017) and PATSTAT 2015

All those patents that do not qualify as standards-related according to the above selection, because they are classified in other IPC subclasses, in principle can be included in the control group of patents unrelated to standardization. However, to have a clear separation between potentially treated and control patents, we want to identify only IPC classes that can be considered completely unrelated to standardization. Again, we base this identification on the relevance of the SEPs, focusing just on IPC subclasses featuring a negligible presence of SEPs. This produced a group of 13 IPC subclasses (see bottom panel in Table 1) with the number of SEPs ranging from 0 to 5, in turn corresponding to at most 0.016 percent of all patents in a subclass. Accordingly, we define as unrelated to standards (STD=0 in Equation 1) all patents assigned to one or more of these 13 IPC subclasses. Notice that the number of patents in the resulting control set is roughly similar to that in the focal set of standards-related patents.

5.3 Identification of EPO-USPTO twin patents

The next crucial step is identifying twin-patents, i.e. patents concerning the same invention filed at the EPO and the USPTO. The 1883 Paris Convention for the Protection of Industrial Property (and the later 1995 TRIPS agreement) allows applicants to apply for patents on the same invention in multiple countries through the concept of 'right of priority'. The first worldwide filing is referred to as the 'priority document' and subsequent filings usually need to be done within 12 months from the first one. Patent databases such as PATSTAT use priority documents to create patent families that span all patents related to the same invention. Several patent family definitions exist (for an extensive discussion, see Martínez 2011). In this study we employ the DOCDB family, a 'narrow' definition that groups all patents sharing precisely the same set of priority documents, which ensures that they do refer to the same invention (see Sipapin and Kolesnikov, 1989; Dernis and Khan, 2004).

Out of the initial sample of all PATSTAT applications with filings between January 1, 2001 and December 31, 2011 (as discussed above), we start by selecting all the DOCDB families that include at least one application filed at the EPO *and* at least one application filed at the USPTO. This means that we discard inventions with patent applications only to the EPO or the USPTO. Also, we exclude patents filed via the Patent Cooperation Treaty (PCT) route with a priority filing country or 'designated country' other than the EPO or the USPTO. The more complex examination process involving these PCT patents could affect our data in various ways that are not easy to anticipate.

The resulting sample includes 83,866 patent families. The large majority of these families (87.7%) already qualify as twin-paired patents, as they contain one single EPO application and one single USPTO application. The remaining 12.3 percent of the families contain multiple applications to at least one of the two patent offices.[18] Multiple applications to the same patent office within the same family usually include re-issued patents, continuation patents, divisionals, and divisionals-in-part (see Hegde et al., 2007). These kinds of families may signal particularly valuable patents, and we may induce possible biases if we would discard them. Thus, we keep them in our sample, but with just the 'original' patent for each patent office (i.e.

[18]Specifically, 8.9% of the DOCDB families have 3 associated applications (1 to the EPO and 2 at the USPTO, or vice-versa), 2.01% have 4 associated applications, and this percentages drop further, to the case of a DOCDB family with 38 associated applications.

the application with the earliest filing date among the multiple applications within a family filed at a given patent office).[19]

5.4 Selecting the pre- and post-policy period

The final step in our sample preparation is identifying those EPO patent applications examined after the implementation of the novel EPO policy. This requires precise information on when the new standards-related NPL infrastructure began to be used by EPO examiners, and when the EPO patent examination for a given patent took place.

As already discussed, we know from internal EPO documentation that the ETSI-NPL database was made available to EPO examiners during 2004. However, we do not know the precise date of its introduction. For the purpose of our analysis, we assume it was halfway through the year, i.e. July 1, 2004. Thus, in order to identify patents potentially affected by the policy change, we need to establish, for each EPO-USPTO patent-twin, whether the EPO patent examination (and particularly the prior art search) was performed before or after July 1, 2004. However, the actual examination date is available neither in PATSTAT nor in any other public patent-level databases to which we have access to.[20] From various communications with the EPO staff we established that examination begins *on average* three months before publication of the search report (known as an A1, A3 or A4 publication).[21] Based on

[19]For a small group of families (3.9%) we find that two or more applications were filed on exactly same date at a given patent office. For theses residual cases, we adopted the following criteria for inclusion in the final sample. In cases of multiple co-occurring USPTO applications we randomly selected a non-granted patent application within the family, whereas in cases of multiple co-occurring EPO applications we randomly selected a granted application. This was a conservative choice since it 'plays against' the size of the EPO policy effects we are examining. In fact, will we find the EPO policy change to influence the outcomes of interest, this cannot be imputed to an artificial reduction in the set of EPO granted patents which would have been introduced by a different selection of co-occurring twins.

[20]Notice that patent filing dates, are not very informative about the examination date, since patent applications are not examined immediately after submission to a patent office, both because patent offices commonly have long backlogs in the processing of the applications, and because it is desirable to wait some time before an application is examined until the information on potentially relevant prior art has "stabilized".

