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

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2016/11 February 2018
ISSN(ONLINE) 2284-0400

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

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Abstract

This paper investigates a policy change undertaken by the European Patent Office (EPO), aimed at improving the quality of their patent granting process. This change involves the inclusion of information revealed by participants to standards-setting processes into the prior art that patent examiners consider when determining patent novelty and inventive step. Our empirical analysis finds a significant reduction in the granting rate, yet no reduction in patent scope. We furthermore find that patent quality has declined, suggesting that the policy actually succeeded in rejecting undeserved, yet high-quality patents. Overall, the policy improved the quality of the patent granting process.

JEL codes: O30, O31, C21

Keywords: quality of patent process, technological standards, policy evaluation

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1 Introduction

The prevalent view is that patents help to achieve an optimum level of inventive activity and disclosure, and 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, such a balance only works if the patent system bestows rewards solely on inventions that truly deserve them, that is, inventions that are novel and non-obvious (Farrell and Shapiro, 2008). Failure to do so, by granting enforceable legal rights to "weak" or "questionable" patents, essentially harms the innovation process (Lemley and Shapiro, 2005). While a patent system will always have some degree of error, recent evidence suggests that a significant share of granted patents does not actually meet the patentability criteria of novelty and being non-obvious. For instance, Henkel and Zischka (2015) estimate that more than 75% of German patents would be partially or fully invalidated if challenged in court. Searching for reasons why weak patents get granted, scholars have drawn attention to a number of possible causes, including high staff mobility and insufficient experience of examiners (Lemley and Sampat, 2012), examiners' ignorance (Lei and Wright, 2017), insufficient time allocated to the examination process (Frakes and Wasserman, 2014), and the way in which patent offices are funded (Jaffe and Lerner, 2004). While most of the above studies focus on the US Patent and Trademark Office (USPTO), similar causes may be present at other patent office.

The uncertainty created by granting weak patents has caught the attention of policy makers. In the US, reports by the Federal Trade Commission (FTC, 2003) and the National Academies of Science (Merrill et al., 2004) have called for reforms within the patent system. Patent offices around the world are indeed taking steps to address the quality of the patent granting process. At the European Patent Office (EPO), improving the quality of the patent granting process, both during the pre-grant and post-grant time frame, is an important part of the EPO Economic and Scientific Advisory Board's mandate (EPO, 2012). The USPTO, since early 2015, has a Deputy Commissioner for Patent Quality.

Improving the quality of the patent granting process is not a simple task, though. Many proposed reforms call for devoting more resources to ameliorate the granting procedure, at a time when the number of patent applications is rising steeply. The costs of broad reforms, moreover, may be considerable. It may thus make sense to focus improvements especially on areas where patents regularly result in legal disputes, with far-reaching consequences for firms, the industry, and society. Technology areas dominated by technical standards represent outstanding cases. There are special concerns about weak patents in these areas, not only because of the large number of disputes and amount of money involved in litigations (Bekkers et al., 2017), but also regarding the policy discussion on the societal impact of (mis)use of patents in this area (EC 2014; Kühn et al. 2013; EC 2017).

In order to decide on the grant of a patent, a patent examiner must ensure that the patent indeed meets the patentability criteria of novelty and inventive step. For both these tests, he or she investigates 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, among other things, earlier patent applications as well as scientific and other literature (together known as non-patent literature, NPL). The precise definition of what constitutes prior art, however, may differ per patent jurisdiction (Cotropia et al., 2013). Patent offices also have different rules concerning the extent to which applicants themselves have a duty to disclose relevant prior art to the patent office. Moreover, there are also differences between the coverage of the databases that patent offices readily make available to their examiners in order to facilitate the prior art search process.

In the year 2004, the EPO implemented an interesting policy change in the context of prior art. Responding to the outcome of several cases before its Board of Appeal, the EPO took the position that documents shared in the context of setting technological standards should also be considered part of prior art, whereas previously, the EPO and other patent offices' policy was that such documents should not be considered by patent examiners for determining novelty and sufficient inventive step. In addition, the EPO entered into collaborations with major Standard Setting Organizations (SSOs) worldwide to ensure that such documents would be systematically collected and made available in the EPOs' internal search databases. This availability marked a significant increase in the knowledge repository available to an EPO examiner when searching for prior art.

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

Despite such positive signals about the success of this policy change, no full impact analysis has yet been carried out. This paper attempts to present such an impact assessment. While we know of no EPO documents that explicitly list the new policy's goals, the documentation that is available (e.g. Karachalios 2010; Willingmyre 2012) make it reasonable to assume that the main goals are: (1) improve the ability of examiners to identify patent applications not worth a grant because of prior art already shared in the context of standards setting; and (2) where appropriate, improve the ability of examiners to better define the scope of granted patents, so that the latter no longer have claims that cover prior art already shared in the context of standards setting (i.e. safeguarding the appropriate patent boundaries, in the terminology of Bessen and Meurer 2008). The first goal thus relates to patents that cannot be granted altogether, the second to patents where some claims can be granted but others cannot.

Given these two goals, our paper examines the potential effects of the policy change by looking at (1) variation in granting rates and (2) the extent of scope changes occurring between the application and the eventual grant of a patent. In addition, we also explore the impact of the EPO policy change on two other outcomes: (3) patent quality, i.e. the size of the technological inventive step associated with the invention that eventually receives a grant, as compared to the "best" pre-existing invention; and (4) patent value, i.e. the economic returns that a patent is able to generate. While these two patent characteristics may not be among the primary targets of the EPO policy change as such, they are interesting to investigate in the broader context of how changes in patent institutions affect the overall functioning of the patents system.

Notwithstanding sustained efforts to improve cooperation and harmonization among major global patent offices (the so-called IP5, composed of the USPTO, JPO, KIPO, SIPO, EPO), the new EPO policy of considering SSOs documentation as part of prior art remains an isolated one. In our study, we exploit this fact by comparing focal outcomes across patent twins, that is 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 the policy change undertaken at the EPO, 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 on how better prior art determination can help to do so (e.g. Lampe 2012; Lemley and Sampat 2012). In addition, this study aims to provide recommendations to patent offices to improve their procedures by providing insights on the various effects of a specific policy change.

The remainder of the paper is organized as follows. Section 2 reviews the role of prior art in the 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 about the EPO policy change we are examining. Section 4 presents the experimental design and the related identification strategy. The data and the definition of the treatment and control groups are then introduced in Section 5, where we also discuss the outcome variables and main controls. Section 6 presents the main findings, while a series of robustness checks are presented in Section 7. We conclude in Section 8.

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

The identification of relevant prior art is of key importance during the patent prosecution/granting procedures, because novelty and non-obviousness (i.e. the presence of an 'inventive step') represent fundamental requirements for the legitimacy of the monopoly that patents create. Patent examiners must disclose in their search reports what 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 IPR describes 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). The disclosure element here 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).

An important note is that, in this context, *'public'* does not necessarily mean it is available for *free.* For instance, academic journals usually demand a subscription fee (and some journals do demand a steep fee), yet the content of the articles published in such journals is considered to be in the public domain, and can, thus, form 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 participants have signed agreements not to disclose information) does generally not qualify as prior art.

A seemingly more technical, yet crucial issue in the determination of prior art pertains to the documentation that patent examiners actually have at their disposal when searching for prior art. 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 existing patent applications. But also the so-called Non Patent Literature (NPL) is provided in readily available in these databases. The USPTO makes NPL available to the examiners in a database known as STIC (Scientific and Technical Information), offering access to an extensive number of electronic books, periodicals, conference proceedings, dissertations, and more (USPTO, 2016). Similarly, the EPO has developed its EPOQUE databases, containing a total of 12 million NPL documents including commercial and non-commercial publications such as journals, conference material, books, thesis, technical reports and monographs (EPO, 2003). Finally, prior art as meant in patent law is of course not restricted to what is available in the patent offices' the internal databases, and patent examiners may also search elsewhere.[1] But this is often not so easy and effective, and also the precise dating of documents (which is essential for proper prior art assessment) is not easily guaranteed. This is also why the Internet is not well suited to search for prior art and patent offices prefer their own databases.

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)[2], little academic research is devoted to understanding its role in the examination procedure. A notable exception is the recent body of work on strategic citations by assignees. Langinier and Marcoul (2016) provide a theoretical investigation of the examination procedure where applicants strategically cover up relevant prior art. Lampe (2012) finds that applicants withhold between 21 and 33 percent of relevant known prior art.[3]

3 Standards development and prior art at the European Patent Office

In many technical fields, standardization is a key alignment mechanism, where the rate and direction of technological progress are negotiated between participating stakeholders (Schmidt and Werle 1998; Farrell and Saloner 1988). Standards shape what future technologies will look like, and this is 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, by their very nature, represent significant value to their owners. However, financial and legal uncertainty regarding the access to and pricing of such essential patents may jeopardize the diffusion and success of standards (Lemley 2002; Lemley and Shapiro 2013). That is why many standard-setting organizations (SSOs) 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 is still a high degree of disputes and litigation. The likelihood of essential patents being subject to litigation is four times as high as that of patents with otherwise similar characteristics (Bekkers et al., 2017). There is an ongoing debate, in industry, among policy makers, antitrust/competition authorities and academia, on the societal impact on (mis)use of patents in this area (EC 2014; Kühn et al. 2013; EC 2017). If patents offices would like to focus on activities for improving the quality of the patent granting process in specific areas, 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*

[1]A humorous example of that 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/`

[2]As Lemley and Shapiro (2005, page 80) note "Defendants in patent cases typically claim that the patent is invalid, usually based on the existence of prior art not found by the Patent and Trademark Office...". Similarly, Allison and Lemley (1998) examine the outcome of 239 patent litigations. They find the large majority of invalidations were rooted in problems with prior art.

