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The impact of including standards-related documentation in patent prior art: Evidence from an EPO policy change

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ABSTRACT
It is crucial that patent offices grant protection only to those inventions that are novel and non-obvious. In 2004, the European Patent Office (EPO) made the unique move to systematically extend its prior art database by including documents shared among members of standard-setting organisations, but not made available to the general audience. This paper investigates the effects of this policy change. We find that it worked thanks to a significant reduction in granting rates rather than reducing the scope of granted patents. Our study demonstrates how a targeted approach can improve the quality of the patent granting process.

1. Introduction
The prevailing view that patents help to achieve an optimum level of inventive activity and disclosure, rests on the hypothesis that the static inefficiency emerging from the temporary monopoly created by patents is counterbalanced by the dynamic efficiency of introducing innovations into society (Nordhaus, 1969). However, this balance is only achievable if the patent system rewards just those inventions that truly deserve protection, that is, inventions that are novel and non-obvious (Farrell and Shapiro, 2008). Imposing enforceable legal rights by granting “questionable”, so-called “weak” patents, seriously harms the innovation process (Lemley and Shapiro, 2005). The phenomenon of weak patents is increasingly recognized and investigated. Recent evidence suggests that highly significant shares of granted patents do not meet the patentability criteria of novelty and non-obviousness. For instance, Henkel and Zischka (2019) estimate that approximately 75% of granted German patents would be partially or fully invalidated if challenged in court.

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

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

Arguably, the most promising area of intervention to reduce the approval of weak patents pertains to improving the process through which patent examiners ensure that the invention filed for a patent...
meets the criteria of novelty and inventive step.\(^1\) Crucial to this process is that examiners evaluate applications against the current state of the art at the time the patent was filed (or, if applicable, at the date of the patent’s right of priority). This state of the art – known as “prior art” – includes earlier patent applications as well as the body of so-called non-patent literature (NPL), which encompasses the scientific and other literature relevant to the invention at stake. However, the precise definition of what constitutes prior art differs across patent jurisdictions (Cotropia et al., 2013), as does the practical assessment of prior art across patent offices around the world. For instance, there are different rules governing the applicant’s duty to disclose relevant prior art to the patent office in the application document, and there are differences in the coverage of databases of earlier patents and NPL which patent offices make available to their examiners to facilitate the prior art search.

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

In this paper, we examine the outcomes of an interesting policy change implemented in year 2004 by the EPO in the context of prior-art definition and examination in technological areas related to standards-setting. Responding to the outcome of several cases ruled in the late 1990s before its Technical Board of Appeal, the EPO took the position that NPL-type documents shared among members in the context of setting technical standards (e.g., technical contributions / submissions, meetings minutes, and draft standards) should be considered prior art, whereas previously the view of the EPO – as well as that of other patent offices – was that such ‘unpublished’ documents (i.e. documents only available to members and not made available to the general audience) should not be considered by patent examiners when judging novelty and inventive step.\(^2\) In addition, the EPO began to collaborate with major Standard Setting Organizations (SSOs) around the world to ensure that those documents were collected systematically and integrated into the EPO’s internal database for prior art search (Verbandt and Vadot, 2018).

From 2004 onward, there was a significant increase in the knowledge repository available to EPO examiners when searching for prior art. Following this change, the EPO reportedly found these newly available documents were of substantive practical value for its patent decision-making processes (see Willingmyre, 2012). From our communications with the EPO, we learned that after the policy change, the use of standards-related documents and drafts was estimated to matter in roughly 30 to 40 percent of the examinations in technical fields that rely heavily on technical standards.

Despite these encouraging signals about the advantage achieved by the EPO policy change, a full impact analysis has yet to be carried out. The present paper aims at filling this gap. Among the potential impacts the policy change might have had, we focus on the effects on two dimensions that are central to the definition of patent quality as proposed by the EPO Economic and Scientific Advisory Board’s 2012 Expert Workshop on Patent Quality (EPO, 2012, p.5). We examine: (1) improvements in the ability of examiners to identify patent applications that do not warrant a grant because the prior art was already shared in the context of standards setting; and (2) where appropriate, improvements in the ability of examiners to define the scope of granted patents, such that they no longer include claims that cover prior art already shared in the context of standards-setting (what Bessen and Meurer, 2008, describe as safeguarding the appropriate patent boundaries).\(^3\) The first effect relates to patents that should be rejected outright. The second to patents where some claims can be approved, while others cannot, or must be modified to avoid clashing with standards-related prior art. Accordingly, our study focuses on two outcome variables: granting rates and changes to patent scope between the initial filing and the eventual grant of a patent.

Notwithstanding sustained efforts to improve cooperation and harmonization among major global patent offices in the IPS,\(^4\) the EPO decision to consider SSOs documentation as part of prior art is an isolated one. Since a patent application for the same invention can be (and often is) filed for in multiple patent offices, this isolated EPO move can be exploited to identify counterfactual “twin patents” not subject to the EPO policy change. In this study, we compare differences in outcomes across EPO-USPTO patent twins, i.e., patent documents filed for the same underlying invention at both the EPO and the USPTO. In order to isolate the effect of the EPO policy change from other possible sources of variation, our identification strategy applies a patent-level Diff-in-Diff estimation, controlling for patent-office specific and technology-area specific confounding factors, before vs. after the implementation of the EPO policy change.

This study contributes to the broad literature on the functioning of the patent system and the need to improve the quality of the patent granting process (Jaffe and Lerner 2004; Bessen and Meurer 2008), and to the more specific literature examining how improving prior art determination (Lampe 2012; Lemley and Sampat 2012) and prior art availability (Choudhury and Khanna 2015) can affect patent system effectiveness. Our analysis also offers recommendations to help patent offices improve their procedures, based on the insights from a specific and targeted reform attempt.

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

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

The identification of relevant prior art is central to the patent prosecution/patent granting process, because novelty and non-obviousness (i.e., the presence of an ‘inventive step’) are fundamental requirements for the legal monopoly that patents create. Patent examiners are

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\(^1\) Other options include changes at the opposition or the litigation stages.

\(^2\) Note that while all patent offices consider final, published standards to be prior art, such documents typically come much later in time. Insofar standards bodies also make other documents available to the general audience (by choice or by mistake), then all patent offices will also consider them to be prior art.

\(^3\) The available documentation implies that these were reasonably the two direct targets of the policy (see, e.g., Karachalios, 2010; Willingmyre, 2012), although no official EPO document explicitly lists the policy targets.

\(^4\) In addition to the USPTO and the EPO, the IPS consists of the following patent offices: the Japanese Patent Office (JPO), the Korean Intellectual Property Office (KIPO), and the Chinese National Intellectual Property Administration (CNIPA, formerly SIPO).
required in their search reports to disclose whatever prior art they believe to be relevant in order to assess a patent application. An important question, then, is what exactly constitutes prior art. While the precise definition of prior art differs to some degree across legislations, the World Intellectual Property Organization (WIPO) handbook on Intellectual Property Rights (IPRs) defines it as follows: “Prior art is, in general, all the knowledge that existed prior to the relevant filing or priority date of a patent application, whether it existed by way of written or oral disclosure.” (WIPO, 2004). Here, the disclosure element refers to whether the relevant knowledge is in the ‘public domain’ as explained by the EPO in Article 54(2) of the European Patent Convention: “The state of the art shall be held to comprise everything made available to the public by means of a written or oral description, by use, or any other way, before the date of filing of the European Patent Application.” (EPO, 2016b).

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

A seemingly more technical, yet crucial issue related to prior art determination pertains to the documentation available to patent examiners when searching for prior art. In fact, although a certain piece of information may meet the definition of prior art, it will not affect the examination process if the examiner does not find it. Given the need for effective, efficient, and conclusive searches for prior art, patent offices provide their examiners with extensive, well-structured databases.