[21]At the EPO, a search report is (part of) an "A1" labeled publication if the search report is ready within 18 months after the patent filing date, an "A3" publication if this search report is ready later than 18 months after patent filing, or an "A4" publication if a supplementary search report is produced. The USPTO publication code system differs slightly, but these differences are not relevant for our study because the USPTO twins by definition are in the control group, i.e. it is not necessary to identify whether an USPTO twin-application was examined before or

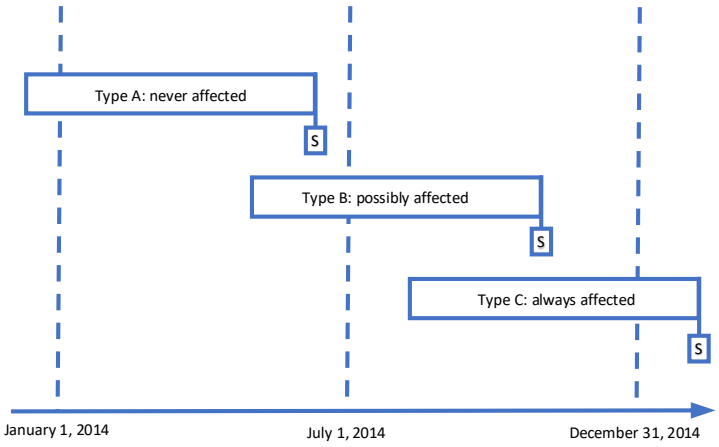

Figure 1: Distinction between pre-policy and post-policy patents. "S" represent hypothetical publication dates of a search report.)

this information, we assume that the examination takes place at some point within the six months preceding the date of publication of the search report (available in PATSTAT).

Figure 1 depicts our distinction between pre-policy and post-policy patents. The horizontal rectangles represent the six month period which we leave for the search activity to be carried out, at some point, and the small boxes designated as "S" represent the moment of publication of the search report. Type A are twins where the EPO search report was published before July 1, 2004 and hence are assigned to the control group of patents not affected by the EPO policy ($POST\_POL$=0 in Equation 1). Type C are twins where the EPO search report was published after December 31, 2004 and we thus consider them as surely affected by the policy ($POST\_POL$=1). In between Types A and C, Type B are twins where the EPO search report was published between July 1, 2004 and December 31, 2004. For this group we cannot be certain of whether they are affected by the new policy, and we thus exclude them from the analysis. In other words, we apply a six month policy-implementation window. Section 7 presents a specific robustness check employing a wider window of 18 months.

After removing the observations falling in the six month policy window, our final working sample includes 71,330 pairs, each having one application to the EPO and one application to the USPTO. Among these pairs, 48,569 twin-applications are in standards-related areas as defined above. Table 2 presents the steps take in the construction of the final sample, and

after the EPO policy change.

Table 2: Sample construction and sample size

	Number of families	%
Initial number of EPO–USPTO families	83,866	
of which		
- already twins (one EPO and one USPTO applications)	73,572	87.7%
- twins after choosing earliest application by patent office	6,953	8.3%
- twins by random choice	3,341	4.0%
Number of EPO–USPTO twins, after removing applications within the policy window	71,330	
of which		
- the EPO application has search report after the policy ($POST\_POLICY$=1)	55,525	77.8%
- are in standards-related areas (STD=1)	48,569	68.1%
- both applications are granted	25,388	35.6%
of which		
- measurement of scope changes could be performed via text analysis of claims	25,239	35.4%
- all the controls are available	60,420	84.7%

reports information on the number of observations involved.

5.5 Outcome variables

Patent grant

Our first dependent variable, labeled *granted*, is a dummy that takes value 1 if a patent application receives a grant, and zero otherwise. We would like this to empirically capture the dichotomous decision whether an application is granted or rejected (the outcome where we expect the policy change to bite), but the very functioning of patent systems and features of PATSTAT complicate this task.

Grant events are directly recorded in PATSTAT, while patents for which such a grant event is not (yet?) recorded in PATSTAT, can be in one of the following status: rejected, pending, or withdrawn/abandoned. How to interpret this situation relates to differences in patent offices' operations. In the USPTO, abandonments/withdrawals are effectively how rejections are determined, while the EPO, in contrast, does issue 'formal' rejections. Yet, these 'formal' rejections are relatively rare compared to withdrawals at the EPO (2.6% and 29.3% of all applications, respectively), suggesting that many applicants who realize they will not obtain a grant in fact withdraw their application.[22] This implies that, in practice, there seem not to be large differences between the USPTO and EPO in the zeroes of our dependent variable. In Section 7, we perform a robustness check using information on rejection status from an EPO dataset.

[22]Figures are calculated on the basis of the EPO-Office Actions Data, see Section 7.

We need also to consider the well known truncation issue, common to patent studies: patents that appear as still pending, might end up granted at a later date. As mentioned, our sample time-span choice ensures that for all patents included in the final working sample we have at least four years of PATSTAT data to observe whether or not they were eventually granted. Section 7 includes a robustness check using a smaller working sample leaving six additional years of data to observe grants.

Patent scope changes

Our second dependent variable concerns changes to patent scope between filing and eventual granting. Patent scope, known also as "scope of protection" or "patent breadth", refers to the boundaries to a technical invention for which a patent awards an exclusion right. Scope can change in between application and granting. In fact, during the patent prosecution process it is common practice that if examiners identify claims in the application that do not meet patentability, then they suggest the applicant to revise such claims (by reducing their scope) as a condition for an eventual patent award.