[3]Note that the study of Lampe study focuses only on patented prior art, not on non-patent literature.

the EPO attempts to raise the bar." (Karachalios, 2010). There are also indications that in court cases, SEPs are found more often found to be invalid than other patents.[4]

The creation of a standard is a collaborative process. Participants discuss ideas at Work Group (WG) meetings and share written technological contributions, and thus work together in a consensus-based way towards a final standard. For a complex interoperability standard, this process may involve hundreds of participants, span over a decade, and include many meetings. For instance, the 3GPP working groups developing the 3G, 4G and 5G telecommunications standards held in total over 1300 meetings between January 1999 and October 2017.[5]

The information exchanged among the participants during and in-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 also come out of combining thoughts shared by participants. Yet, before the EPO 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 an actual risk that companies would file for a patent on ideas that *other* participants shared in the standard-setting context, or on combinations of such ideas.[6] In fact, the literature does refer to cases of purported 'stealing of ideas' in standard-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.[7] Then, some interesting developments took place at the EPO in the late 1990s. In November 1996, a third party opposed EP0249181, a patent that the EPO granted in March 1994.[8] The opponent argued that the patent in question was not novel, and cited preliminary documents and minutes of a meeting of a standard-developing working group (in this case, ISO/TC22/SC3/WG9, which was developing a plug for an electrical connection between a truck and a trailer). It furthermore argued these documents were available to all relevant stakeholders and therefore should be considered as publicly accessible. While the opponent initially lost their case, they later applied to the EPO Technical Board of Appeal (Case T 202/97). This Board eventually concluded, in its 1999 ruling, that a proposal sent to an SSO working group in preparation for a meeting does not usually underlie a confidentiality obligation and is, therefore, public. In other words, the EPO acknowledged that information shared in the standards-setting context could be considered prior art.[9] In the following years,

[4]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 to June 30, 2014 showed that in only approx. 25% of the challenged patents were found to be both valid and infringed. For ITC cases this was 33%. These numbers are considerably lower than for other patents. (RPX, 2014)

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

[6]Now that the USPTO has recently moved away from its "first to invent" system, virtually all patent offices around the world have a "first to file" system that assigns patents to the entity that files, not to the one found to be the real inventor.

[7]Source: discussions with EPO staff.

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

[9]The Court's decision of 10 February 1999 offers the following summary "*Mit einer Tagesordnung an Mitglieder einer internationalen Normenausschußarbeitsgruppe versandter Normungsvorschlag zur Vorbereitung einer Normen-Sitzung unterliegt gewöhnlich nicht der*

several other rulings by the same Technical Board of Appeal provided further guidance on when SSO-related documentation should be considered as prior art, and when not (including cases T 0050/02, T 0273/02 and T 0738/04). Together, these cases established the general principle that, absent specific reasons,[10] preliminary and other documents produced within open SSOs need to be considered publicly available and therefore to be part of the state of the art.[11]

Recognizing that the outcome of these appeal cases could improve the quality of the European patent granting process, the EPO realized that additional steps would be necessary for them to really have a wider impact. The first step the EPO took was to ensure itself systematic access to preliminary standardization documents that meet the requirements for prior art. It did so by becoming member of several SSOs, as well as by signing Memoranda of Understanding (MoU) with the European Telecommunications Standards Institute (ETSI) and with the Institute of Electrical and Electronics Engineers (IEEE), and signing a High Level Technical Agreement with the International Telecommunication Union (ITU) (Willingmyre, 2012). These agreements gave the EPO access to a broad repository of relevant documents such as (i) standards documents finalized after discussions, agreements and voting; (ii) preliminary standards drafts that serve as basis for discussion and voting; (iii) documents related to the temporary drafting of the standards later replaced by a new, published version; (iv) contributions to working groups, predominantly first disclosures of new technical information shortly before or during a working group meeting.

The EPO's second step was a substantial process of preparation, harmonization, classification, proper date checking, creation of bibliographical information, and technical document formatting and/or language translation, with the ultimate aim being to make the standardization documents part of the EPO NPL-databases and infrastructure, thus readily available for prior art search by EPO examiners.

After several years of preparation, the ETSI-NPL database – arguably the most important part of the planned standards-related NPL database at EPO – was fully launched at the EPO by 2004. From that moment on, patent examiners could access and consider standards-related NPL in their work flow. The ITU and IEEE databases were then completed in 2006 and 2008, respectively.

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

[10]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 publication date of the document, for instance because of a missing front page (Case T 0738/04).

[11]Here we specifically refer 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 are not publicly published – even final ones – and are only available to consortia members under the acceptance of a non-disclosure agreement (examples are CD-ROM, DVD and Blu-ray disc). These standards – final versions or preliminary documents – are obviously never in the public domain.

4 Empirical framework

4.1 Models and identification strategy

In order to assess the effect of the EPO policy change concerning standards-related NPL on patent outcomes, we adopt a policy evaluation framework. We believe such an approach is appropriate as: (1) there is a clear point in time when the policy came into force, since patent examiners simply did not have standards-related NPL documentation at their disposal before 2004; (2) the policy change was not (and could not be) anticipated by examiners, in the sense that, despite knowing about the change in the EPO view on prior art, they could not change their "granting propensity" and examination routines until the new standards-related NPL documentation became available to them; and (3) the EPO policy change was not anticipated by applicants, since there had not yet been a previous trend in the rejecting patents on the grounds of standards-related confidential NPL.[12]

We exploit the exogenous nature of the EPO policy change to build a quasi-natural experiment, taking advantage of a specific feature of the functioning of patent systems whereby the same invention can be filed at multiple patent offices around the world, in order to obtain patent protection in multiple countries. Thus, we can observe the outcomes of interest (granting decision, changes in scope between application and grant, patent quality and patent value) for an invention applied for a patent at the EPO, where the policy change actually took place, and compare the outcomes for the very same invention filed for a patent at a different patent office, where standards-related NPL documentation is not provided to examiners. In this study we use "twin" patent applications across EPO and USPTO to build the counterfactual situation in which the same unit of analysis (a given invention filed for patent) is observed both under the policy treatment (the EPO patent application) and without treatment (the application for the same invention at the USPTO).

The treatment group is obviously made up of all applications that involve a standards-related invention, applied for a patent at the EPO in the period after the EPO examiners were given full access to the standards-related NPL search database. Observing twin-patents across EPO and USPTO allows for flexibility in the empirical identification of the relevant control group. At a minimum, we could just take the USPTO twins filed in the same post-policy years in standards-related technologies, and compare the average difference in outcomes (e.g., the granting decision) across EPO and USPTO twins. This strategy would identify the effect of the EPO policy change by assuming that there are no other factors influencing the outcomes across the two patent offices in those technological areas, besides the EPO policy change itself. Yet, a number of technology-specific and patent-specific unobserved confounding factors may make this assumption untenable. Moreover, patent offices work under different legal and procedural frameworks, and in fact may use different notions of prior art and inventive-step (apart from the one we are studying here), making differences in patent outcomes across EPO and USPTO dependent to other institution-specific factors, beyond the EPO policy change.

Our study controls for such patent office-specific and technological area-specific unobserved confounding factors by including in the analysis: (i) the EPO-USPTO twin-patents 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 put in place. Our empirical strategy exploits all of these sources of variation to make the underlying parallel trends assumption more convincing.

In designing the empirical strategy, we first take all the EPO-USPTO twin patents observed in diverse technological areas over time. Next, we frame our identification of the EPO policy

[12]We can ignore the appeal cases in the previous section as clearly negligible compared to the total number of patent applications related to standards.

effects as the following patent-level Differences-in-Differences-in-Differences (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 one of the four outcomes we are interested into (receiving a grant, changes in patent scope, patent quality and patent value). On the right hand side, the dummy EPO_i equals one for patents filed at the EPO, and zero for the twin applications filed at the USPTO; the dummy $POST\_POL_i$ equals one 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 one if the patent is in a technological area where standards are relevant, and zero otherwise. Thus, the coefficient γ_0 yields our estimate of the causal effect of the EPO policy change. It captures the difference in average outcomes for the group of patents subject to the policy (filed at EPO, in areas related to standardization, after the standards-related NPL was available to EPO examiners).

Note that all the outcomes vary across the EPO-USPTO patent-twins. This variation is straightforward to understand for granting and patent scope: even if exactly the same patent application was filed at EPO and USPTO for patenting the same object, the two applications may well end up as one granted and the other rejected, or one with a different scope reduction than the other, exactly depending on the different evaluation of novelty step and prior art in the two patent offices. In the eyes of a non-expert reader, however, it would appear that patent quality and patent value are inherent properties of the invention filed for a patent, which thus do not vary across patent offices. This is not the case: the two distinct twin-documents may also differ in terms of the characteristics used to empirically measure these two further outcomes of interest.

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

The details on the construction of the treatment and control groups, and the exact definitions of outcome and control variables appearing in Equation (1) are presented in Section 5. Before that, we first discuss the theoretical effects the EPO policy is expected to have on the focal outcome variables.

4.2 Expected policy effects

As we discussed in Section 1, the main goals of the new EPO policy were twofold. Firstly, to improve the ability of examiners to identify patent applications not worth a grant because of prior art already shared in the context of standards setting. Secondly, where appropriate, improve the ability of examiners to better define the scope of granted patents, so that the latter no longer have claims that cover prior art already shared in the context of standards setting. What do we then expect the effects on the outcome variables of interest to be, if the policy indeed meets its goals? We here below develop our working hypotheses and summarize them in Table 1.

Table 1: Expected effects of the policy

Dependent variable	**Expected effect**
Grand rate	(–) Reduced grant rate
Scope changes	(+) Increased scope changes
Quality	(–) Reduction of quality if EPO mostly rejects high-quality (undeserved) applications, or if surviving patents whose scope was reduced are of relatively low quality (+) Increase of quality if EPO mostly rejects low-quality (undeserved) applications or if surviving patents, whose scope was reduced, are of relatively high quality
Value	(–) Reduction of value if EPO mostly rejects high-value (undeserved) applications, or if surviving patents whose scope was reduced are of relatively low value (+) Increase of value if EPO mostly rejects low-value (undeserved) applications or if surviving patents whose scope was reduced are of relatively high value

In terms of granting probabilities, we clearly expect that more applications not worth a patent are identified and, thus, rejected at the EPO in standards-related areas after the policy change, vis-à-vis the counter-factual USPTO twins. So, controlling for other factors, we should observe granting rates to *decrease* at EPO in standards-related areas as a result of the policy. Such an effect will be picked up by a negative coefficient on the three-way interaction, meaning a negative difference in average granting rates across treated EPO patents and controls.