These do not only include all already existing patent applications, but also encompass a large body of NPL documents. The USPTO makes NPL available to the examiners in its STIC (Scientific and Technical Information) database, which provides access to a large number of electronic books, periodicals, conference proceedings, dissertations, and more (USPTO, 2016). The EPO makes NPL available to its examiners via its EPOQUE database, which contains a total of about 12 million NPL documents, including commercial and non-commercial publications such as journals, conference material, books, academic dissertations, technical reports and monographs (EPO, 2003). Certainly, prior art as understood in patent law is not restricted to what is made available in patent offices’ internal databases, and patent examiners may also search elsewhere. However, such a search is often difficult and not very effective, and a major issue is that the precise dating of documents – which is essential for proper prior art assessment – is not easily guaranteed when searching outside the databases of patent offices.

Despite the crucial role of prior art in determining patentability and therefore patent validity (Allison and Lemley, 1998; Lemley and Sampat, 2012; Lemley and Shapiro, 2005), little academic research is devoted to understanding its role in the patent examination process. A remarkable exception is by Choudhury and Khanna (2015), who, in a setting similar to ours, find that providing patent examiners with new prior-art about traditional Indian medical knowledge, reduces both filing and granting in the area of herbal patents. In addition to that, some indirect discussion of the role of prior art is provided in recent works on strategic citations by assignees. Langinier and Marcoul (2016) propose a theoretical model of the examination procedure where applicants strategically cover up relevant prior art. Lampe (2012) finds evidence that patent applicants in the US, despite having a legal obligation to disclose relevant prior art to the patent office (‘Duty of Candor’), still withhold between 21 and 33 percent of the relevant prior art known to them.

3. Standards development and prior art at the European Patent Office

In many technical fields, standardization is a key alignment mechanism, allowing the rate and direction of technological progress to be negotiated among participating stakeholders (Schmidt and Werle 1998; Farrell and Saloner 1988). Standards shape what future technologies will look like, particularly in areas where the market requires interoperability, such as in telecommunications, IT and media, and in future technological areas such as e-health, smart grids, and smart cities. 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. Financial and legal uncertainties regarding access to and pricing of SEPs may jeopardize the diffusion and success of standards (Lemley 2002; Lemley and Shapiro 2013). For this reason, many SSOs adopted IPR policies that require members to disclose potential SEPs during the development of standards, and request the owners of potential SEPs to commit themselves to license these patents on fair, reasonable and non-discriminatory (FRAND) conditions, should these patents indeed become essential (Lemley 2002; Bekkers and Updegrove 2013). Despite such policies governing essential patents, there continue to be high levels of disputes and litigation. The likelihood of litigation for disclosed potential SEPs is four times higher than for patents with otherwise similar characteristics (Bekkers et al., 2017). There are also indications that in court cases, disclosed potential SEPs are more often found invalid than other patents.

This is why the Internet is not well suited to prior art searches. Some SSOs also allow non-members to participate in standard-setting. If so, they normally have to agree to similar rules in the context of meeting participation as those that apply to members.

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

For instance, the 3GPP workgroup developing the 3G, 4G and 5G telecommunications standards involved a total of over 1,300 meetings between January 1999 and October 2017. See http://www.3gpp.org/3gpp-calendar.
can also come from members’ shared thinking.

Before the EPO policy change that we examine in the present paper, patent examiners could not systematically consider the body of information shared by members within standards-setting in their evaluation of the prior art relevant to assess the patentability of a patent application. This not only allowed companies or individuals to file for patents on ideas that they had already disclosed to industry partners at SSO meetings; it also created the real risk that any member could file for a patent on ideas that other members shared in the standards-setting context, or based on combinations of such ideas. The literature indeed refers to cases of purported “stealing of ideas” in standards-setting processes (Granstrand, 1999, p. 204).

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

In the ensuing years, several other rulings by the High Court of Justice confirmed this understanding. For instance, in a case concerning a proposal sent to an ETSI workgroup in preparation for a meeting (ISO/IEC 12841/01/16), the ETSI Technical Board of Appeal ruled, in 1999, that a proposal sent to a SSO workgroup in preparation for a meeting is not protected by a confidentiality obligation and, therefore, is public. In other words, the EPO acknowledged that information shared among members in the context of standards-setting could be prior art. Recognizing that the outcome of these appeal cases could improve the quality of the European patent granting process, the EPO realized that additional steps were necessary for their wider impact. The first step taken by the EPO was to ensure itself systematic access to preliminary standardization documents that met the requirements for prior art. This was achieved by becoming a member of several SSOs, and signing Memoranda of Understanding (MoU) with the European Telecommunications Standards Institute (ETSI) and the Institute of Electrical and Electronics Engineers (IEEE), and a High Level Technical Agreement with the International Telecommunication Union (ITU) (Willingmyre, 2012). These agreements gave the EPO access to a large repository of relevant documents such as (i) standards documents finalized after discussions, agreements and voting; (ii) preliminary drafts of standards which were the basis for discussion and voting within the SSOs; (iii) documents related to the initial drafting of standards, but later replaced by the published versions; and (iv) other relevant contributions to workgroups meetings, predominantly first disclosures of new technical information made shortly before or during a meeting.

Documents in the last three categories are typically available to members only, and not made available to the general audience.

The second action by the EPO involved a substantial process of preparation, harmonization, classification, proper date checking, bibliographical information collection, and technical document formatting and/or language translation, aimed ultimately at including standards-related documents in the EPO NPL databases and infrastructure, eventually making them readily available to EPO examiners for their prior-art searches.

After several years of preparation, the ETSI-NPL database was made available to the EPO examiners in 2004 (Bourbon, 2006, p.20). This database, internally known as XPETSI, is arguably the most important part of the standards-related NPL infrastructure set up by EPO. Although EPO examiners, in theory, could have already referenced SSO-related NPL since the above-mentioned rulings of the EPO Technical Board of Appeal in the late 1990s, in practice this could only have happened sporadically – in specific cases where an examiner happened to have access to such internal SSO documents. Compared to the large number of patent applications related to standards, the overall impact of such sporadic cases would have been negligible. A measurable impact of the change in the EPO treatment of SSO documentation can only be expected from 2004 onward, when examiners were given large scale, systematic access to the documents in the ETSI-NPL database. In agreement with this line of reasoning, the EPO revealed to us that prior-art references to documents resulting from the MoU with ETSI immediately appeared and actually sharply increased already in 2004, as soon as the XPETSI database was introduced, confirming it was extensively used since the very beginning. The ITU and IEEE databases were completed in 2006 and 2008, respectively, but it was the XPETSI introduction in 2004 that really marked a major change. In fact, ITU and IEEE databases are, from their introduction and as of today, much less cited at the EPO than the XPETSI database.

4. Empirical framework and working hypotheses

As mentioned in the introduction, we examine the effects of the EPO policy change on two crucial aspects of patent quality. First, on the ability of examiners to identify patent applications not worthy of being granted because of prior art already shared in the context of standards-setting. Second, on the ability of examiners to define the scope of patentability (footnote continued) to consortia members subject to a non-disclosure agreement (examples are CD-ROM, DVD, and Blu-ray disc). Thus, these standards – final versions or preliminary documents – never enter the public domain.

Information about prior-art references to the different SSO-related NPL databases was provided to us in private communication with EPO staff.

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10 Following the USPTO’s recent abandonment of its “first to invent” system, all the major patent offices around the world now work under a “first to file” system which assigns patents to the entity that files, not to the actual inventor.