Since the classical study by Lerner (1994), the proxy for patent scope traditionally used in patent empirics was the raw count of the number of IPCs assigned to a patent. However, it is now acknowledged that scope is determined primarily by the wording of the patent claims, and improved measures of patent scope have been proposed based on the analyses of the text of the claims (Osenga, 2012; Okada et al., 2016; Marco et al., 2016), and the first claim in particular (see Kuhn and Thompson, 2017).[23]

In line with this work, we start from the wording of the first claim in our empirical measurement of patent scope. Accordingly, to measure changes to scope, we compare the text of the first claim in the patent application with the text of the first claim in the granted patent. We define our second dependent variable, labeled *scope changes*, as the absolute value of the difference in the number of words of the first claim between the application and the grant document, normalized by the number of words in the first claim in the application. Note that, by definition, the scope of a patent cannot increase after the initial application (see WIPO, 2004,

[23]The first claim is by definition an independent claim and it is generally the broadest claim, in practice encompassing all the information about what is covered by legal protection. At the EPO, this is obligatory for the first claim, see `www.epo.org/law-practice/legal-texts/html/guidelines/e/f_iv_4_24.htm`

Section 2.72–2.73). Therefore, a change in the wording of a claim reflects a reduction in scope, regardless whether the change in between application and grant manifested itself as an increase in or a decrease in the number of words. [24]

Obviously, scope changes can be calculated only for patents that are granted. The number of EPO-USPTO twins to which this applies is presented in Table 2. Since the full texts of the patents and the patent claims are not directly available in PATSTAT, we retrieved full-text patent documents from Google Patents. Included in the robustness checks in Section 7, is a test for the sensitivity of results to a different definition of scope changes adopted in the recent literature; also, we extend the analysis to explore whether, in response to the new EPO policy, the applicants changed behavior already at application stage, by presenting an EPO application with narrower scope compared to twin application filed at the USPTO.

5.6 Patent-level controls

In our DDD-specification, we want to control for a number of factors that potentially influence the outcomes across twin patents filed at the EPO and the USPTO, beyond the policy effect. In line with de Rassenfosse et al. (2016), we include a standard set of patent-level characteristics, defining the following three variables.

First, we consider if a patent document has a "local assignee", i.e. an assignee from the same country as the patent office where the application is filed. The presence of a local assignee may have better knowledge about the local patenting system, or signal particular interest in obtaining patent protection in a specific market, resulting in improved odds that an application is granted and/or involves a smoother examination of patent scope (e.g. fewer 'disputes'

[24] Whence our choice to take absolute values in our definition of scope changes. We illustrate this using a simplified example. Suppose that the first claim in an application document reads "A bike brake using a round disc" (7 words) whereas the first claim of the granted patent reads "A bike brake using a round disc made of carbon ceramic composites"(12 words). Apparently, during the patent prosecution process, the examiner believed that the first claim was too broad: the granted patent is reduced in scope, as it no longer covers, for instance, metal discs. Thus, in this example, reduced scope is obtained by an increase in the number of words reflects. Consider, next, a different case where the first claim at application reads "A bike brake using a round disc of metal, or of carbon ceramic composites" (14 words), whereas the first claim of the granted patent reads "A bike brake using a round disc made of carbon ceramic composites." (12 words). Also in this case the granted patent has reduced scope compared to initial submission, since it no longer covers metal discs. However, in this second example, reduced scope comes with a reduction in the number of words.

triggering changes to the wording of the first claim). Assignees' nationality is reported directly in PATSTAT. We define a dummy $LOCAL\_ASSIGNEE$, which is equal to 1 if at least one of the assignees is from the country of the patent office where the application is filed, and zero otherwise.[25]

Second, we control for the possibility that within each EPO-USPTO twin pair, one of the two documents is a priority within the family. This might also affect the outcomes of the examination process, since applicants may exhibit a tendency to apply first to the office with which they are most familiar, or which they consider to be more important to obtain the first patent. PATSTAT provides information on priority. We exploit this to include an additional dummy variable, $IS\_PRIORITY$, which is equal to 1 if the application is a priority within the family of the EPO-USPTO twins.

Lastly, we complement PATSTAT with the OECD-Patent Quality Indicators database (April 2017 edition, see Squicciarini et al., 2013) to include a variable reporting the number of claims (in logs) listed in the application, LN_CLAIMS. This feature of patents has been found to influence the outcome of the examination process (Lanjouw and Schankerman, 2001). Table 2 presents the number of twins for which all the control variables were available.[26]

6 Main analysis

We begin with a descriptive graphical analysis of the average behavior of the outcomes across technologies and patent offices over time. Figure 2 depicts monthly granting rates (i.e. the percentage of patents granted over total applications) at the EPO and the USPTO, over the sample time-window 2001–2011, distinguishing between patents in standards-related areas (left panel) and other patents in technologies unrelated to standards (right panel).

In general, both before and after the implementation of the EPO policy change towards standards-related NPL, applications to the USPTO are more likely to be granted than applications to the EPO. This reflects a well-known stylised fact about institutional differences

[25]For a USPTO application, this dummy is set to 1 if at least one of the assignees is from the US. In the case of an EPO application, the dummy equals 1 if there is at least one assignee from one of the 38 EPO member states.

[26]Basic descriptive statistics for the dependent and the control variables are reported in Appendix A, Table A1.