Regarding the impact on patent scope changes between initial filing and eventual grant, the new policy provides EPO examiners with an extended basis of knowledge through which they can judge the extent of legal protection that is worth recognizing to a given invention filed for a patent in standards-related areas. As a result of this improved assessment vis-à-vis USPTO examiners and compared to the pre-policy period, we expect that: (1) EPO examiners are more likely to inform patent applicants that the claims in their application do not meet the patentability criteria; and (2) in response, applicants will make more substantive changes to these claims to still have a chance that their patent is eventually granted. Therefore, we expect that in our empirical model the size of scope changes *increase* as a result of the policy change: as compared to the control group of counter-factual USPTO twins, and controlling for other factors, EPO applications undergo more substantive scope reductions in the process going from initial application to the eventual grant. If this is the case, we should observe an estimated positive coefficient on the three-way interaction.

The effects that the policy may exert on patent quality and patent value are more difficult to predict. The key question is whether the patents that pass the more accurate examination at EPO (not rejected and with better defined scope) turn eventually out to be of higher or lower quality and value, as compared to the USPTO twins. We could observe that the policy *reduces* the average quality and value of EPO patents vis-à-vis USPTO twins in standards-related areas (i.e. negative coefficient on the three-way interaction) either if (1) the patents still receiving a grant at the EPO after a scope reduction, are of relatively low quality or low value; or if (2) the patents rejected at the EPO are of relatively high quality or value, but undeserved because they do not meet patentability criteria.[13] Conversely, we expect an *increase* in the quality and value of patents granted post-policy at the EPO in standards-related areas vis-à-vis USPTO twins (positive coefficient on the three-way interaction), if the EPO examiners either (1) reject mostly low-quality or low-value applications; or (2) still concede a grant, albeit with reduced scope, to patents of relatively high-quality and high-value.

Which of the different underlying effects prevails is ultimately an empirical question, since a-priori the policy change is neutral on these aspects. In fact, even reducing patent quality and patent value can be seen as a success of the policy change, to the extent that these effects stem from an improved ability to trim out of the system applications that do not deserve legal protection, despite of high quality or high value. In this respect, it is important not to confuse the quality of an *individual patent* (i.e. size of the inventive step) with the quality of *the patent granting process.*

[13]Patents not worth a grant, but nonetheless of high quality and value are not rare. An example is patent EP2119287. Filed in February 2007 by Ericsson, and disclosed by that firm as a SEP, this patent has 40 INPADOC patent family members worldwide, and in the PATSTAT 2017 database this family in total received over 250 citations, making it reasonable to assume this patent scores high on the metrics of patent quality and patent value. Later in its life, the patent was transferred to Unwired Planet, who used it in a UK court case against Huawei Technologies (along other patents). During that case, the judge determined the patent in question to be invalid for obviousness in light of a publicly available document detailing proposals made by Qualcomm for LTE standardization discussions (IAM, 2016).

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 then discuss the empirical proxies for our four outcome variables (granting rates, changes in scope, patent quality and patent value) and the 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 upon internal databases of the EPO and other patent offices and is formatted specifically for statistical work. It contains over 100 million patent records and over 200 million legal status records from 90 patent authorities around the world. As such, it is one of the most comprehensive and widely used data sources for studying patent empirics.[14] Among other information, PATSTAT includes patent family information that links patent documents from different countries, allowing us to implement our "twin-patent" approach, and a number of variables that we exploit to distinguish between treated and control patents, as wellas to define our outcome and control variables. In the analysis, we complement PATSTAT with a number of indicators extracted from the OECD-Patent Quality Indicators database (April 2017 edition, see Squicciarini et al., 2013), mostly needed for computing patent quality and patent value.

The initial sample for the analysis is made of all EPO and all USPTO patents recorded in PATSTAT with an application date between January 1, 2001 and December 31, 2011. For the analysis, we need to access patent applications documents as well as patent grant documents at both the EPO and the USPTO, but PATSTAT does not contain USPTO patent applications earlier than March 2000, for the simple reason that this patent office did not publish such documents before that date. By choosing January 1, 2001 as the starting date of the data, which is 9 months after the USPTO began to make applications public, we net out potential initial slack in the availability of USPTO application documents in PATSTAT.

The end date set on December 31, 2011 is prompted by the need to determine in a reliable way whether a patent is granted, rejected, still pending, or withdrawn, taking into account well known truncation issues. In fact, the time that passes between patent application and eventual grant can mount up to several years (Hall et al., 2001). By including patent applications up to December 31, 2011, we ensure that even for the most recent patents in our set there are 4 additional years of PATSTAT data to observe their eventual grant. We feel confident this is enough for a reliable observation of the grant decision.

5.2 Identification of standards-related vs. other technological areas

Our construction of the treatment and control groups starts with identifying patents that are standards-related and, thus, potentially affected by the EPO policy change. For this purpose, our strategy is to identify IPC subclasses that span technologies in which standardization is a prominent phenomenon. We do that by observing which IPC subclasses have a high occurrence rate of Standard Essential Patents (SEPs). Here, we employ a recent, public database that compiles disclosed SEPs from the 14 largest global standard setting bodies (the dSEP database, see Bekkers et al., 2017) and screen the IPC subclasses that most frequently appear in this kind of patents. The distribution of SEPs by IPC subclasses is very skewed. The five subclasses shown in the upper panel in Table 2 already cover 63 percent of all disclosed SEPs. We take these

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

five subclasses as identifier 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 5 IPC subclasses.[15] The number of EPO applications in each selected IPC subclass (see last column of Table 2) shows that these are quite large subclasses, presumably because they are dominated by telecommunications and other technological areas that are cumulative in nature and thus cover many patents.

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

Table 2: 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 the patents that do not qualify as standards-related according to the above criteria, can in principle be included in the control group of patents unrelated to standardization. However, in order to have a clear separation between potentially treated and control patents, we want to select only IPC classes that can be safely considered as unrelated to standardization. Therefore, we identified the IPC subclasses with a negligible low number of SEPs. Of the IPC subclasses meeting this requirement, we select a group of 13 IPC subclasses, ensuring that the number of patents in the resulting control set is approximately similar to that in the focal set of standards-related patents (see again Table 2). The number of SEPs in the 13 classes we selected ranges from 0 to only 5 SEPs, corresponding to 0% to 0.016% of all patents in that class. Finally, we define as unrelated to standards (STD=0 in Equation 1) all patents assigned to one or more of these 13 IPC subclasses.

5.3 Identification of EPO-USPTO twin patents

The subsequent, crucial step regards the actual identification of twin-patents, that is, patents for the same invention filed at both the EPO and the USPTO. The 1883 Paris Convention for the Protection of Industrial Property (and later the 1995 TRIPS agreement) allows applicants to apply for patents on the same invention in multiple countries through the concept of 'right of priority'. Subsequent filings usually need to be done withing 12 months, and refers to the first worldwide filing as a 'priority document'. Patent databases such as PATSTAT use these 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 which share precisely the same set of priority documents, ensuring that they really refer to the very same invention (see Sipapin and Kolesnikov, 1989; Dernis and Khan, 2004).

We start by selecting all the DOCDB families that include at least one application filed at the EPO *and* one at the USPTO (out of the initial selection of all PATSTAT applications with filings between January 1, 2001 and December 31, 2011, as discussed above). This means that we discard innovations for which patents are only applied for either at the EPO or the USPTO. We furthermore exclude patents filed via the PCT route and whose priority filing country or 'designated country' was neither the EPO nor the USPTO. The more complex route that these patents follow may affect our data in a variety of ways that are not always easy to anticipate.

The resulting sample includes 83,866 patent families (see Table 3). The large majority of these families (87.7%) already qualifies as twin-paired patents, as they contain exactly one single EPO application and one single USPTO application. The remaining 12.3% of the families contains multiple applications either at one of the two patent offices or at both the patent offices.[16] Multiple applications at 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). Such multiple applications may signal particularly valuable patents, and we shall avoid possible bias due to discarding these larger, possibly more valuable families. We therefore kept these larger families and applied the following criterion to build paired-patent twins in these cases. Among the multiple applications in the family filed in each patent office, we only selected the application with the earliest filing date, thus the 'original patent' at the patent office in question.[17]

[16]Specifically, 8.9% of the DOCDB families have three associated applications (one at the EPO and two at the USPTO, or vice-versa), 2.01% have four associated applications, and this number drops further down, to the case of a single DOCDB family with 38 associated applications.

[17]For a small group (3.9% of all families) there are more than two applications filed on exactly the *same* date at a given patent office. For theses residual cases, the criteria for inclusion in

5.4 Selecting the pre- and post-policy period

The final step in our sample preparation is to identify which EPO patent applications were examined after the new EPO policy was implemented. For this, we need to know precisely when the new standards-related NPL infrastructure became used by EPO examiners, and when the EPO patent examination took place for a given patent.

As mentioned, we know from internal EPO documentation that the ETSI-NPL database was made available to EPO examiners during 2004, but do not know the precise date of introduction. For our analysis, we assume that this was halfway trough the year, that is, July 1, 2004. Thus, in order to identify potentially affected patents, we need to establish, for each EPO-USPTO patent-twins, if the EPO patent examination (and particularly the prior art search) was performed before or after July 1, 2004. Because the actual examination date is neither available in PATSTAT nor in other sources we had access to (and it is not usually reported in public patent-level databases), we had to explore other routes.[18] We learned from communications with EPO staff that examination occurs, on average, three months before publication of a so-called search report (known as an A1, A3 or A4 publication).[19] Accordingly, we assume that the actual examination takes place sometime in the six months preceding the publication of the search report, and we finally distinguish between pre- and post-policy patents as follows: (i) twins for which the EPO search report is published before July 1, 2004 cannot be affected by the policy change, and thus are assigned to the control group of pre-policy twins ($POST\_POL$=0 in Equation 1); (ii) twins for which the EPO search report is published after January 1, 2005 are surely exposed to affected by the policy change ($POST\_POL$=1); (iii) since we cannot classify with certainty as affected or not by the policy those twins for which the EPO search report is published between these two dates, we leave them out of our analysis. In other words, we leave a gap of 6 months as the policy-implementation window. In Section 7 we present a specific robustness check employing a wider policy window of 18 months.