11 Source: discussions with EPO staff.

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

13 The Court’s decision of February 10, 1999, offers the following summary “Mit einer Tagesordnung an Mitglieder einer internationalen Normenausschussarbeitsgruppe versandter Normungsvorschlag zur Vorbereitung einer Normen-Sitzung unterliegt gewöhnlich nicht der Geheimhaltung und gilt daher als der Öffentlichkeit zugänglich.” (Translated: A proposal for a standard, sent along with the draft agenda to members of an international standards body, is generally not subject to confidentiality and should, therefore, be considered as publicly available.)

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

15 Here we refer specifically to SSOs where membership is open to any interested party. There are many more dimensions and interpretations of what an “open SSO” comprises (see Andersen, 2008; Kreckher, 1998; Wijkström and McDaniels, 2013; WTO, 2000). Note that in some private standards consortia, standards – even final ones – are not publicly published, and are available only
granted patents, intervening on claims that cover up prior art already shared in the context of standards-setting. In this section, we describe the empirical strategy designed to identify the effects of the policy on these outcomes, and offer a brief discussion of the effects we expect to observe.

4.1. Identification strategy and empirical model

Several features of the EPO policy change provide support that it can be considered as exogenous, opening up the possibility to identify its effects by comparing patent outcomes before and after the implementation of the policy. In fact: (1) there is a clear point in time when the policy came into force, since EPO examiners did not have full, systematic access to standards-related NPL documentation before 2004; (2) relatedly, the policy change was not and could not be anticipated by examiners, since, even if they knew about the new EPO’s view on prior art, they could not change their “granting propensity” and examination routines until the new standards-related NPL documentation became fully available to them; and (3) the EPO policy change was not anticipated by applicants, since there had been no previous trends toward questioning patents on the grounds of standards-related confidential NPL.

In addition to exploiting these characteristics of the EPO policy change, we take advantage of a particular feature of the way the international patent systems function, which allows for a very specific identification of counterfactuals, i.e., that the same invention can be filed for obtaining a patent at multiple patent offices around the world, in order to obtain patent protection in multiple countries. This implies that we can observe the outcomes of interest (granting decision and changes in scope between initial filing and eventual grant) for a given patent application for a given standards-related invention filed at the EPO – thus subject to the policy change – and compare them with the outcomes of the application filed for the same invention at a different patent office, where standards-related NPL documentation shared only between members is not systematically provided to examiners for their prior art searches.

In our analysis, we select the USPTO to build counterfactuals. This patent office is indeed the best candidate for several reasons. First and foremost, USPTO examiners are not allowed to use documents shared between members in the context of setting technological standards (e.g., technical contributions / submissions, meetings minutes, and draft standards) if these documents are not publicly available (e.g., not accessible by non-members). Moreover, all the data and variables required for our analysis are available for the USPTO, while this would not be the case taking other patent offices. In particular, the USPTO publishes patent applications and granted patents in a roman language, allowing us to perform patent scope analysis on the basis of the text in the patent claims.

Based on these considerations, in our study, we use a “twin-patents approach” comparing outcomes between two patents filed for the same invention at the EPO and the USPTO. The treatment group consists of all applications involving an invention related to standards setting, applied for at the EPO in the period after the EPO examiners were given full access to the XPETSI and the other SSO-related NPL search databases. For the definition of the control group, one could, at a minimum, just take the corresponding USPTO twin of each treated EPO patent application. However, identification of the policy change effects on grant rates or scope changes may be biased by unobserved changes in technology-area specific and/or patent-office specific factors that affect trends in outcomes, both before and after the policy change. Examples of such changes are, in particular, general institutional changes at patent offices (not specifically targeted to standards-related applications), such as the Convention on the Grant of European Patents (EPC) which came into force in December 2007 and which contained changes to the use of prior art, or the USPTO Accelerated Examination program, introduced in 2006. We aim to control for these confounding sources of variation. Therefore, in order to provide a cleaner identification of the control group and make the underlying parallel trends assumption more convincing, we include in the analysis: (i) the EPO-USPTO twins filed for a patent 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) not only after but also before the EPO policy was in place.

Eventually, we frame the identification of the EPO policy effects according to the following patent-level Diff-in-Diff-in-Diff (DDD) regression:

\[ Y_i = \beta_0 + \beta_1 \text{EPO}_i + \beta_2 \text{POST}_\text{POL}_i + \beta_3 \text{STD}_i + \gamma_1 \text{EPO}_i \times \text{POST}_\text{POL}_i + \gamma_2 \text{EPO}_i \times \text{STD}_i + \gamma_3 \text{POST}_\text{POL}_i \times \text{STD}_i + \alpha_i + b_i + u_i. \]  

(1)

For each patent \( i \), the dependent variable \( Y \) is alternatively one of the two outcomes of interest (receiving a grant, and changes in patent scope between application and grant). On the right-hand side, the dummy \( \text{EPO}_i \) equals 1 for a patent filed at the EPO, and zero for the twin-document filed at the USPTO; the dummy \( \text{POST}_\text{POL}_i \) equals 1 if the patent can be considered as under examination for prior art in the period after the EPO policy change, and zero otherwise; the dummy \( \text{STD}_i \) equals 1 if the patent is in a technological domain where standards are relevant, and zero otherwise. Thus, the coefficient \( \gamma_1 \) yields an estimate of the effect of the EPO policy change, capturing the difference in average outcomes for the group of patents subject to the policy (i.e., filed at EPO in areas related to standardization after the standards-related NPL became fully available to EPO examiners).

To ease identification, Eq. (1) also includes a full set of year fixed-effects (\( \alpha_i \)), controlling for time trends in the dependent variables. We also include a set of patent-level variables (\( X_i \)) to control for patent-specific characteristics otherwise unobserved, but possibly relevant in inducing differences in the outcomes of the examination process within twins across patent offices.

The details on the empirical definition of the variables appearing in Equation (1) are presented in Section 5. Before that, we discuss the policy effects we theoretically expect to observe.

4.2. Expected policy effects

What can one say a-priori about the effects of the policy on the outcome variables of interest, if the policy achieved its objective to improve the quality of the granting process? In terms of granting probabilities, we expect that EPO examiners became more likely to identify and reject applications not worthy of a patent grant, as a result of the improved knowledge and extended definition of prior art. Thus, controlling for other factors, after the policy change we should observe a decrease in granting rates at the EPO in standards-related areas vis-à-vis the counterfactual USPTO twins. This effect would show up as a negative estimated coefficient on the three-way interaction \( \gamma_0 \), meaning a negative difference in average granting rates across treated and control patents.

Regarding the impact on changes to patent scope between the initial filing and eventual granting, the policy change substantially extended the basis of knowledge available to EPO examiners to assess the appropriate extent of legal protection to be afforded to patent applications filed for inventions in standards-related areas. As a result, we expect EPO examiners of standards-related applications to more frequently inform patent applicants that the claims in their application do not meet the patentability criteria, vis-à-vis USPTO examiners of the twin patent application and compared to the pre-policy period. In response to that, we expect applicants to be “forced” to make more substantive
changes to patent scope in their EPO applications, in an attempt to retain the possibility that a patent is granted. We thus predict that standards-related EPO applications undergo more substantive reductions in scope in the process from application to the final grant, compared to counterfactual USPTO twins (controlling for other factors). This would imply an estimated positive coefficient on the three-way interaction $\gamma_0$ in the regressions taking scope changes as the dependent variable.