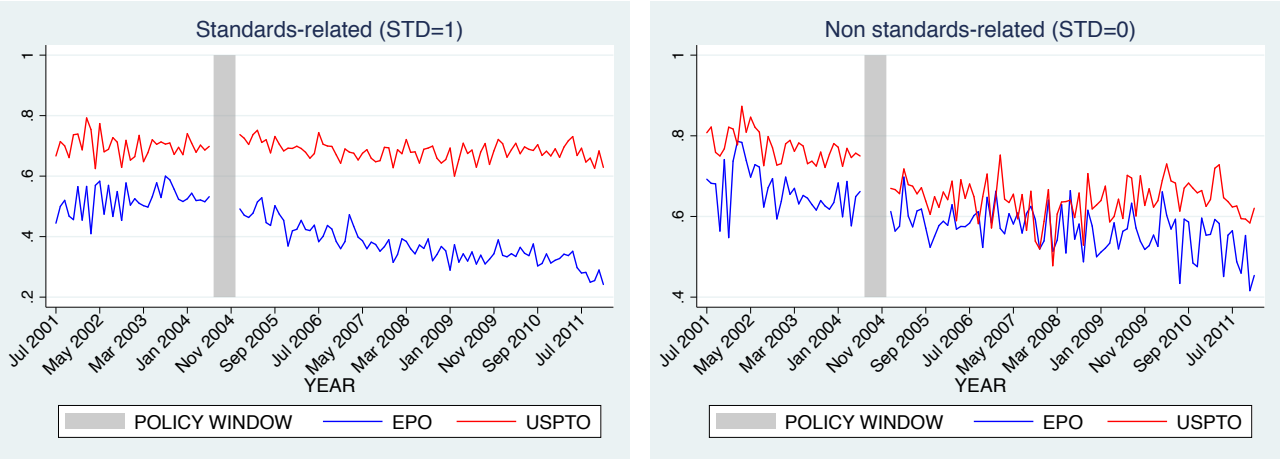

Figure 2: Granting rates by search report date

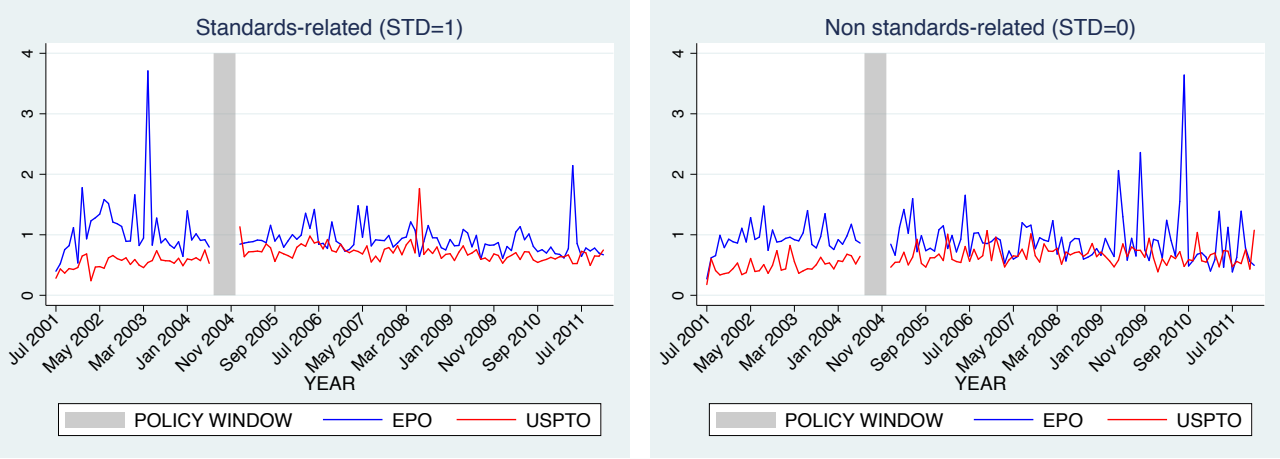

Figure 3: Scope changes by search report date

between the two offices, with the USPTO being usually more 'generous' awarding grants (see Jensen et al., 2005; Webster et al., 2007; Jensen et al., 2008). Nevertheless, some clear differences emerge between technological groups and across patent offices in the period after the policy implementation. At the EPO, standards-related patent applications are less likely to be granted than patents filed in other areas, while at the USPTO granting rates across technologies are roughly comparable.

Figure 3 provides a similar analysis for our second outcome of interest, reporting monthly averages of scope changes, again across offices and technologies over time. In this case, however, we do not observe major differences between EPO and USPTO, in either standards-related (left panel) or in other technology areas (right panel). The patterns are in fact quite comparable regardless we consider periods before or after the implementation of the EPO policy.

Overall, the average trends seem to suggest that the EPO policy change primarily influenced

Table 3: Main results

Dependent variable:	GRANTED	ΔSCOPE
	(1)	(2)
EPO	-0.365***	0.305***
	[0.005]	[0.043]
POST_POLICY	-0.234***	-0.174***
	[0.011]	[0.047]
EPO×POST_POLICY	-0.080***	-0.122*
	[0.007]	[0.061]
STD	0.013***	0.066*
	[0.002]	[0.027]
EPO×STD	-0.129***	0.117
	[0.008]	[0.109]
POST_POLICY×STD	0.017***	0.044
	[0.002]	[0.035]
EPO×POST_POLICY×STANDARDIZED	-0.074***	-0.174
	[0.009]	[0.118]
IS_PRIORITY	0.025***	-0.241***
	[0.003]	[0.053]
LOCAL	0.035***	0.529***
	[0.003]	[0.051]
LN_CLAIMS_CONTROLS	-0.106***	-0.147***
	[0.002]	[0.015]
CONSTANT	1.242***	0.615***
	[0.010]	[0.057]
YEAR DUMMIES	YES	YES
Obs.	120841	50479
R^2	0.394	0.012