After removing the observations that fall in the 6 months policy-implementation window, our final working sample includes 71,330 pairs, each having one application at the EPO and one application at the USPTO, of which 48,569 pairs concern applications for patents in standards-related areas, as defined above. Table 3 summarizes the steps of sample construction and reports information on the number of observations involved.

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the final sample were as follows. In cases of multiple co-occurring USPTO applications we randomly selected a non-granted patent application within the family, whereas we randomly selected a granted application in cases of multiple co-occurring EPO applications. This choice is conservative, as it "plays against" the size of the EPO policy effects we are going to estimate: if the EPO policy change has any effect on the outcomes of interest, this cannot be imputed to an artificial reduction in EPO granted patents that would have been introduced by a different selection of co-occurring twins within multiple application families.

[18]The patent filing date is not very informative on the examination date, since patents applications are not examined right after they are submitted to a patent office: not only because patent offices have a backlog in processing the applications, but also because it is desirable to wait some time until the information on potentially relevant prior art has "stabilized" before an application is examined.

[19]At the EPO, a search report is (part of) an "A1" labeled publication if the search report is ready within 18 months after 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 is slightly different, but this is not relevant for our study because the USPTO twins are by definition in the control group, i.e. we do not need to distinguish whether the USPTO twin patent application was examined before or after the EPO policy change.

Table 3: 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%

5.5 Outcome variables

Patent grant

Our first dependent variable is a dummy that takes value 1 if a patent application is eventually granted a patent, and 0 otherwise. We measure this by observing patent grant events in PATSTAT. As noticed above, however, a lack of a grant event does not necessarily mean that a patent is rejected. Since a substantial lag between the application and the grant date is the rule (under normal operations of patent offices), lacking to observe a grant event could also mean that the patent examination is still pending. Another common possibility is also that a patent is withdrawn or abandoned by an applicant.

We address this potential truncation following the accepted practice in the literature. As mentioned before (see the discussion on the sample time span), we ensure that even for the youngest patent in our set we have an additional four years of data points to observe whether that patent experience a grant event or not. While this is commonly considered as enough for a reliable observation of the grant decision, two specific robustness checks to address truncation are presented in Section 7, where we change the final sampling date and exploit a different dataset to recover information on whether patent applications are abandoned.

Patent scope changes

Our second outcome of interest concerns changes in patent scope between filing and final grant. Patent scope, also known as the "scope of protection" or "patent breadth", refers to the boundaries of technical invention for which a patent offers an exclusion right. Scope can change between the application and the granted patent: during the patent prosecution process, it is common practice that when examiners see certain claims in the application that do not meet the patentability criteria, they suggest the applicant to change such claims (by reducing scope), so the patent can eventually still be granted. The new NPL documentation available to EPO examiners may have played a role exactly in this process.

Since the classical study by Lerner (1994), the traditional proxy for scope used in patent empirics has been the raw count of the number of IPC classes assigned to a patent. More recently, however, scholars recognize that scope is primarily determined by the wording of the patent claims, and started to propose improved measures of patent scope that actually analyze the text of the patent claims (Osenga, 2012; Okada et al., 2016; Marco et al., 2016) and, in particular, the length of the first claim (see Kuhn and Thompson, 2017).[20] Following this recent literature, we also analyze the wording of the first claim to proxy patent scope. Since we are specifically interested in *changes* in scope, our outcome variable is the *absolute value* of the difference in number of words in the first claim between the application and the grant document, normalized by the number of words in the same first claim at the application. The word counting was performed by scraping the full-text patent documents available through Google Patents. It is important to recognize that the scope of a patent, by definition, can never increase after the original filing (see WIPO, 2004, Section 2.72–2.73). Hence, the larger the changes made to the length of text of the first claim (in whatever direction), the more substantial the reduction in scope. Of course, scope changes, as we define them, can only be recorded for patent applications that finally see a grant. The number of EPO-USPTO twins for which this was the case in our data is shown in Table 3. While our main analysis is primarily looking at *changes* in patent scope between application and grant, our robustness checks in

[20]One reason to focus on the first claim is that this is generally the broadest claim, thus including most of the information about what is covered by legal protection. At the EPO, this fact is even an obligation, see `www.epo.org/law-practice/legal-texts/html/guidelines/e/f_iv_4_24.htm`

Section 7 also investigate the possible effect of the policy on the scope of the application as such.

Patent quality and patent value

Quality and value of patents are two concepts that might positively correlate, but still are distinctive concepts. As mentioned in the introduction, patent *quality* is the size of the inventive step, i.e. the distance that separates a granted invention to previously existing inventions along a technology line. Conditional on being granted, a patent on an invention with a larger inventive step is more likely to be upheld as valid if challenged. Patent *value* refers to the benefits of patent *protection*, and refers to the capability of the patent to generate (private or public) economic returns.

Patent quality and patent value are not directly observable to the researcher, and several approaches to measuring these patent characteristics exist. We follow here the recent approach proposed in de Rassenfosse and Jaffe (2014), which expands upon the latent quality model developed by Lanjouw and Schankerman (2004). The method returns a joint estimation of quality and value, by allowing for a number of patent-level characteristics usually adopted as alternative proxies for quality or value to contribute to two separate latent factors, one for quality and the other for value.

Four indicators of patent characteristics, which we take from the OECD-Patent Quality Database (Squicciarini et al., 2013), enter into our estimation as the observed determinants of the two latent factors: the number of independent claims, the number of renewals, the number of citations to the application in the first five years after publication, and the size of the INPADOC patent family. [21] In the calculation of the latent factors, we follow the assumption in de Rassenfosse and Jaffe (2014) that all four indicators contribute to the 'value vector', while only claims and forward citations contribute to the 'quality vector'. Note that because the measurement of quality and value requires data that is only available for granted patents, the dataset for these analyses is smaller (see Table 3). In Section 7 we present specific robustness checks that exploit other commonly used proxies for patent quality and value.

5.6 Patent-level controls

Our DDD-specification also includes patent-level characteristics controlling for unobserved factors that, following de Rassenfosse et al. (2016), can potentially determine the outcomes across twin patents filed at EPO and USPTO, beyond the policy effect.

First, we consider the presence of a "local assignee", i.e. an assignee from the same country as the patent office where the application is filed. A local assignee may have a better knowledge of the local patent system, resulting into improved odds that an application is granted, and/or a smoother examination of patent scope (less "disputes" on the definition of the first claim). Also, a local assignee may signal particular interest in getting patent protection in a specific market, in turn correlating with technical quality and value. The nationality of assignees is available information in PATSTAT documents. We define a dummy $LOCAL\_ASSIGNEE$, which is equal to 1 if at least one of the assignees is from the same country of the patent office where the application is filed, and 0 otherwise. [22]

[21] We do not use the DOCDB definition of a family, as we did for the identification of patent twins, since here the goal is to proxy for an invention's market scope. This is better captured via a less strict family definition, implied by the INPADOC, which includes all the patents sharing at least one priority.

[22] More specifically, for a USPTO application, this dummy is set to 1 if at least one of the assignees is from the US, while in the case of an EPO application, the dummy equals one if

Second, we control for the possibility that, within each EPO-USPTO twin pair, one of the two documents is a priority within the family. As firms might apply first to offices that they know better or consider more important for getting a patent first, this could also affect the outcomes of the examination process beyond the EPO policy change. We have information on priority directly from PATSTAT and, thus, we also include an additional dummy variable, $IS\_PRIORITY$, which is equal to 1 if the application is a priority within the family. Lastly, we resort to the OECD-Patent Quality database to also include 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 3 shows the number of twins for which all the control variables are available. Table A1 in Appendix A reports basic descriptive statistics of all dependent the control variables.

6 Main analysis

To recap, EPO policy treatment is whether patents are filed at the EPO (dummy EPO =1) with a search report issued after January 1 2005 (dummy $POST\_POL$=1) in standards-related application (dummy STD=1), as compared to the twin patents filed at the USPTO, and accounting for both observed patent-level controls and unobserved confounding factors pre/post policy, across patent offices and technological areas.

6.1 Average outcomes across treated and controls

We begin by presenting a descriptive graphical analysis of the average behavior of the outcomes across technologies and patent offices, over time. Figure 1 shows monthly averages of granting rates, i.e. the percentage of granted over total applications, at the EPO and the USPTO, over the sample time-window of 2001–2011, distinguishing between patents in standards-related areas (left panel) and patents in areas not related to standards (right panel).

there is at least one assignee from one of the 38 EPO member states.