5. Sample design and main variables

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

5.1. Data sources and initial sample

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

The initial sample we retrieve from PATSTAT includes all EPO and all USPTO patents recorded in PATSTAT with an application date between January 1, 2001, and December 31, 2011. For our analysis, we need to access EPO and USPTO patent applications as well as patent grant documents. However, USPTO patent applications are available only since March 2000, because the USPTO did not publish applications previous to that date. By taking January 1, 2001 as the start date for our data, we net out potential initial slack in the availability of USPTO applications. The end date on December 31, 2011 is meant to account for well-known truncation issues. In fact, the time between the patent application and an eventual grant can span several years (Hall et al., 2001). By including patent applications filed up to December 31, 2011, we can exploit at least four more years of PATSTAT data to observe if a grant manifests for the most recent application in the PATSTAT edition at hand, and an even longer time period for older patent applications.

5.2. Identification of standards-related vs. other technological areas

Out of the pool of EPO and USPTO patent documents available in PATSTAT in the selected time span, our construction of the treatment and control groups starts with providing a criterion to distinguish patents that are standards-related and, thus, potentially affected by the EPO policy change. Our strategy is to identify those International Patent Classification (IPC) subclasses covering technologies where standardization is a prominent phenomenon. We do that by observing which IPC subclasses have a high rate of occurrence of disclosed SEPs. A disclosed SEP is a patent which has been disclosed to a SSO in the belief it is essential or it may become essential for a technical standard. We exploit a publicly available database (the dSEP database, see Bekkers et al., 2017) which compiles disclosed SEPs from the 14 largest global standard-setting bodies, allowing us to identify the most frequent IPC subclasses in these kinds of patents. The distribution of disclosed SEPs by IPC subclasses is heavily skewed: the five top ranked subclasses in terms of number of disclosed SEPs (see upper panel in Table 1) cover 63 percent of all disclosed SEPs. We take these five subclasses as identifiers of standards-related patents: a given patent enters our focal set (i.e., $STD = 1$ in Eq. (1)) if it is classified in at least one of these five IPC subclasses. The number of EPO applications in each class (last Column in Table 1) shows that these subclasses are quite large, presumably because they are dominated by telecommunications and other technology areas that are cumulative in nature and, thus, involve many patents.

All those patents that do not qualify as standards-related according to the above selection, because they are classified in other IPC subclasses, can in principle be included in the control group of patents unrelated to standardization. However, in order to achieve a clear separation between potentially treated and control patents, we want to identify only IPC classes that can be considered as completely unrelated to standardization. Again, we base this identification on the relevance of the disclosed SEPs, looking for IPC subclasses that feature a negligible presence of disclosed SEPs. This produced a group of 13 IPC subclasses (see the bottom panel in Table 1) where the number of disclosed SEPs ranges from zero to five, corresponding to at most 0.016 percent of all patents in each subclass. Accordingly, we define as unrelated to standards ($STD = 0$ in Eq. (1)) all patents assigned to one or more of these 13 IPC subclasses.

5.3. Identification of EPO-USPTO twin patents

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

We proceed as follows. Out of the initial sample of USPTO and EPO applications with filings between January 1, 2001 and December 31, 2011, we firstly select all the DOCDB families that include at least one application filed at the EPO and at least one application filed at the USPTO. This means that we discard families with patent applications filed only at the EPO or only at the USPTO (or at neither of these offices).

Furthermore, we exclude patent applications filed via the Patent Cooperation Treaty (PCT) route, as these applications could affect our data in various ways which are not easy to anticipate, likely biasing the analysis. Firstly, we may face a bias due to the fact that the search report for PCT is prepared by a designated office, chosen by the applicant. If EPO was chosen as the designated office, we do not know whether the handling EPO examiner is supposed to use the specific SSO-related prior art available in the EPO database services, or not. Secondly, a PCT application may have a previous priority filing (so it is not a ‘first filing’ at PCT), and this may introduce uncertainty about how such an earlier filing – which may have been at EPO or elsewhere – affected the PCT search report and what the further effects were on prior art considered by the PCT contracting state. Thirdly, we have no certainty whether an EPO examiner, handling an incoming PCT application, has done additional work to complement the PCT search report

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18 For further information, see EPO (2016a).

19 See Bekkers and Martinelli (2012) for a similar selection.
Specifically, 9.1% of the DOCDB families have three associated applications. The magnitude and direction of the possible bias due to the above factors are uncertain, which convinced us to exclude all patents originating from the PCT route. While we acknowledge there is self-selection in terms of whether applicants choose the PCT route or not, we believe that this does not affect our analysis. Firstly, while some applicants chose the PCT route for reduced costs, this does not seem to be very relevant for the technological areas related to standards we focus on, in which patents, as discussed above, are considered to be of high strategic value. Indeed, several studies have shown that patents in this area are usually renewed for the full 20 years and have large patent families (Bekkers et al., 2014; 2020; ECSIP, 2014; IPlytics, 2016), suggesting that the patent owner is not saving on costs. Secondly, applicants may opt for the PCT route to gain more time before having to decide whether the patent is worth pursuing. While this may be relevant in technological areas where future markets are uncertain, this seems less relevant for technological areas related to standards.

After the above steps, the resulting selected sample includes 81,931 patent families. The large majority of these families (87.5%) already qualify as twin-paired patents, encompassing one single EPO application and one single USPTO application. The remaining 12.5 percent of the families contain multiple applications to at least one of the two patent offices. Multiple applications to the same patent office within the same family usually include re-issued patents, continuation patents, divisions, and divisionals-in-part (see Hegde et al., 2007). This seems less relevant for the technological areas related to standards

As the last step in our sample preparation, we need to distinguish between patent applications subject to examination before vs. after the EPO policy change took place. As already discussed, we know that the ETSI-NPL database was made available to EPO examiners in the year 2004 (Bourbon, 2006, p. 20). However, we do not know the precise date of its introduction. For the purpose of our analysis, we assume it was fully operational halfway through the year, i.e., on July 1, 2004, and we take this point in time as the policy change date. Thus, in order to identify patents potentially affected by the policy change, we need to establish, for each EPO-USPTO patent-twin, whether the EPO patent was examined before or after July 1, 2004. Unfortunately, the actual examination date is neither available in PATSTAT nor in other public patent-level databases which we can access. From various communications with the EPO

with SSO-related prior art available in the EPO databases. In addition, PCT applications pose methodological challenges in the context of our identification method: for two of our variables (the number of claims and the number of words in the first claim) there would simply not be any variation for any given twin that originates from a PCT application.

#### Table 1 Standards-related and non standards-related IPC subclasses.

<table>
<thead>
<tr>
<th>IPC subclass</th>
<th>Brief description of subclass topic</th>
<th>Number of disclosed SEPs</th>
<th>Number of EPO applications between 2002 and 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>H04L 3717</td>
<td>Transmission of digital information, e.g., telegraphic communication</td>
<td>120,097</td>
<td></td>
</tr>
<tr>
<td>H04B 1509</td>
<td>Transmission systems used in telecommunications</td>
<td>61,527</td>
<td></td>
</tr>
<tr>
<td>G06F 782</td>
<td>Electric digital data processing</td>
<td>149,192</td>
<td></td>
</tr>
<tr>
<td>H04M 489</td>
<td>Telephonic communication</td>
<td>36,760</td>
<td></td>
</tr>
<tr>
<td>H04W 3452</td>
<td>Wireless communication networks</td>
<td>61,284</td>
<td></td>
</tr>
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<tr>
<td>H04W 3452</td>
<td>Wireless communication networks</td>
<td>61,284</td>
<td></td>
</tr>
</tbody>
</table>

#### 5.4. Selecting the pre- and post-policy period

As the last step in our sample preparation, we need to distinguish between patent applications subject to examination before vs. after the EPO policy change took place. As already discussed, we know that the ETSI-NPL database was made available to EPO examiners in the year 2004 (Bourbon, 2006, p. 20). However, we do not know the precise date of its introduction. For the purpose of our analysis, we assume it was fully operational halfway through the year, i.e., on July 1, 2004, and we take this point in time as the policy change date. Thus, in order to identify patents potentially affected by the policy change, we need to establish, for each EPO-USPTO patent-twin, whether the EPO patent examination (and particularly the prior art search) was performed before or after July 1, 2004. Unfortunately, the actual examination date is neither available in PATSTAT nor in other public patent-level databases which we can access. From various communications with the EPO

20 Specifically, 9.1% of the DOCDB families have three associated applications (one at the EPO and two at the USPTO, or vice-versa), 2.2% have four associated applications, and the percentage drops further, to one single case of a DOCDB family with 38 associated applications.