Notes: OLS estimates of Equation (1). Robust standard errors in parenthesis, clustered by patent family (DOCDB). Significance levels:

the granting rates, while not influencing refinements to patent scope. [27]

Next, we move to the analysis of our baseline regression model in Equation 1. To recap, treated patents are filed in standards-related domains (dummy STD=1) at the EPO (dummy EPO=1) with a search report issued after December 31, 2004 (dummy $POST\_POL$=1), and we compare their outcomes against those of their twin-patents filed at the USPTO, accounting for observed patent-level controls and unobserved confounding factors pre/post policy across patent offices or technological areas.

Table 3 reports our main estimates.[28]

[27]This is is consistent also with figures in Appendix A, Table A2, where we report descriptive statistics (mean and standard deviation) of the outcome variables broken down by technological area, patent office, and pre/post-policy period.

[28]See Appendix B, Table B1 for preliminary estimates excluding patent-level and other controls. Results are in line with the more reliable estimates discussed here.

column 1 presents the findings for the effect of the EPO policy change on granting probability.[29] The results are in line with our theoretical expectations: the estimate of the three-way interaction γ_0 (EPO×POST_POLICY×STANDARDIZED) shows that, all else being equal, the EPO policy change reduces the probability of award of a standards-related patent by approximately 7.5 percentage points compared to the reference group.

column 2 presents the policy effect on changes to scope between application and grant. The observed effect does not match pur prediction that EPO patents should experience more marked scope reductions than the reference control group of USPTO twins. Instead, the estimated three-way interaction coefficient shows that treated and controls do not exhibit statistically significant differences. A possible explanation is that, for potentially treated patents covering standards-related prior art, the EPO policy change led to *the whole* rather than just parts of first claim being disputed, because *all* the elements referred to in that first claim have already been disclosed in (or anticipated by) standards-related prior art. In this case, scope reductions are not a feasible option: the patent are just rejected altogether. A second possible explanation might be that in knowledge areas related to standards, the parties usually seek to obtain SEPs. If the stricter examination triggered by the EPO policy challenges the part of the first claim that relates to essentiality, then the applicant might not be interested in reducing patent scope (and obtaining a patent which would not be essential any more). In this case, the patent would be withdrawn/abandoned, even if the first claim is not being challenged in its entirety and some parts of it (or other claims in the application) are likely to be accepted. Third, and lastly, our results may be revealing of an adaptation effect. It might be that, once the new EPO policy became known to be in place, applicants of patents in a standards-related area chose to modify the first claim before submitting the initial application to the EPO.

We do not have data for our large sample to further explore the first two possible explanations. However, we can investigate the third, by focusing on differences in patent scope at application. This is one of the robustness analysis we present in next Section 7.

[29]While the dependent variable is binary, we use a linear probability model. Since, most of the covariates are discrete, the linearity assumption is adequate.

7 Robustness analysis

As a first robustness check, we re-estimate our baseline regressions adding patent office×year fixed effects. The respective estimation results for the two outcomes are reported in columns 1-2 of Table 4. The estimated three-way interaction coefficients confirm our main conclusion that the policy significantly reduced granting rates, but it did not induce statistically significant differences in scope reductions across treated and control patents.

columns 3-4 of Table 4 report results obtained adding family fixed-effects (by DOCDB family). The variation exploited to identify γ_0 is within twins, whereas, by definition, $POST\_POL$ and STD do not vary within the same family. Compared to the baseline estimates, the results reveal an even stronger negative effect of the policy on granting rates, and confirm the insignificant results for scope changes.