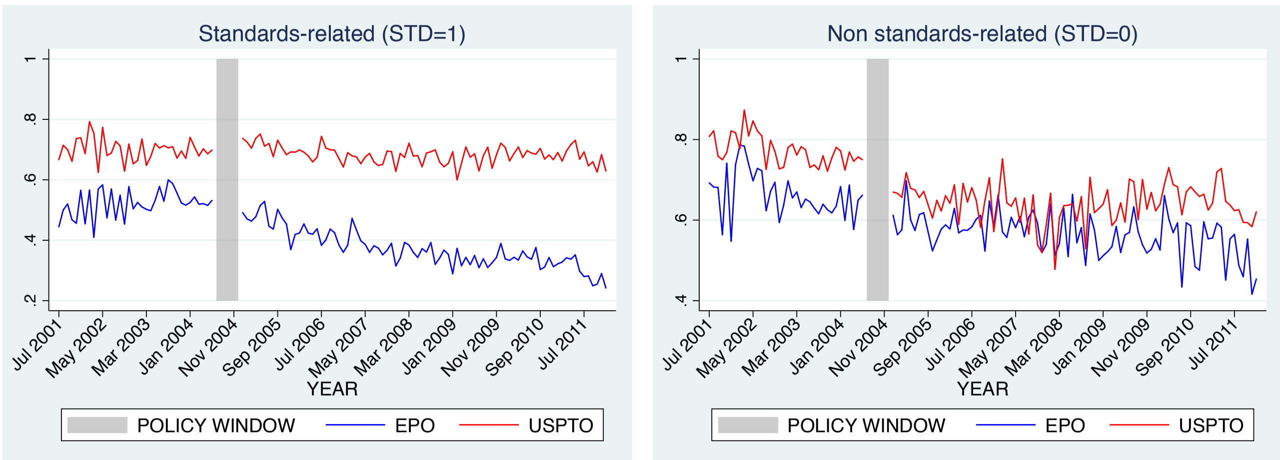

Figure 1: Granting rates by search report date

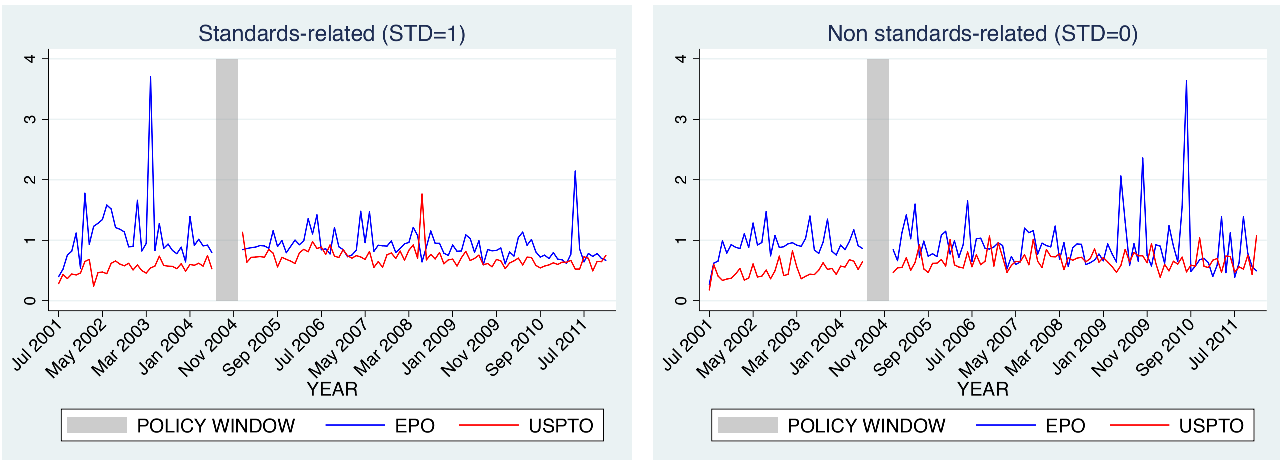

Figure 2: Scope changes by search report date

In general, USPTO patent applications are more likely to be granted than EPO applications, both before and after the implementation of the new EPO policy on standards-related NPL. This reflects a well known stylised fact about institutional differences between the two patent offices, with the USPTO usually more generous in granting patents (see Jensen et al., 2005; Webster et al., 2007; Jensen et al., 2008). Still, some differences between the two technological groups emerge in the period after the policy implementation, besides the common reduction in granting rates. At the EPO, standards-related patent applications are less likely to be granted than patents filed in other areas. The same does not apply for the USPTO, where the granting rates across technologies are roughly comparable.

Figure 2 shows monthly averages of scope changes between application and grant, at the EPO and the USPTO. The figure does not suggest there are large differences between the two patent offices, neither between patents in standards-related areas (left panel) nor in areas unrelated to standards (right panel).

Figure 3 shows monthly averages of patent quality. Interestingly, the data suggests that USPTO patents display larger quality improvement than their corresponding EPO twins. Such differences remain rather constant both over time and across technological areas.

Figure 4, reporting monthly averages of patent values, shows a different picture. Here we observe that EPO patents generally display higher value than their USPTO twins. This difference persist over time, despite the decreasing trend observed at both patent offices. These patterns are similar across standardized and non-standardized technological areas.

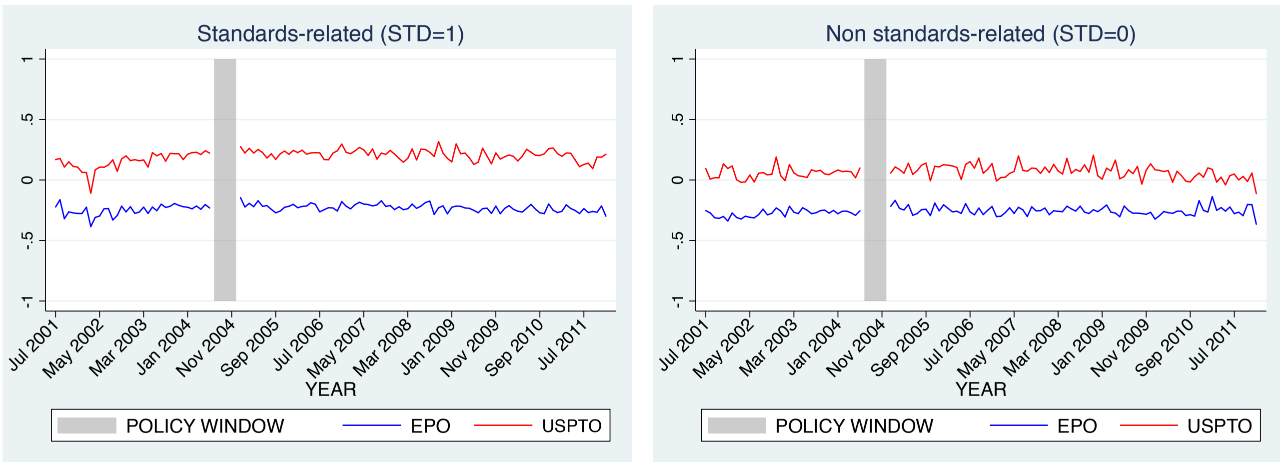

Figure 3: Patent quality by search report date

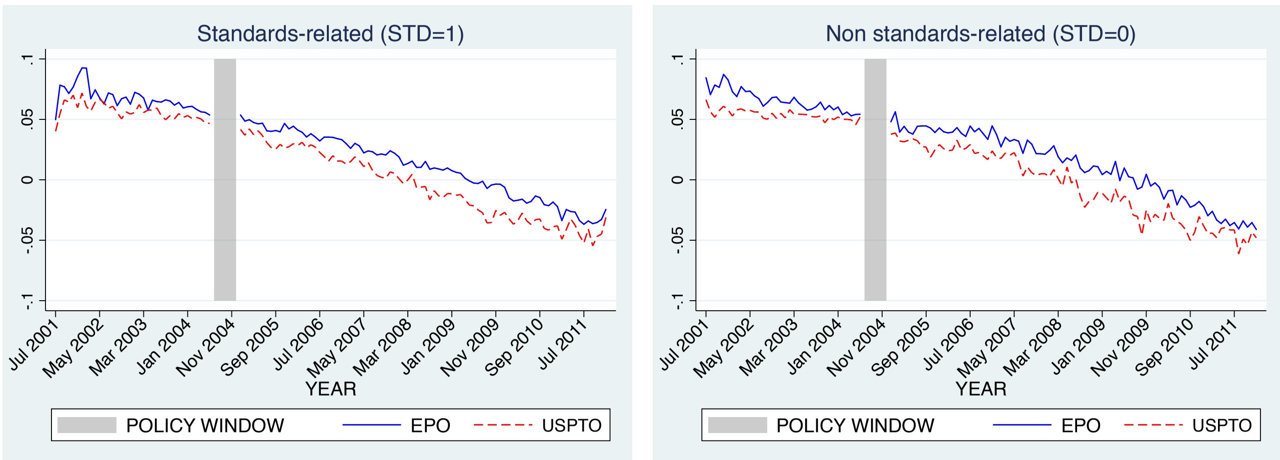

Figure 4: Patent value by search report date

Overall, just looking at average trends seems to suggest that the EPO policy change might have influenced primarily the granting rates, more so than the other outcome variables.[23]

6.2 Regression results

Table 4 reports the estimates of our baseline regression model in Equation 1.[24] Column 1 shows our assessment of the effect of the new EPO policy in terms of granting probability.[25] The results are in line with our expectations: the estimated coefficient on the three-way interaction γ_0 tell us that, all else equal, the EPO policy change reduces the probability of a standards-related patent being granted, as compared to the reference group, by approximately 7.5 percentage points.

Column 2 considers the policy effect on scope reductions. In this case, the observed effect does not match our expectation that EPO patents should experience more marked scope changes than the reference control group of USPTO twins. Instead, the estimated coefficient on the three-way interaction show that the treated patents undergo smaller changes in the number of words in the first claim between application and grant, and that this difference is not statistically significant. A possible explanation is that, for patents covering standardization-related prior art, the claims in their *entirety* are challenged: the application does not contain anything that has not yet been disclosed or anticipated in standardization meetings. In such a case, reduction of scope is not a feasible option, and the patent will be rejected altogether. A second explanation may be that in knowledge areas related to technical standards, parties usually seek to obtain standard-essential patents. If the new policy challenges the actual claim in the patent that would give rise to essentiality, than the patent owner might no longer be interested any more in a patent with reduced scope, and then stops its efforts in the persecution procedure - even when the claims are not challenged in their entirety, and some of the claims in the patent application may still be accepted. A last possible explanation would be that applicants, once the policy became revealed, started to adapt to it by *applying* for more narrow patents then they would have done absent the policy. We provide a specific robustness check of this adaptation effects Section 7, looking at scope in the initial application documents.

Estimates in Column 3 show that the policy had an effect on quality. On average, treated patents are of lower quality, although the difference is statistically significant only at a 5% confidence level. Compared to our predictions, this results suggests that after the policy is implemented, EPO examiners rejects patents of relatively high quality (yet undeserved), or that those patents that still find a grant after narrowing their scope, are of relatively lower quality. However, since we found above that the policy did not significantly affected scope changes, the overall reduction of patent quality arguably comes from rejection of undeserved high-quality patent.

In Column 4, finally, we report the results for patent value. In this case, the estimated coefficient on the three-way interaction is not significant (standard error essentially equal to the coefficient). In view of the expected effects, and read together with the results on grant rates and scope reductions, this finding suggests that the policy was neutral to patent value. On average, the patents rejected by the policy as well as the patents that survive (but with narrower scope) are neither of higher value nor of lower value than the reference twin patents in the control set.