21 For a small group of families (4.1%) we find that two or more applications were filed on exactly the same date at a given patent office. For these residual cases, we adopt the following criteria for inclusion in the final sample. In cases of multiple co-occurring USPTO applications, we randomly select a non-granted patent application within the family, whereas in cases of multiple co-occurring EPO applications we randomly select a granted application. This is a conservative choice since it 'plays against' the EPO policy effects we are examining, in the sense that we avoid somewhat artificially increasing the number of selected pairs where the USPTO twin is more likely to be granted than the associated EPO twin.

22 Note that patent filing dates are not very informative about the
staff, we established that examination begins on average three months before the search report is published (known as an A1, A3, or A4 publication). On the basis of this information, we assume that the examination takes place at some point within the six months preceding the date of publication of the search report, which is a date available in PATSTAT.

Fig. 1 depicts our distinction between pre-policy and post-policy twins, based on the above assumptions about dating of the policy and of patent examination. The rectangles represent different types of twins according to the publication date of the corresponding EPO search report, reported on the horizontal axis. Type A twins are those with an EPO search report published before July 1, 2004, and hence their examination certainly occurred before the assumed date of the policy change. These cases are therefore assigned to the control group of twins not affected by the EPO policy \((\text{POST}_\text{POL} = 0\) in Eq. (1)). Type C are twins with an EPO search report published after December 31, 2004, and thus examined after July 1, 2004, according to our assumption that examination takes place in the six months preceding the search report publication. We thus consider them as surely affected by the policy change \((\text{POST}_\text{POL} = 1\) ). Type B twins represent cases where the associated EPO search report was published between July 1, 2004, and December 31, 2004, and therefore, we cannot assess with certainty whether their examination took place before or after the policy change. We thus exclude Type B twins from our main analysis, which implies that we define a six-month policy implementation window. Section 7 presents a series of robustness checks implementing alternative dating of the policy change within the year 2004.

The final working sample we exploit in our main analysis includes 78,194 pairs, each having one application to the EPO and one application to the USPTO. Among these pairs, 47,696 twin-applications are in standards-related areas as defined above, and 62,938 are classified as examined after the policy change. Table 2 presents the steps to create the final sample and reports on the number of observations involved.

5.5. Outcome variables

5.5.1. Patent grant

Our first dependent variable, labelled GRANTED, is a dummy that takes value one if a patent application receives a grant, and zero otherwise. In theory, we would like this to empirically capture the dichotomous decision whether an application is granted or rejected, the latter being the outcome where we expect the policy change to bite. While grant events are directly recorded in PATSTAT, patents for which such a grant event is not recorded in PATSTAT (and thus GRANTED is zero), can be the result of a rejected, withdrawn, or pending status.

Applicants may have different reasons to withdraw a patent application. They might do so because they no longer believe that the granted patent would be of value to them – even if they would receive a grant if they did not withdraw. While this may be a common reason for withdrawal when there are uncertainties about the market related to a patent, this is unlikely to be the case in the technology areas our paper focuses on, where, as mentioned, markets are proven valuable and patents are considered to be of high strategic value. Instead, we expect that for the patents in our data, the main reason for withdrawal lies in the applicant’s belief that it is unlikely that the patent at stake will eventually be granted. Hence, within the scope of this work, a patent withdrawal can be considered to have essentially the same nature as a patent rejection.

Concerning pending patents, we need to consider the well-known truncation issue, common to patent studies: patents that appear as still pending at a given point in time, might end up granted at a later date, with the final grant date possibly quite distant in time from application date, due to backlogs and other aspects of patent office functioning. As mentioned, our decision to limit the empirical analysis to applications filed until December 31, 2011, ensures that for all the patents included in the final working sample we have at least four years of PATSTAT data to observe whether or not they were eventually granted. Section 7 includes robustness checks related to possible truncation effects.

5.5.2. Patent scope changes

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

Since the classic study by Lerner (1994), the empirical proxy for patent scope has for long been the raw count of the number of IPC classes assigned to a patent. However, it is now acknowledged that scope is determined primarily by the wording of the patent claims. Improved measures of patent scope have been proposed, based on the analysis of the text in the claims (Marco et al., 2016; Okada et al., 2016; Osenga, 2012), and the first claim in particular (see Kuhn and Thompson, 2019).24

In line with these works, we take the wording of the first claim for our empirical measurement of patent scope. Accordingly, to measure changes to scope, we compare the text of the first claim in the patent application with the text of the first claim in the granted patent. We define our second dependent variable, scope changes \((\Delta \text{SCOPE})\), as the absolute value of the difference in the number of words of the first claim between the application and the grant document, normalized by the number of words in the first claim in the application.

Note that, by definition, the scope of a patent can never increase after the initial application (see WIPO, 2004, Section 2.72–2.73). Therefore, a change in the wording of a claim reflects a reduction in scope, regardless of whether the change between application and grant manifested itself as an increase or a decrease in the number of words. This motivates the choice to use the absolute values in our definition of scope changes.25 Among the robustness checks in Section 7, we explore

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\(^{24}\) The first claim in a patent is by definition an independent claim, and is generally the broadest claim (see also EPO, 2016, Section 4.23).

\(^{25}\) We illustrate this using a simplified example. Suppose that the first claim in an application document reads “A bike brake using a round disc” (7 words) whereas the first claim of the granted patent reads “A bike brake using a round disc made of carbon ceramic composites” (12 words). Apparently, during the patent prosecution process, the examiner believed that the first claim was too broad: the granted patent is reduced in scope, as it no longer covers, for instance, metal discs. Thus, in this example, reduced scope is obtained by an increase in the number of words. Consider, next, a different case where the first claim at application reads “A bike brake using a round disc of metal, or of carbon ceramic composites” (14 words), whereas the first claim of the granted patent reads “A bike brake using a round disc made of carbon ceramic composites” (12 words). Also in this case the granted patent has reduced scope.
which is equal to 47,696 (62.7%). The number of claims has been suggested to influence the outcomes of the examination process at least since Lanjouw and Schankerman (2001), and de Rassenfosse et al. (2016) found a negative relationship between the number of claims and patent grants. Note that even though EPO-USPTO twins cover the same underlying invention, the number of claims may vary across patent offices. PATSTAT data do not offer complete information on the number of claims for the two patent offices we are interested in, and we resort to other sources. In the case of EPO patents, we get the number of claims from the OECD-Patent Quality Indicators database (April 2017 edition, see Squicciarini et al., 2013). For USPTO patents, we retrieve the number of claims from the USPTO ‘Patent Claims Research Dataset’.²⁷

5.6. Patent-level controls

To make our DDD-identification of the policy effects cleaner, we need to control for patent-document level characteristics that may be relevant in the type of within-family analysis we perform here. That is, we do not need to control for generic, patent-level characteristics, but for specific factors that vary between EPO-USPTO twins and, at the same time, may induce variation in our focal patent outcomes across the two patent offices. In line with de Rassenfosse et al. (2016), we identify three patent-level characteristics that are particularly likely to involve heterogeneity in the examination outcomes of the same invention across patent offices.