Table 4: Robustness checks I

	OFFICE-YEAR FE		FAMILY FE		18 MONTHS POLICY WINDOW		PLACEBO
Dependent variable:	GRANTED	ΔSCOPE	GRANTED	ΔSCOPE	GRANTED	ΔSCOPE	#INVENTORS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
EPO	-0.399***	0.069	-0.287***	0.280***	-0.364***	0.337***	-0.005
	[0.016]	[0.068]	[0.009]	[0.064]	[0.006]	[0.048]	[0.004]
POST_POLICY	-0.052***	-0.061	0.000	0.000	-0.228***	-0.148**	0.064
	[0.014]	[0.037]	[.]	[.]	[0.011]	[0.049]	[0.043]
EPO×POST_POLICY	-0.387***	-0.349***	-0.067***	-0.127	-0.085***	-0.192**	-0.014**
	[0.022]	[0.085]	[0.012]	[0.087]	[0.008]	[0.065]	[0.005]
STD	0.014***	0.068*	0.000	0.000	0.011***	0.075*	-0.202***
	[0.001]	[0.027]	[.]	[.]	[0.002]	[0.029]	[0.012]
EPO×STD	-0.129***	0.114	-0.102***	0.106	-0.130***	0.126	-0.007
	[0.008]	[0.105]	[0.013]	[0.156]	[0.009]	[0.134]	[0.006]
POST_POLICY×STD	0.005*	0.041	0.000	0.000	0.018***	0.016	0.085***
	[0.002]	[0.034]	[.]	[.]	[0.003]	[0.037]	[0.014]
EPO×POST_POLICY×STANDARDIZED	-0.054***	-0.168	-0.122***	-0.169	-0.076***	-0.129	0.010
	[0.009]	[0.115]	[0.016]	[0.169]	[0.011]	[0.142]	[0.008]
IS_PRIORITY	0.025***	-0.241***	0.063***	-0.168*	0.030***	-0.203***	-0.026***
	[0.003]	[0.052]	[0.008]	[0.069]	[0.004]	[0.057]	[0.006]
LOCAL	0.035***	0.531***	0.049***	0.536***	0.034***	0.503***	-0.023***
	[0.003]	[0.051]	[0.006]	[0.067]	[0.003]	[0.052]	[0.004]
LN_CLAIMS_CONTROLS	-0.106***	-0.147***	-0.161***	-0.303***	-0.109***	-0.152***	0.065***
	[0.002]	[0.015]	[0.005]	[0.042]	[0.002]	[0.017]	[0.004]
CONSTANT	1.261***	0.735***	1.335***	1.330***	1.250***	0.617***	0.889***
	[0.005]	[0.050]	[0.014]	[0.114]	[0.010]	[0.058]	[0.024]
YEAR DUMMIES	YES	YES	YES	YES	YES	YES	YES
PATENT-OFFICE FE	YES	YES	NO	NO	NO	NO	NO
FAMILY FE	NO	NO	YES	YES	NO	NO	NO
Observations	120841	50479	120841	50479	105474	42214	120841
R^2	0.398	0.012	0.790	0.554	0.406	0.013	
Pseudo Log-likelihood							-222857.617

Notes: columns 1-6 report OLS estimates; estimates in column 7 obtained via a Poisson quasi-maximum likelihood method. Robust standard errors in parenthesis, clustered by patent family (DOCDB). Significance levels:* 5%, ** 1%, ***0.1%.

Third, we test our assumption that the standards-related NPL information became available to EPO examiners midway through 2004. We still assume that examination occurs within the six months prior to the search report, but we allow for the new NPL databases being used at *anytime* in 2004. That is, we widen the policy implementation window by excluding from the analysis all the twins with an EPO search report in the 18 months between January 1, 2004 and July 1, 2005. The results, in columns 5–6 of Table 4, are in line with the main estimates.[30]

Next, we run a "placebo on the outcome" exercise, taking the number of inventors named in the application document as the dependent variable. This number can vary across between twin-applications filed at the EPO and the USPTO, but there is no a-priori reason why it should be influenced by the EPO policy change. The results, obtained using a Poisson quasi-maximum likelihood estimator, are reported in column 7 of Table 5: they confirm our main analysis.

A further concern is potential mis-classification of not-granted patents. In the main analysis, we defined the zeros in the granting outcome following the commonly accepted empirical solution that a patent is considered as rejected if a formal granting decision does not reveal some years after the filing date. However, this could inflate the number of not-granted patents compared to 'true' rejections. If for unmeasured reasons pending or abandoned patents are more frequent at the EPO in standards-related areas, we might be overestimating the reduction in granting rates associated to the EPO policy. Table 5, in columns 1–2, presents two different exercises addressing this potential bias. Column 1 tackles the issue of truncation by re-estimating the effect on granting probability on a reduced sample which includes only patents filed up to the end of 2009. The results confirm the conclusions from our baseline analysis: the estimated three-way interaction coefficient is negative and very close to the main estimate, although slightly lower, at around 6.5 percent. The estimates in column 2, exploit the EPO Office Actions Dataset made available to us by Prof. Dietmar Harhoff which allow to distinguish up to 2013, whether a patent has been abandoned. Therefore, we can refine our definition of 'truly' not granted patents by re-estimating our baseline regression on the sample of twin-applications not involving an abandoned patent. We still find that the EPO-policy change significantly reduced the granting rates in the treated vis a vis the control group. The

[30]To ease comparability with the main estimates, estimates reported here do not include family fixed-effects. However, we checked that the results did not change under this more stringent identification strategy. This holds for all the robustness checks in the rest of this section. All the estimates are available upon request.

estimated effect of about 4 percent is smaller than in the main analysis.

Table 5: Robustness checks II

	TRUNCATION: DATA UP TO 2009	TRUNCATION: DROP WITHDRAWN PATENTS	ALTERNATIVE PROXY FOR SCOPE CHANGES	ADAPTATION EFFECTS
Dep. Variable:	GRANTED	GRANTED	WORDS DIFFERENCE	#WORDS in FIRST CLAIM
	(1)	(2)	(3)	(4)
EPO	-0.365***	-0.349***	0.054*	-0.156***
	[0.005]	[0.005]	[0.024]	[0.006]
POST_POLICY	-0.194***	-0.269***	0.573***	0.201***
	[0.012]	[0.048]	[0.053]	[0.039]
EPO×POST_POLICY	-0.073***	-0.001	-0.141***	0.021**
	[0.007]	[0.007]	[0.030]	[0.008]
STD	0.013***	0.012***	0.331***	0.060***
	[0.002]	[0.002]	[0.031]	[0.011]
EPO×STD	-0.128***	-0.124***	-0.050	0.054***
	[0.008]	[0.008]	[0.034]	[0.007]
POST_POLICY×STD	0.014***	0.008***	-0.125***	-0.056***
	[0.002]	[0.002]	[0.036]	[0.014]
EPO×POST_POLICY×STANDARDIZED	-0.064***	-0.038***	0.062	0.007
	[0.009]	[0.009]	[0.040]	[0.010]
IS_PRIORITY	0.021***	0.019***	-0.032	0.017**
	[0.004]	[0.004]	[0.016]	[0.007]
LOCAL	0.035***	0.033***	0.013	-0.115***
	[0.003]	[0.003]	[0.012]	[0.005]
LN_CLAIMS_CONTROLS	-0.105***	-0.100***	-0.173***	-0.081***
	[0.002]	[0.002]	[0.009]	[0.004]
CONSTANT	1.240***	1.224***	4.296***	4.997***
	[0.010]	[0.010]	[0.053]	[0.023]
YEAR DUMMIES	YES	YES	YES	YES
Observations	103720	92747	39964	119533
R^2	0.374	0.274		
Pseudo Log-likelihood			-1343313.636	-2814864.933