[23]Table A2 in Appendix A provides a similar picture, reporting averages of the outcome variables broken down by technological areas, patent office and pre/post-policy period.

[24]Table B1 in Appendix B shows preliminary estimates without control variables and without year fixed effects. They are all in line with the more reliable estimates we discuss here below.

[25]While the dependent variable is binary (granted vs. not granted), we use an OLS linear probability model. As most covariates are discrete, the linearity assumption is adequate.

Table 4: Main results

DEPENDENT VARIABLE:	GRANTED	Δ SCOPE	QUALITY	VALUE
	(1)	(2)	(3)	(4)
EPO	-0.369	0.303	-0.222	0.013
	[0.005]	[0.047]	[0.004]	[0.001]
POST_POLICY	-0.018	0.050	0.030	0.002
	[0.003]	[0.037]	[0.006]	[0.001]
EPO x *POST_POLICY*	-0.076	-0.124	0.005	0.006
	[0.007]	[0.065]	[0.006]	[0.001]
STD	0.013	0.075	0.86	0.001
	[0.002]	[0.025]	[0.006]	[0.001]
EPO x *STD*	-0.125	0.117	-0.095	-0.002
	[0.008]	[0.111]	[0.007]	[0.001]
POST_POLICY x *STD*	0.003	0.026	-0.004	-0.004
	[0.002]	[0.033]	[0.007]	[0.001]
EPO x *POST_POLICY* x *STD*	-0.075	-0.172	-0.014	0.001
	[0.009]	[0.121]	[0.008]	[0.001]
IS_PRIORITY	0.021	-0.238	0.041	-0.001
	[0.003]	[0.052]	[0.004]	[0.000]
LOCAL_ASSIGNEE	0.038	0.527	0.025	0.003
	[0.003]	[0.050]	[0.003]	[0.000]
LN_CLAIMS	-0.107	-0.147	0.381	0.007
	[0.002]	[0.014]	[0.002]	[0.000]
CONSTANT	1.251	0.760	-0.921	0.044
	[0.005]	[0.048]	[0.007]	[0.001]
YEAR DUMMIEs	YES	YES	YES	YES
Obs.	120841	50479	50776	50776
R^2	0.391	0.012	0.698	0.680

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

7 Robustness checks

We first test the sensitivity of our results by including (DOCDB) family fixed-effects in our baseline regression model. The estimation results are reported in Columns 1–4 of Table 5, respectively for the four different outcome variables. The available variation for identification of γ_0 is within twins, whereas, by definition, $POST\_POL$ and STD do not vary within the same family. As compared to the main estimates, these results confirm that the policy has a relatively strong effect on granting rates. Concerning the other outcomes, the sign and magnitudes of the three-way interaction coefficient are in line with the baseline estimates. However, possibly due to the stringent identification strategy, we loose statistical significance for the effect of the policy on patent quality, as indeed the standard errors gets larger.

Table 5: Robustness checks I

	FAMILY FE				18 MONTHS POLICY WINDOW			
	GRANTED	Δ SCOPE	QUALITY	VALUE	GRANTED	Δ SCOPE	QUALITY	VALUE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EPO	-0.289	0.282	-0.234	0.013	-0.367	0.333	-0.224	0.015
	[0.009]	[0.065]	[0.005]	[0.001]	[0.006]	[0.048]	[0.004]	[0.001]
POST_POLICY					-0.032	0.083	0.039	0.004
					[0.004]	[0.046]	[0.007]	[0.001]
EPO x *POST_POLICY*	-0.066	-0.130	0.008	0.005	-0.083	-0.191	0.005	0.005
	[0.012]	[0.088]	[0.007]	[0.001]	[0.008]	[0.064]	[0.005]	[0.001]
STD					0.010	0.081	0.082	0.003
					[0.002]	[0.028]	[0.007]	[0.001]
EPO x *STD*	-0.101	0.102	-0.095	-0.002	-0.127	0.130	-0.090	-0.003
	[0.013]	[0.152]	[0.008]	[0.001]	[0.009]	[0.135]	[0.007]	[0.001]
POST_POLICY x *STD*					0.004	0.001	-0.004	-0.006
					[0.003]	[0.036]	[0.009]	[0.001]
EPO x *POST_POLICY* x *STD*	-0.122	-0.163	-0.014	0.001	-0.077	-0.133	-0.018	0.001
	[0.016]	[0.164]	[0.010]	[0.001]	[0.011]	[0.142]	[0.008]	[0.001]
IS_PRIORITY	0.033	-0.164	0.008	0.003	0.025	-0.205	0.038	-0.002
	[0.013]	[0.167]	[0.010]	[0.001]	[0.004]	[0.055]	[0.004]	[0.000]
LOCAL_ASSIGNEE	0.048	0.535	0.067	0.002	0.037	0.501	0.028	0.003
	[0.006]	[0.065]	[0.004]	[0.000]	[0.003]	[0.052]	[0.003]	[0.000]
LN_CLAIMS	-0.162	-0.302	0.352	0.004	-0.110	-0.152	0.381	0.007
	[0.005]	[0.042]	[0.005]	[0.000]	[0.002]	[0.017]	[0.003]	[0.000]
CONSTANT	1.447	1.255	-0.665	0.045	1.260	0.750	-0.923	0.043
	[0.056]	[0.681]	[0.040]	[0.005]	[0.005]	[0.053]	[0.008]	[0.001]
YEAR DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES
FAMILY FIXED EFFECTS	YES	YES	YES	YES	NO	NO	NO	NO
Observations	120841	50479	50776	50776	105474	42214	42440	42440
R^2	0.790	0.554	0.897	0.896	0.402	0.013	0.696	0.702

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

As a second robustness check, we test our assumption that the new NPL infrastructure became available halfway 2004. We still assume that the actual examination occurs within six months prior to the search report, but we allow for the new NPL infrastructure being used *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 from January 1, 2004 to July 1, 2005. The results, reported in Columns 5–8 of Table 5, are essentially in line with the main estimates.[26]

A further possible point of concern is a potential mis-classification of not-granted patents due to truncation issues arising in patent-data datasets. In the main analysis, we defined the zeros in the granting outcome following the commonly accepted empirical solution that a patent is considered rejected if a formal granting decision does not reveal some years after the filing date. This may inflate the number of not-granted patents as compared to "true" rejections, however. If pending or abandoned patents are, for unmeasured reasons, more frequent at the EPO in standards-related areas, we may overestimate the reduction in granting rates associated to the EPO policy.

In Table 6 we provide two robustness exercises addressing this potential bias. In Column 1, we re-estimate the effect on granting probability after cutting the estimation sample at the end of 2009. The main conclusion is essentially confirmed: the estimated coefficient on the three-way dummy is negative and very close to the main estimate (slightly lower, about 6.5%). In Column 2, we take advantage of the EPO Office Actions Data kindly made available to us by Prof. Dietmar Harhoff. In this dataset, we can distinguish, for the entire set of patents in PATSTAT and until 2013, whether a patent has been actually abandoned. We thus re-estimate our main model after dropping all the twin-applications involving an abandoned patent. We still find that the EPO-policy change has significantly lowered the granting rates. The estimated effect is sensibly smaller than in the main analysis, now amounting to about -4%.

[26] To ease comparability with the main analysis, reported estimates do not include family fixed-effects. However, we did check that results do not change if we apply this more stringent identification strategy. The same holds for all the robustness checks we present in the rest of the section. All the estimates are available upon request.

Table 6: Robustness checks II

	TRUNCATION: DATA UP TO 2009	TRUNCATION: DROP WITHDRAWN PATENTS	ALTERNATIVE PROXY FOR SCOPE	ALTERNATIVE PROXY FOR QUALITY	ALTERNATIVE PROXY FOR VALUE	PLACEBO Y
Dep. Variable:	GRANTED	GRANTED	# WORDS in FIRST CLAIM	#CITATIONS	#RENEWALS>8	#Inventors
	(1)	(2)	(3)	(4)	(5)	(6)
EPO	-0.368	-0.352	-0.155	-1.479	-0.043	-0.008
	[0.005]	[0.005]	[0.006]	[0.024]	[0.007]	[0.004]
POST_POLICY	-0.024	-0.061	0.072	0.147	-0.076	-0.003
	[0.003]	[0.004]	[0.014]	[0.035]	[0.009]	[0.013]
EPO x *POST_POLICY*	-0.071	-0.001	0.020	0.124	0.235	-0.011
	[0.007]	[0.007]	[0.008]	[0.032]	[0.010]	[0.005]
STD	0.012	0.011	0.065	0.454	-0.040	-0.201
	[0.001]	[0.001]	[0.011]	[0.029]	[0.008]	[0.012]
EPO x *STD*	-0.125	-0.121	0.053	-0.503	0.091	-0.005
	[0.008]	[0.008]	[0.008]	[0.037]	[0.010]	[0.006]
POST_POLICY x *STD*	0.003	0.005	-0.056	-0.046	0.012	0.089
	[0.002]	[0.002]	[0.014]	[0.037]	[0.010]	[0.014]
EPO x *POST_POLICY* x *STD*	-0.065	-0.040	0.007	-0.330	-0.025	0.008
	[0.009]	[0.009]	[0.009]	[0.047]	[0.014]	[0.008]
IS_PRIORITY	0.022	0.023	0.022	0.041	0.005	-0.028
	[0.004]	[0.004]	[0.007]	[0.030]	[0.005]	[0.006]
LOCAL_ASSIGNEE	0.037	0.033	-0.116	0.360	-0.013	-0.023
	[0.003]	[0.003]	[0.005]	[0.027]	[0.004]	[0.004]
LN_CLAIMS	-0.106	-0.099	-0.079	0.287	0.011	0.064
	[0.002]	[0.002]	[0.004]	[0.013]	[0.002]	[0.004]
CONSTANT	1.247	1.228	5.038	0.872	0.898	0.899
	[0.005]	[0.005]	[0.013]	[0.041]	[0.008]	[0.013]
YEAR DUMMY	YES	YES	YES	YES	YES	YES
FAMILY FIXED EFFECT	NO	NO	NO	NO	NO	NO
Observations	103720	92747	119533	50776	50776	120841
R^2	0.371	0.274			0.495	
Log Pseudo-likelihood			-2814678.10	-162906.02		-222844.19

Notes: Columns (1), (2) and (5) report OLS estimates of Equation (1); Models in Columns (3), (4) and (6) are estimated via a Poisson quasi-maximum likelihood (QMLE Poisson) method. Robust standard errors in parenthesis, clustered by patent family (DOCDB).