First, we consider whether a patent document has a “local” assignee, i.e., an assignee from the same country as the patent office where the application is filed. Previous studies find evidence that a patent of a local assignee has a higher likelihood of being granted (de Rassenfosse et al., 2016; Webster et al., 2014). This home bias may reflect prejudice against foreign applicants, but it may also reflect that domestic applicants have stronger incentives to push the patent application in their home market, or that they are more familiar with their home patent system than foreign applicants. The assignees’ nationality is reported against foreign applicants, but it may also reflect that domestic applicants have stronger incentives to push the patent application in their home market, or that they are more familiar with their home patent system than foreign applicants. The assignees’ nationality is reported in PATSTAT. We define a dummy \( \text{LOCAL_ASSIGNEE} \), which is equal to one if at least one of the assignees is local to the patent office where the application is filed, and zero otherwise.²⁶

Second, we control for the possibility that within an EPO-USPTO twin pair, one of the two documents is a priority within the family. Firms usually submit a priority filing at the office they know best, which may affect the likelihood that they receive a grant at that office. The country of the priority office may also be the most important market, where incentives to push for a grant are stronger. Yet, de Rassenfosse et al. (2016) show that the effect of priority on patent grant is inconsistent across offices (positive for EPO, negative for others). PATSTAT records direct information on priority. We can thus include an additional dummy variable, \( \text{IS_PRIORITY} \), which is equal to one if the application is a priority within the family of the EPO-USPTO twins.

Lastly, we include a variable reporting the number of claims (in logs) listed in the application, \( \text{LNCLAIMS} \). The number of claims has been suggested to influence the outcomes of the examination process at least since Lanjouw and Schankerman (2001), and de Rassenfosse et al. (2016) found a negative relationship between the number of claims and patent grants. Note that even though EPO-USPTO twins cover the same underlying invention, the number of claims may vary across patent offices. PATSTAT data do not offer complete information on the number of claims for the two patent offices we are interested in, and we resort to other sources. In the case of EPO patents, we get the number of claims from the OECD-Patent Quality Indicators database (April 2017 edition, see Squicciarini et al., 2013). For USPTO patents, we retrieve the number of claims from the USPTO ‘Patent Claims Research Dataset’.²⁷

6. Main analysis

We begin with a descriptive, graphical analysis of the average intertemporal trends of outcome variables over the sample time-window

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²⁶ For EPO patents, the dummy equals one if there is at least one assignee from one of the 38 EPO member states.

2001–2011, across technologies and patent offices.\textsuperscript{28}

Fig. 2 depicts monthly granting rates (i.e., the percentage of patents granted over total applications) at the EPO and the USPTO, distinguishing patents in standards-related areas (left panel) and patents in technologies unrelated to standards (right panel). In general, both before and after the implementation of the EPO policy change, applications to the USPTO are more likely to be granted than applications to the EPO. This reflects a well-known stylized fact about institutional differences between the two offices, with the USPTO being usually more ‘generous’ in awarding grants (see Jensen et al., 2005; 2008; Webster et al., 2007). Nevertheless, clear differences emerge both between technological groups and between patent offices in the period after the EPO policy change. At the EPO, standards-related patent applications are less likely to be granted than patents filed in other areas, while at the USPTO, granting rates across technologies are roughly comparable.

Fig. 3 provides a similar analysis, reporting monthly averages of scope changes, distinguishing again by patent office and technologies. In this case, we do not observe major differences between EPO and USPTO, in either standards-related (left panel) or in other technology areas (right panel). The patterns are, in fact, quite comparable regardless of whether before or after the implementation of the EPO policy change.

Overall, the average trends suggest that the EPO policy change may have primarily influenced the granting rates, while not influencing refinements to patent scope.\textsuperscript{29}

Next, we move to a regression analysis of the DDD model in Eq. (1). To recall, treated patents are patents filed in standards-related domains (dummy STD = 1) at the EPO (dummy EPO = 1) and examined after the policy change was enacted (dummy POST POLICY = 1), and we compare their outcomes against those of their twin-patents filed at the USPTO, accounting for observed patent-level controls and unobserved confounding factors pre/post, policy across patent offices or technological areas.\textsuperscript{30}

Table 3 reports coefficient estimates. As a reference, in Columns 1–2 we show the estimates of a specification that includes the main variables and their interactions only, while results of the complete model specification, including year dummies and patent-level controls, are presented in Columns 3–4. Fig. 4 provides a graphical representation of the main effects.

Concerning the effect on granting rates, the results are in line with our theoretical expectation to observe a decline in grants: the estimates of the three-way interaction coefficient $\gamma_0$ (EPO $\times$ POST POLICY $\times$ STD) show that, all else being equal, the EPO policy change reduces the probability of being awarded a standards-related patent by approximately 19 percentage points compared to the reference group.\textsuperscript{31}

Conversely, the estimated policy effect on scope changes between application and grant, does not match our prediction that EPO patents should experience more marked scope reductions than the reference group of USPTO twins. Indeed, the estimated three-way interaction coefficients do not reveal any statistically significant difference across treated and controls. A first possible explanation is that, for potentially affected patents, the first claim is challenged as a whole: the patent cannot be ‘saved’ by just reducing the scope of the first claim, and the patent is eventually rejected or withdrawn. As a result, there are no observed scope reductions induced by the policy across patents that enter our estimates (since our measurement of changes in scope is only possible when the patent is actually granted). A second interpretation of the finding relates to the notion that in technological domains involving standards, the parties usually seek to obtain SEPs. If the stricter examination triggered by the EPO policy change challenges the part of the first claim that relates to essentiality, then the applicant might not be interested in a patent with a reduced scope, as it would no longer be an essential patent. In this case, the patent is likely to be withdrawn altogether, even if here the first claim is not challenged in its entirety. A third possible interpretation points towards an adaptation effect on the part of the applicants, which could also not be observed as a reduction of scope between initial application and eventual grant. Once the policy was known to be in place, applicants of patents in standards-related technologies might have reacted by reducing the scope of patent documents filed to the EPO already at the application stage, while keeping a broader scope in the twin application filed for the same invention at the USPTO.\textsuperscript{31} We do not have detailed data on applicants’ strategies and choices that would help to further explore the first two possible explanations. We instead examine the adaptation effect hypothesis in the robustness analysis of Section 7.

Regarding the control variables, we find that the presence of a local assignee has a positive association with grant rates. This is similar to what is found by Webster et al. (2014) and de Rassenfosse et al. (2016). The presence of a local assignee also has a positive association with scope changes. Perhaps, this might indicate that local assignees (or their patent attorneys) dedicate more efforts to the patent prosecution phase and make more changes to the scope of their patents in order to get the patent granted. Next, we find that priority filing does not affect grant rates in a statistically significant way. This is not surprising, given the mixed results already documented in de Rassenfosse et al. (2016) for the priority effect across different patent offices. We do find a negative association between priority and scope changes, however. Finally, we find that the number of claims has a negative relation with patent grant, a result indeed consistent with the findings in de Rassenfosse et al. (2016).

7. Robustness analysis

We start examining the robustness of our main results by including fixed-effects at various levels, exploiting the multiple sources of variation allowed by the data. Results are reported in Table 4. First, in Columns 1–2, we add patent office $\times$ year fixed-effects. The estimated three-way interaction coefficients confirm our main finding that the policy significantly reduced granting rates: the point estimate of $\gamma_0$ is slightly lower (17.5 percent) than in the main estimates, but the effect is statistically equal to the above results (considering one standard deviation). At the same time, we also confirm that the EPO policy change did not induce statistically significant differences in scope reductions across treated and control patents.