Notes: Results in columns 1-2 report OLS estimates; Models in columns 3-4 are estimated via a Poisson quasi-maximum likelihood method. Robust standard errors in parenthesis, clustered by patent family (DOCDB).

In columns 3 and 4 of Table 5 we present two additional investigations of the effect of the EPO policy on patent scope. First, we show that our results are robust to measuring scope reductions in a different way. Following Kühn et al. (2013), we measure scope changes as the simple difference in the number of words in the first claim between application and grant. This assumes that scope reductions imply a reduction in the number of words, while in the baseline analysis we used the absolute value to avoid this assumption since, in principle, rewriting the claim to narrow the scope could also result in a larger number of words. The results taking the different definition, in column 3, are consistent with our baseline estimates, confirming that the EPO policy change did not induced difference in the extent of scope reduction across treated and controls.

Second, in column 4, we re-run our main regression taking patent scope *at application* as the dependent variable, measured as the raw count of the number of words in the first claim in the application documents of the EPO-USPTO twins. This sheds light on a possible mechanism underlying the insignificant effects of the EPO policy on scope changes, relating to adaptation effects whereby applicants for a patent in a standards-related area modify the first claim at the time of filing an application to the EPO, not during the examination process. The estimates, obtained via a Poisson quasi-maximum likelihood method to deal with a count dependent variable, show an insignificant coefficient of the three-way interaction, indicating that the policy did not induce an adaptation effect.[31] This finding confirms that the EPO policy change did not impacted through refinement to the definition of legal protection.

8 Discussion and conclusion

This paper provides an empirical assessment of the effect of an endeavor by the EPO to improve the quality of the patent granting process. To tackle concerns that the problem of weak patents is especially important in the area of standards-related inventions, EPO, from 2004 on, considers documents shared by participants in the context of setting technical standards to be relevant prior art. We designed an EPO-USPTO twin patents approach to build counterfactuals combined with a DDD estimation to isolate the effect of the EPO policy change from technology-specific and patent-office specific trends.

[31] Consistent results were obtained from OLS estimates, available upon request.

Overall, we conclude that the EPO policy change affected the overall quality of the patent granting process by significantly improving the ability to reject patents on undeserving applications, rather than by contributing to refinement of the definition of legal protection of granted patents. First, as expected, we found that the EPO policy change reduced the probability of a standards-related patent being granted by the EPO. Controlling for other factors, the main analysis revealed that the induced reduction in granting rates vis-à-vis control patents was about 7.5 percent, while the effect estimated in a series of robustness analyses ranged from 4 percent to 12 percent. Second, and against our expectations, the novel EPO policy did not induce more substantial scope reductions during the patent prosecution of standards-related patent filed and granted at the EPO vis-à-vis the USPTO twins. It also did not induce applicants to adapt to the policy change by diversify the scope of the initial application across patent offices. We discussed two possible explanations for this unexpected result: (a) patent applications threatened by 'new' standards-related NPL prior art are threatened in their entirety, and thus rejection rather than scope refinements are the main outcome of the EPO policy change; or (b) standards-related NPL prior art threatens the part of the patent that provide it a SEP status, with the result that applicants at the EPO withdraw from the patent process, rather than 'accepting' a scope reduction, because they are not interested in a patent with reduced scope which does not include elements essential to the standard in question. Further analysis could help to identify the relative strengths of these alternative explanations, although they may require additional information on applicants strategies and choices that it is difficult to collect, especially for such a large sample as we use here.

There are also other interesting directions for future research. Firstly, it would be interesting to investigate whether applicants engage in 'extreme forms' of adaptation to the policy, not captured in the present analysis.[32] For example, when the new policy was implemented, it might be that some applicants reacted by starting to forgo applications to the EPO patent altogether, on the thought that a patent family lacking an EPO member is anyway more attractive than a patent family with a rejected EPO member. An alternative strategy in reaction to the EPO policy change might be that the applicant made so drastic changes to the EPO application

[32]In fact, it seems that patent attorney firms inform their clients about the fact that the EPO now considers standards-related documents as prior art, possibly triggering specific strategies to circumvent this practice of the EPO. See: `https://www.elkfife.com/news-and-views/2016/02/24/epo-approach-to-standards-related-documents-as-prior-art`

compared to the USPTO twin application for the same invention, that the two documents no longer shared the same set of priority documents. Neither of these adaptation strategies will be captured by our approach, since our identification of counter factual outcomes relies upon constructing EPO-USPTO twin-patents. Identifying and evaluating the impact of such adaptation effects would require a different set-up. For instance, a dataset could be built that include all applications to the five largest patent offices around the world, and thus base the definition of the counter-factual outcomes on a less strict notion of patent family. Such an investigation would be an interesting extension, but at the price of a much less precise and less convincing identification strategy than in the present analysis.