In Column 3 of the same Table 6, we provide a further investigation of the effect of the EPO policy on patent scope. Among the possible explanations for our insignificant results on patent scope changes, we mentioned possible adaptation effects whereby EPO applicants, after the policy becomes known to be in place, modify the first claim already at the time they file the application to the EPO for a patent in standards-related areas. We thus re-run our main regression taking as the dependent variable the scope *at the application*, measured as the raw count of the number of words in the first claim of the EPO-USPTO twin application documents. The results, obtained via a Poisson quasi-maximum likelihood method to deal with a count dependent variable, show an insignificant coefficient on the three-way interaction.[27] Thus, the policy did not induce any adaptation effect in terms of the initial scope. Coupled with the result on scope changes obtained in the main analysis, this finding confirms that the policy change did not worked through refining the definition of legal protection, but rather by killing undeserved patent altogether.

Next, we test our conclusions against two alternative proxies for patent quality and patent value, avoiding some of the assumptions underlying the latent factor methodology for joint determination of quality and value. In Column 4 of Table 6, we take the number of forward citations in the five years after the application (from the OECD-Patent Quality Database) as an alternative measure of patent quality, and estimate a Poisson quasi-maximum likelihood model to tackle the well-known overdispersion of citations count. The results corroborate our main finding that the policy lowered the average quality of patents granted by the EPO in standards-related technologies.[28] In Column 5, we exploit information on renewals (again from the OECD-Patent Quality Database) to proxy for patent value. In particular, since we observe that patents in the sample are renewed on average 8 times, we build a dummy for "high-value patents" that equals one if a given patent has been renewed for more than 8 times, and zero otherwise.[29] The (OLS-linear probability) estimates are in line with the baseline finding that the EPO policy did not significantly affect patent value.

Finally, 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 the twin-applications filed at the EPO and at the USPTO, but there is no a-priori reason why it should be influenced by the new EPO policy. The results, obtained via Poisson quasi-maximum likelihood estimator, are reported in Column 6 of Table 6 and validate our main analysis.

8 Conclusions and discussion

In this paper, we provide an empirical assessment of the effect of an endeavor by the EPO to improve the quality of the patent granting process. Tackling concerns that the problem of weak patents is especially important in the area of standards-related inventions, the EPO started from 2004 to consider as relevant prior art the information revealed by parties when they together set technical standards. We design an EPO-USPTO twin patents approach to build counterfactuals combined with a Dif-in-Diff-in-Diff estimation to isolate the effect of the EPO policy change from technology-specific and patent-office specific trends.

We find, as expected, that the EPO policy change reduced the probability of a standards-related patent to be granted at the EPO. Controlling for other factors, a series of robustness analysis support that the induced reduction vis-à-vis control patents ranges from 4% to 12%, as compared to a 7.5% emerged in the main analysis.

Second, contrary to our expectations, the policy did not affect the definition of patent scope.

[27] Consistent results are obtained in OLS estimates, available upon request.

[28] The same conclusion is delivered by OLS estimates, available upon request.

[29] This strategy mitigates the truncation problem of renewals (van Zeebroeck, 2011).

Controlling for other factors and vis-à-vis the control group, the patent prosecution process at the EPO under the new policy did not induce more substantial scope reductions in between initial application and final grant. Also, it did not induced applicants to modify scope at the initial application. As discussed, two possible explanations for this unexpected result may be that: (a) patents threatened by standards-related NPL prior art are such that they are threatened in their entirety (all claims), and thus rejection rather than scope refinements turns out to be the main outcome; or (b) standards-related NPL prior art threatens the claim that would provide the patent with the status of standard-essential patent, and thus applicants are induced by the policy to drop out of the patent prosecution, because they are not interested in a reduced scope patent if it is no longer essential to a standard. Further analysis and different data would help to identify the relative strength of these alternative explanations.

We furthermore find that the EPO policy change had different effects on quality and value of patents. The policy did not affect the average value of granted patents, as compared to the average value of the control patents. It did result, however, in a significant decrease of the average quality of the EPO patents. Since the policy mostly worked through rejecting undeserved patents, more than through improving the definition of patent scope, we believe this result comes mostly from the EPO examiners rejecting relatively high quality, yet undeserved patent applications. So, while average patent quality has gone down, the quality of the *patent granting process* has improved.

All in all, we conclude that the EPO policy change had a positive impact on the overall quality of the patent granting process. We also find that the policy change did not work through refining the definition of legal protection by reducing the scope of granted patents, but rather by killing undeserved patent altogether.

Obviously, our analysis has some limitations, which set avenues for future research. Firstly, one could consider that applicants engage in "extreme" forms of adaptation-to-the-policy, that we cannot observed within our analysis.[30] One possible reaction, for instance, would be that an applicant might decide to forgo an EPO patent altogether, once the policy is revealed to be in place. A rationale for this choice might be that a patent family without an EPO member is still more attractive than a patent family with a rejected EPO member. An alternative strategy to adapt to the new EPO policy might be that an applicant changes the EPO application for a given invention so drastically, compared to the USPTO application, that the two documents no longer share the same set of priority documents. Both these adaptation strategies are not captured in our approach, since there would not exist EPO-USPTO twin-patents of the type we consider as the starting point of our analysis. Identifying and evaluating the impact of such adaptation effects would require a rather different set-up from ours. For instance, one could build a dataset including all applications at the five largest patent offices around the world, and then base the definition of the counterfactual outcomes on a more loose definition of patent family. Such an analysis would surely offer interesting extensions to our work, but at the price to give up the quite precise definition of twins and the relatively clean identification strategy that we employ in this paper.

Secondly, we foresee another interesting question, not yet answered by our research, concerning whether the EPO policy was effective in fighting stealing of ideas. Such an investigation would require to carefully consider when one can really talk of stealing, and when not. While normally one would not automatically talk of stealing when a patent application meets the novelty or inventive step criteria because of a third party prior art, patents rejected as a result of the new EPO policy are more prone to actual stealing: the killing prior art was very likely

[30]We do see that patent attorney firms inform their clients about the fact that the EPO now considers standards-related documents as prior art. See: `https://www.elkfife.com/news-and-views/2016/02/24/epo-approach-to-standards-related-documents-as-prior-art`

disclosed in a meeting that was presumably attended by the applicant as well. Thus, assuming availability of the required data, stealing of ideas would be relatively simple to asses in the case the idea was made public in its entirety by somebody different from the applicant, and the applicant was present at the meeting when this happened, or she was on the distribution list for the written documents and submissions for that meeting. Yet, one would arrive in a gray area, for instance, when a patent is rejected on grounds of lack of inventive step, because the examiner combined two documents shared by others in standards setting. Does such a case constitute stealing or not? While intriguing, also this type of analysis would require a substantially different research design than the one we adopt in this study. It is probably best addressed by more qualitative data and methodologies.

Nonetheless, the twin-patents approach, and the related narrow identification of the underlying common invention that we proposed here, can be extended to examine the effects of the EPO policy change on other potentially interesting outcomes. More broadly, we hope our methodology could inspire researchers to investigate the impact of other endeavors by patent offices around the world took to improve the quality of the patent granting process, such as the 'Peer to Patent' scheme as piloted by the USPTO (Noveck, 2006).

Our study has implications for policy. While the EPO policy change certainly did not come without implementation costs, it demonstrates that by relatively focused efforts, a quite sizable effect can be obtained, impacting a relatively large and important technological area. As such, 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.

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
QUALITY	50776	-0.05	0.39	-0.77	3.38
VALUE	50776	0.02	0.05	-0.15	0.22
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]

VARIABLE: ***QUALITY***				
	STD=1		*STD=0*	
	PRE_POLICY	*POST_POLICY*	*PRE_POLICY*	*POST_POLICY*
USPTO	0.19	0.21	0.06	0.07
	[0.41]	[0.39]	[0.39]	[0.37]
EPO	-0.23	-0.23	-0.27	-0.25
	[0.29]	[0.26]	[0.26]	[0.25]

VARIABLE: ***VALUE***				
	STD=1		*non_STD=0*	
	PRE_POLICY	*POST_POLICY*	*PRE_POLICY*	*POST_POLICY*
USPTO	0.05	0.00	0.05	0.00
	[0.03]	[0.04]	[0.03]	[0.04]
EPO	0.06	0.01	0.06	0.02
	[0.04]	[0.04]	[0.04]	[0.04]

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		QUALITY		VALUE	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EPO	-0.109	-0.108	0.446	0.445	-0.329	-0.330	0.011	0.012
	[0.006]	[0.006]	[0.045]	[0.044]	[0.005]	[0.005]	[0.001]	[0.001]
POST_POLICY	-0.127	-0.073	0.139	0.078	0.015	0.061	-0.053	0.002
	[0.006]	[0.007]	[0.026]	[0.037]	[0.008]	[0.010]	[0.001]	[0.001]
EPO x *POST_POLICY*	0.020	0.022	-0.181	-0.183	0.006	0.008	0.005	0.005
	[0.008]	[0.008]	[0.061]	[0.060]	[0.006]	[0.006]	[0.001]	[0.001]
STD	-0.070	-0.070	0.066	0.063	0.132	0.131	0.001	0.002
	[0.007]	[0.007]	[0.025]	[0.026]	[0.009]	[0.009]	[0.001]	[0.001]
EPO x *STD*	-0.061	-0.061	0.071	0.071	-0.093	-0.094	-0.001	-0.002
	[0.009]	[0.009]	[0.106]	[0.105]	[0.008]	[0.008]	[0.001]	[0.001]
POST_POLICY x *STD*	0.111	0.113	0.009	0.006	0.008	0.008	-0.003	-0.003
	[0.008]	[0.008]	[0.033]	[0.033]	[0.011]	[0.011]	[0.001]	[0.001]
EPO x *POST_POLICY* x *STD*	-0.190	-0.190	-0.139	-0.137	-0.022	-0.022	0.000	0.001
	[0.010]	[0.010]	[0.116]	[0.115]	[0.009]	[0.009]	[0.001]	[0.001]
CONSTANT	0.767	0.777	0.510	0.468	0.056	0.043	0.053	0.062
	[0.005]	[0.005]	[0.021]	[0.028]	[0.006]	[0.007]	[0.000]	[0.001]
YEAR DUMMIES	NO	YES	NO	YES	NO	YES	NO	YES
FAMILY FIXED EFFECTS	NO	NO	NO	NO	NO	NO	NO	NO
Observations	142660	142660	50479	50479	50776	50776	50776	50776
R^2	0.092	0.100	0.004	0.005	0.270	0.275	0.289	0.670

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

References

Allison, J. R. and M. A. Lemley (1998). Empirical evidence on the validity of litigated patents. *AIPLA Quarterly Journal 26*, 185.