Next, in Columns 3–4 of Table 4, we add family fixed-effects (based on the DOCDB family). In this case, the variation exploited to identify $\gamma_0$ is within-twins, whereas, in contrast, the variables POST POLY and STD by definition do not vary within the same family. Compared to the main estimates, we confirm the negative effect of the policy change on granting rates (of a similar magnitude as the main estimates, about 19 percent), and also the statistically insignificant impact on scope changes.

\textsuperscript{28} Basic descriptive statistics for the dependent and the control variables are reported in Appendix A, Table A.1.

\textsuperscript{29} See also Table A.2 in Appendix A, where we report descriptive statistics (mean and standard deviation) of the outcome variables broken down by technological area, patent office, and pre/post-policy period.

\textsuperscript{30} Even though the dependent variable is binary, we use an OLS linear probability model. We are interested in ranking patents by their probability of being granted, and not in the predicted grant probability scores per se. Thus, it is of little concern to us if some predicted probabilities end up lying outside the unit interval. Moreover, as most of the covariates are discrete and interactions, the linearity assumption is adequate.

\textsuperscript{31} Some patent attorney firms inform their clients about the fact that the EPO now considers standards-related documents as prior art, possibly triggering specific strategies to circumvent this EPO practice. See: https://www.ellisfilfe.com/news-and-views/2016/02/24/epo-approach-to-standards-related-documents-as-prior-art.
In Columns 5–6 of Table 4 we then show estimates obtained after including assignee fixed-effects. Doing so, we control for unobserved differences across applicants in their patent application strategies, such as different degrees of sophistication with drafting patent applications. Identifying assignees is a challenging task. Often, large companies file patents using the names of many different legal entities, and patent databases also contain typographic errors in the recorded names of (especially foreign) patent owners. While there have been various attempts to harmonize patent assignee names, both manually and automatically, they all have limitations, and there is not yet a well-established and commonly accepted method for doing so. We here resort to the Harmonized Applicant Name (HAN) database, developed by the OECD (Dernis, 2015). For a number of cases in our working sample, the harmonized names were not available in the HAN database, and this was the case especially for patents assigned to individuals. Also, a non-negligible number of patents were associated with multiple harmonized

Fig. 2. Patent granting rates (GRANTED) by search report publication date.

Fig. 3. Patent scope changes (ΔSCOPE) by search report publication date.

Fig. 4. Estimated marginal means of GRANTED and ΔSCOPE obtained from the estimates reported in Columns 3 and 4 of Table 3.
names, thus preventing a clear association with an assignee fixed-effects. Consequently, the sub-sample we can use in the analysis with assignee fixed-effects is approximately 17% smaller than our full sample. The estimates of the policy effect on granting rates drop, compared to the main analysis, from about 19% to about 12%. We believe that this weaker effect is, at least in part, attributable to patents assigned to individuals (excluded from these estimates), who lack the sophistication of experienced firms in the context of patent

Table 3
Main results.

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>GRANTED</th>
<th>ΔSCOPE</th>
<th>GRANTED</th>
<th>ΔSCOPE</th>
</tr>
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<td>(3)</td>
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<td>−0.118***</td>
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<tr>
<td>POST_POLICY</td>
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<td>0.172**</td>
<td>−0.318***</td>
<td>−0.277***</td>
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<tr>
<td>EPO × POST_POLICY</td>
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<td>−0.171*</td>
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<tr>
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<td>−0.074***</td>
<td>0.030</td>
</tr>
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<tr>
<td>POST_POLICY × STD</td>
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<tr>
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<td>−2.83***</td>
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<tr>
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<td>0.092***</td>
<td>0.509***</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0.148***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTANT</td>
<td>0.766***</td>
<td>0.549***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.008)</td>
<td>(0.014)</td>
<td>(0.005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YEAR DUMMIES</td>
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<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
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<td>154,948</td>
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<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.083</td>
<td>0.003</td>
<td>0.098</td>
<td>0.011</td>
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Note: OLS estimates of Equation (1). Robust standard errors in parenthesis, clustered by patent family (DOCDB). Significance levels:* 5%, ** 1%, ***0.1%.

Table 4
Robustness checks – Part I.

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<tr>
<th>Dependent variable:</th>
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<th>FAMILY FE</th>
<th>ASSIGNEE FE</th>
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<tr>
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<td>GRANTED</td>
<td>ΔSCOPE</td>
<td>GRANTED</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
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<tr>
<td>EPO</td>
<td>−0.177***</td>
<td>0.179*</td>
<td>−0.114***</td>
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<td>POST_POLICY</td>
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<td>−0.112**</td>
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<td>EPO × POST_POLICY</td>
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<td>0.030**</td>
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<tr>
<td>STD</td>
<td>−0.077***</td>
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<td>[0.010]</td>
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<tr>
<td>EPO × STD</td>
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<td>POST_POLICY × STD</td>
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<td>0.044**</td>
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<td>LOCAL</td>
<td>0.089***</td>
<td>0.510***</td>
<td>0.099***</td>
</tr>
<tr>
<td>LNCLAIMS</td>
<td>−0.021***</td>
<td>0.148***</td>
<td>−0.010</td>
</tr>
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<td>CONSTANT</td>
<td>0.821***</td>
<td>−0.046</td>
<td>0.669***</td>
</tr>
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<td>YEAR DUMMIES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>PATENT-OFFICE × YEAR FE</td>
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<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>FAMILY FE</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>ASSIGNEE FE</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Observations</td>
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<td>48,002</td>
<td>154,948</td>
</tr>
<tr>
<td>R²</td>
<td>0.105</td>
<td>0.011</td>
<td>0.667</td>
</tr>
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</table>

Note: OLS estimates of Equation (1). Robust standard errors in parenthesis, clustered by patent family (DOCDB). Significance levels:* 5%, ** 1%, ***0.1%.
We thank Professor Dietmar Harhoff for making these data available to us.

Timing scenarios. First, we allow for the new SSO-NPL documentation through the year (i.e., July, 1). We now consider three alternative available to EPO examiners in the year 2004, but do not know the exact we know that the new prior art databases became systematically of exercises experimenting with the timing of the policy. As explained, Also, we confirm that the policy did not affect scope changes. Still, the policy change started in reality). Robust standard errors in parenthesis, clustered by patent family (DOCDB). Significance levels: 5%, ** 1%, ***0.1%.

For robustness checks – Part II.

Table 5
Robustness checks – Part II.

<table>
<thead>
<tr>
<th>POLICY CHANGE</th>
<th>GRANTED</th>
<th>ΔSCOPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPO</td>
<td>−0.124***</td>
<td>0.389***</td>
</tr>
<tr>
<td>POST_POLICY</td>
<td>−0.319***</td>
<td>−0.269***</td>
</tr>
<tr>
<td>EPO × POST_POLICY</td>
<td>0.031***</td>
<td>−0.225**</td>
</tr>
<tr>
<td>STD</td>
<td>−0.083***</td>
<td>0.039</td>
</tr>
<tr>
<td>EPO × STD</td>
<td>−0.051***</td>
<td>0.118</td>
</tr>
<tr>
<td>POST_POLICY × STD</td>
<td>0.150***</td>
<td>0.017</td>
</tr>
<tr>
<td>EPO × POST_POLICY × STD</td>
<td>−0.206***</td>
<td>−0.117</td>
</tr>
<tr>
<td>IS_PRIORITY</td>
<td>−0.000</td>
<td>−0.241***</td>
</tr>
<tr>
<td>LOCAL</td>
<td>0.098***</td>
<td>0.480***</td>
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<tr>
<td>LN CLAIMS</td>
<td>−0.024***</td>
<td>0.145***</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>0.802***</td>
<td>−0.138*</td>
</tr>
<tr>
<td>YEAR DUMMIES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>Observations</td>
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<td>40,196</td>
</tr>
<tr>
<td>R²</td>
<td>0.102</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Note: OLS estimates of variations of Eq. (1). Columns 1–6 show estimates with different dating of the EPO policy change within 2004; Column 7 presents a “fake” anticipation of the policy in the years before the EPO implemented the new policy (and leaving out patents with search report from 01-01-2004 onward, when the policy change started in reality). Robust standard errors in parenthesis, clustered by patent family (DOCDB). Significance levels: 5%, ** 1%, ***0.1%.

applications, and thus may be more affected by the policy. Still, the effect of the policy change on grants is strong and highly significant. Also, we confirm that the policy did not affect scope changes.