Another important question that is not addressed in our research relates to whether the EPO policy change was effective in reducing the poaching of ideas. This would of course require a definition of what does (and does not) constitute stealing. Normally, one would not immediately talk about the "stealing of ideas" in the case of a new patent application failing to meet the criterion of novelty or inventive step. However, in the specific context of standards setting, there is a realistic risk that a party could apply for a patent related to an idea that had been expressed by another party during an SSO meeting, or in a submitted technical proposal for a standard. Patents rejected as a result of the novel EPO policy might well reflect this form of theft. Assuming availability of the required data, theft of ideas would be relatively simple to assess in the case that the idea had been shared in its entirety by somebody other than the applicant in a meeting where the applicant was present, or via documentation on a technical proposal that was distributed to the standards members. However, there might be situations where deciding about stealing would constitute a gray area. For instance, consider the case of a patent rejected due to lack of inventive step because the examiner combined two documents, both shared by others in standards setting: would this constitute stealing? While intriguing, the effects of the EPO policy change on stealing would require a substantially different research design than adopted in the present study, and it would probably benefit from more qualitative data and methodologies.

Finally, whereas granting rates and patent scope represent the arguably more direct target of the EPO policy change, the twin-patents approach and the related narrow identification of the underlying common invention that we propose here, could be extended to examine the

effects of the EPO policy change on other potentially interesting outcomes. More broadly, we hope our paper could inspire researchers to investigate the impact of other endeavors by patent offices around the world to improve the quality of the patent granting process.

Our study has implications for policy. While the EPO policy change was not free of implementation costs, it demonstrates that relatively focused efforts can produce a quite sizable effect, and influence relatively large and important technological area. It shows that there are feasible ways of improving the quality of the patent granting process. We would recommend other patent offices to consider similar measures, and SSOs to consider working with patent offices to make data available.

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Appendix A: Descriptives

Table A1: Descriptive statistics on dependent and independent variables

Variable	Obs	Mean	Std. Dev.	Min	Max
GRANTED	142660	0.56	0.50	0	1
Δ *SCOPE*	50479	0.80	2.52	0	255
EPO	142660	0.50	0.50	0	1
POST_POLICY	142660	0.78	0.42	0	1
STD	142660	0.68	0.47	0	1
IS_PRIORITY	142660	0.16	0.36	0	1
LOCAL_ASSIGNEE	142660	0.27	0.44	0	1
LN_CLAIMS	120841	2.55	0.64	0	5.72

Table A2: Average outcomes by patent office, technological areas, pre- vs. post-policy

VARIABLE: *GRANTED*				
	STD=1		*STD=0*	
	PRE_POLICY	*POST_POLICY*	*PRE_POLICY*	*POST_POLICY*
USPTO	0.70	0.68	0.77	0.64
	[0.46]	[0.47]	[0.42]	[0.48]
EPO	0.53	0.34	0.66	0.55
	[0.50]	[0.47]	[0.47]	[0.50]
VARIABLE: Δ *SCOPE*				
	STD=1		*STD=0*	
	PRE_POLICY	*POST_POLICY*	*PRE_POLICY*	*POST_POLICY*
USPTO	0.58	0.72	0.51	0.65
	[0.84]	[1.44]	[1.40]	[1.22]
EPO	1.09	0.92	0.96	0.91
	[5.65]	[2.41]	[3.01]	[3.14]

Note: Sample average and standard deviation in the brackets.

Appendix B: Preliminary estimates

Table B1: Estimates without year dummies and excluding patent-level controls

Dep. Variable:	GRANTED		Δ SCOPE	
	(1)	(2)	(3)	(4)
EPO	-0.109***	-0.109***	0.446***	0.446***
	[0.006]	[0.006]	[0.045]	[0.045]
POST_POLICY	-0.127***	-0.317***	0.139***	-0.338***
	[0.006]	[0.018]	[0.026]	[0.044]
EPO×POST_POLICY	0.020**	0.020**	-0.181**	-0.181**
	[0.008]	[0.008]	[0.061]	[0.061]
STD	-0.070***	-0.068***	0.066**	0.057*
	[0.007]	[0.007]	[0.025]	[0.027]
EPO×STD	-0.061***	-0.061***	0.071	0.071
	[0.009]	[0.009]	[0.106]	[0.106]
POST_POLICY×STD	0.111***	0.122***	0.009	0.020
	[0.008]	[0.008]	[0.033]	[0.034]
EPO×POST_POLICY×STANDARDIZED	-0.190***	-0.190***	-0.139	-0.139
	[0.010]	[0.010]	[0.116]	[0.116]
CONSTANT	0.767***	0.762***	0.510***	0.341***
	[0.005]	[0.013]	[0.021]	[0.038]
YEAR DUMMIES	NO	YES	NO	YES
Observations	142660	142660	50479	50479
R^2	0.092	0.100	0.004	0.005

Notes: OLS Estimates. Robust standard errors in parenthesis, clustered by patent family (DOCDB).

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