Andersen, P. (2008). *Evaluation of Ten Standard Setting Organizations with Regard to Open Standards*. Copenhagen, Denmark: IDC.

Bekkers, R., C. Catalini, A. Martinelli, C. Righi, and T. Simcoe (2017, July). Disclosure rules and declared essential patents. NBER Working Papers 23627, National Bureau of Economic Research.

Bekkers, R. and A. Martinelli (2012). Knowledge positions in high-tech markets: Trajectories, standards, strategies and true innovators. *Technological Forecasting and Social Change 79*(7), 1192–1216.

Bekkers, R. and A. Updegrove (2013). *A study of IPR policies and practices of a representative group of Standards Setting Organizations worldwide (updated version).* Washington, DC: National Academies of Science.

Bessen, J. and M. J. Meurer (2008). *Patent Failure: How Judges, Bureaucrats, and Lawyers Put Innovators at Risk*. Princeton University Press.

Cotropia, C. A., M. A. Lemley, and B. Sampat (2013). Do applicant patent citations matter? *Research Policy 42*(4), 844–854.

de Rassenfosse, G. and A. B. Jaffe (2014, December). Are patent fees effective at weeding out low-quality patents? NBER Working Papers 20785, National Bureau of Economic Research, *forthcoming in Journal of Economics and Management Strategy.*

de Rassenfosse, G., A. B. Jaffe, and E. Webster (2016). Low-quality patents in the eye of the beholder: Evidence from multiple examiners. NBER Working Papers 22244, National Bureau of Economic Research.

Dernis, H. and M. Khan (2004). *Triadic patent families methodology: STI working paper 2004/2*. Paris: OECD.

EC (2014). *Patents and Standards: A modern framework for IPR-based standardization.* Brussels: European Commission.

EC (2017). *Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee: Setting out the EU approach to Standard Essential Patents COM(2017) 712 final (Brussels, 29.11.2017).* Brussels: European Commission.

EPO (2003). *EPOQUE Quick Reference Guide, Third Edition (EPO-95-001).* Rijswijk, The Netherlands: European Patent Office.

EPO (2004). Technical Board of Appeal decision T0050/02. Technical report, Munich: European Patent Office, Munich.

EPO (2012). Report on the Workshop on Patent Quality, initiated by the EPO Economic and Scientific Advisory Board, 7 May 2012. Technical report, Munich.

EPO (2016). European Patent Convention, 16th edition. Technical report, Munich: European Patent Office, Munich.

Farrell, J. and G. Saloner (1988). Coordination through committees and markets. *The RAND Journal of Economics 19*(2), 235–252.

Farrell, J. and C. Shapiro (2008, September). How Strong Are Weak Patents? *American Economic Review 98*(4), 1347–1369.

Frakes, M. D. and M. F. Wasserman (2014). Is the time allocated to review patent applications inducing examiners to grant invalid patents? evidence from micro-level application data. NBER Working Papers 20337, National Bureau of Economic Research.

FTC (2003). *To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy*. Washington, DC: Federal Trade Commission.

Granstrand, Ø. (1999). *The Economics and Management of Intellectual Property: Towards Intellectual Capitalism*. Edward Elgar.

Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2001, October). The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools. NBER Working Papers 8498, National Bureau of Economic Research.

Hegde, D., D. Mowery, and S. Graham (2007). Pioneers, submariners, or thicket-builders: Which firms use continuations in patenting? NBER Working Papers 13153, National Bureau of Economic Research.

Henkel, J. and H. Zischka (2015). Why most patents are invalid - extent, reasons, and potential remedies of patent invalidity. Working Paper dated December 2015, Available at: https://www.tim.wi.tum.de/index.php?id=200.

IAM (2016). Court battle over Unwired Planet patents continues (24 February 2016). Report.

Jaffe, A. B. and J. Lerner (2004). *Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It*. Princeton University Press.

Jensen, P. H., A. Palangkaraya, and E. Webster (2005). Disharmony in International Patent Office Decisions. *The Federal Circuit Bar Journal 15*(4), 679–704.

Jensen, P. H., A. Palangkaraya, and E. Webster (2008, April). Application Pendency Times and Outcomes across Four Patent Offices. Melbourne Institute Working Paper Series 2008/06, Melbourne Institute of Applied Economic and Social Research, The University of Melbourne.

Karachalios, K. (2010). The Challenge of Patent Governance in ICT Standards, Seen from a Patent Authoritys Perspective. Economics Series No. 110, East-West Center, Honolulu, Hawaii.

Krechmer, K. (1998). The principles of open standards. *Standards Engineering 50*(6), 1–6.

Kuhn, J. M. and N. Thompson (2017). How to measure and draw causal inferences with patent scope. *International Journal of the Economics of Business, forthcoming*.

Kühn, K.-U., F. Scott Morton, and H. Shelanski (2013). Standard setting organizations can help solve the standard essential patents licensing problem. *CPI Antitrust Chronicle March 2013 (Special Issue)*.

Lampe, R. (2012, February). Strategic Citation. *The Review of Economics and Statistics 94*(1), 320–333.

Langinier, C. and P. Marcoul (2016, Nov). The search of prior art and the revelation of information by patent applicants. *Review of Industrial Organization 49*(3), 399–427.

Lanjouw, J. O. and M. Schankerman (2001). Characteristics of patent litigation: A window on competition. *The RAND Journal of Economics 32*(1), 129–151.

Lanjouw, J. O. and M. Schankerman (2004). Patent quality and research productivity: Measuring innovation with multiple indicators. *The Economic Journal 114*(495), 441–465.

Lei, Z. and B. D. Wright (2017). Why weak patents? testing the examiner ignorance hypothesis. *Journal of Public Economics 148*, 43 – 56.

Lemley, M. A. (2002). Intellectual property rights and standard-setting organizations. *California Law Review 90*(6), 1889–1980.

Lemley, M. A. and B. Sampat (2012). Examiner characteristics and patent office outcomes. *The Review of Economics and Statistics 94*(3), 817–827.

Lemley, M. A. and C. Shapiro (2005, June). Probabilistic patents. *Journal of Economic Perspectives 19*(2), 75–98.

Lemley, M. A. and C. Shapiro (2013). A Simple Approach to Setting Reasonable Royalties for Standard-Essential Patents. *Berkeley Technology Law Journal 28*(2), 1136–1166.

Lerner, J. (1994). The importance of patent scope: An empirical analysis. *The RAND Journal of Economics 25*(2), 319–333.

Marco, A., J. D. Sarnoff, and C. deGrazia (2016). Patent claims and patent scope. USPTO Economic Working Paper 2016-04, USPTO.

Martínez, C. (2011). Patent families: when do different definitions really matter? *Scientometrics 86*(1), 39–63.

Merrill, S. A., R. C. Levin, and M. B. Myers (Eds.) (2004). *A Patent System for the 21st Century*. Washington, DC: National Research Council of the National Academies.

Nordhaus, W. (1969). *Invention growth, and welfare: a theoretical treatment of technological change*. Monographs in economics. MIT Press.

Noveck, B. S. (2006). Peer to patent: Collective intelligence, open review, and patent reform. *Harvard Journal of Law & Technology 20*(1), 123–162.

Okada, Y., Y. Naito, and S. Nagaoka (2016). Claim length as a value predictor of a patent. IIR Working Paper 16-04, Institute of Innovation Research, Hitotsubashi University.

Osenga, K. (2012). The shape of things to come: What we can learn from patent claim length. *Santa Clara Computer and High - Technology Law Journal 28*(3), 617–656.

RPX (2014). Standard Essential Patents: How Do They Fare? Report.

Schmidt, S. and R. Werle (1998). *Coordinating technology: Studies in the international standardization of telecommunications*. Cambridge: The MIT Press.

Sipapin, Y. V. and A. P. Kolesnikov (1989). Patent equivalents: Problems of retrieval and patent family tracing in databases. *World Patent Information 11*(3), 139–146.

Squicciarini, M., H. Dernis, and C. Criscuolo (2013, June). Measuring Patent Quality: Indicators of Technological and Economic Value. OECD Science, Technology and Industry Working Papers 2013/3, OECD, Paris.

USPTO (2016). Electronic Non-Patent Literature Available at the USPTO. Report, US Patent and Trademark Office, Washington, DC.

van Zeebroeck, N. (2011). The puzzle of patent value indicators. *Economics of Innovation and New Technology 20*(1), 33–62.

Webster, E., A. Palangkaraya, and P. H. Jensen (2007, June). Characteristics of international patent application outcomes. *Economics Letters 95*(3), 362–368.

Wijkström, E. and D. McDaniels (2013). International standards and the WTO TBT Agreement: Improving governance for regulatory alignment. WTO Staff Working Papers ERSD-2013-06, World Trade Organization (WTO), Economic Research and Statistics Division.

Willingmyre, G. T. (2012). *Cooperation between Patent Offices and Standards Developing Organizations*. Washington, DC: National Academies of Science.

WIPO (2004). *WIPO Intellectual Property Handbook. WIPO Publication No. 489 (E).* Geneva, Switzerland: World Intellectual Property Organization.