The next set of robustness analyses, in Table 5, encompasses a series of exercises experimenting with the timing of the policy. As explained, we know that the new prior art databases became systematically available to EPO examiners in the year 2004, but do not know the exact date of introduction. In our main analyses, we assume it was halfway through the year (i.e., July, 1). We now consider three alternative timing scenarios. First, we allow for the new SSO-NPL documentation being used at anytime in 2004. Still assuming that examination occurs actually withdrawn patents are more frequent at the EPO in standards-related areas than at the USPTO, we might overestimate the reduction of this additional exercise show insignificant effects on granting rates, corroborating parallel trends in the years before 2004. Altogether, we conclude that our results are robust to uncertainty related to policy timing.

A further concern relates to possible misclassification of not-granted patents. In the main analysis, we define the zeros in the dependent variable GRANTED following the commonly accepted empirical solution to truncation: a patent is considered as rejected or withdrawn by applicants if a formal granting decision is not revealed some years after the filing date. If, due to unobserved reasons, seemingly pending but actually withdrawn patents are more frequent at the EPO in standards-related areas than at the USPTO, we might overestimate the reduction in granting rates associated with the EPO policy change. Table 6, Columns 1–2, presents two exercises addressing this potential bias. In Column 1, we re-estimate our empirical model using a reduced sample which includes patents filed only up to the end of 2009. This leaves six years of available data for a grant decision to manifest in PATSTAT, against the four years left out in the main analysis. The results we obtain here confirm the conclusion from the main analysis: the estimated three-way interaction coefficient is negative and very close in magnitude to the main estimate. The estimates in Column 2 exploit the EPO Office Actions Dataset. These data allow us to distinguish whether the patent is rejected, withdrawn, or still pending, though for the smaller sample of EPO applications only. Therefore, we can refine the definition of the zeros in GRANTED by excluding the twins with an EPO pending application. The results obtained on this reduced sample confirm that the policy change indeed induced a drop in granting rates. The size of the estimated effect is approximately 15 percent, which is

32 We thank Professor Dietmar Harhoff for making these data available to us. A comparable data source does not exist for USPTO applications.
smaller compared to the main analysis, not surprisingly given the cleaner definition of not-granted patents.

Lastly, we present two additional investigations into the effect of the EPO policy on patent scope. First, we check that our results are robust to measuring scope reductions in a different way. Following Kühn et al. (2013), we now define scope changes as the simple difference in the number of words in the first claim between application and grant. This assumes that scope reductions are reflected in an increase in the number of words, while in the main analysis we use the absolute value to avoid this assumption, since, in principle, rewriting the claim to narrow the scope could also result in a smaller number of words. The results, in Column 3 of Table 6, are in line with the conclusion from our main analysis: the EPO policy change did not affect the extent of scope reductions across treated and controls.

Second, we try to shed light on whether the observed insignificant effect of the EPO policy on scope changes, may relate to applicants adapting to the policy through modifying the first claim already at the time of filing an application at the EPO, not during the examination process. Our main analysis simply cannot capture this behaviour, since it would not manifest in refinements of scope between application and grant, but induce differences in scope across treated and controls already at the application stage. Accordingly, we perform a new regression taking patent scope at the application stage as the dependent variable, measured as the raw count of the number of words in the first claim in the application documents of the EPO-USPTO twins. The results, in Column 4 of Table 6, show an insignificant coefficient of the three-way interaction, implying that the EPO policy change did not induce an adaptation effect.

8. Discussion and conclusion

This paper provides an empirical assessment of an endeavour by the EPO to improve the quality of the patent granting process. To tackle concerns that the problem of weak patents is especially important in the area of standards-related inventions, EPO examiners have been given systematic access to documents shared by SSO members in the context of setting technical standards, in order to consider them for prior art assessment. We designed an EPO-USPTO twin patents approach to build counterfactuals, combined with a Diff-in-Diff-in-Diff estimation, to isolate the effect of the EPO policy change from technology-specific and patent-office specific trends.

Our results demonstrate that the EPO policy change indeed affected the quality of the patent granting process in a positive way. It did so by significantly improving the ability to reject patents on seemingly undeserving applications, rather than refining the scope of legal protection of granted patents. Indeed, controlling for other factors, the main analysis reveals that the induced reduction in granting rates vis-à-vis control patents is about 19 percent, while the magnitude of the effect estimated in a series of robustness analyses ranges from 12 percent to 20 percent. Conversely, and against our expectations, we do not observe more substantial scope reductions during the patent prosecution of standards-related patents filed and granted at the EPO compared to USPTO twins. We also do not find evidence that applicants adapted to the policy change by diversifying the scope of the initial application documents filed at the two patent offices. We advance two possible explanations for the unexpected effect on scope: either (a) patent applications threatened by standards-related NPL prior art, are threatened in their entirety, and thus rejection rather than scope refinements is the main outcome of the EPO policy change; or (b) standards-related NPL prior art threatens the part of the patent that provides it with a SEP status, with the result that applicants at the EPO withdraw from the patent process, rather than accepting a scope reduction, because they are not interested in a patent with reduced scope which is not going to be essential. Further analysis could help to identify the relative strengths of these alternative explanations, although this may require additional information on applicants’ strategies and choices that is
difficult to collect, especially for such a large sample as we use here.

Even with these caveats, our study has relevant implications for policy. While the EPO policy change incurred implementation costs, it demonstrates that relatively focused efforts can produce a quite sizable effect, and influence a relatively large and important technological area. It shows that there are feasible ways of improving the quality of the patent granting process. We would recommend other patent offices to consider similar measures, and SSOs to consider working with patent offices to make prior art documentation shared among members available.

There are several possible directions for future research. Firstly, it would be interesting to investigate whether applicants engage in ‘extreme forms’ of adaptation to the policy. For example, when a new policy was implemented, some applicants might have reacted by starting to forgo applications to the EPO altogether, on the premise that a patent family lacking an EPO member is anyway more attractive than a patent family with a rejected EPO member. An alternative strategy in reaction to the EPO policy change might have been that some applicants started to make so drastic changes to the EPO application compared to the USPTO twin application for the same invention, that the two documents no longer shared the same set of priority documents. Neither of these adaptation strategies can be observed within our approach, since our identification of counterfactual outcomes relies upon the availability of EPO-USPTO twin-patents within a narrowly defined (DOCDB) family. Examination of such behaviour would require a different set-up, basing the definition of counterfactual outcomes on a less strict notion of a patent family. For instance, a dataset could be built that includes all applications to the IPS offices or to other large patent offices around the world. This would provide an interesting extension, but at the price of a much less precise and less convincing identification strategy than in the present analysis.

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

Finally, whereas granting rates and patent scope represent the arguably more direct target of the EPO policy change, the twin-patents approach and the related narrow, precise identification of the underlying common invention that we propose here, could be extended to examine the effects of the EPO policy change on other potentially interesting outcomes. More broadly, we hope our paper inspires researchers to investigate the impact of other endeavours by patent offices around the world to improve the overall quality of the patent granting process.

CRediT authorship contribution statement

Rudi Bekkers: Conceptualization, Data curation, Investigation, Methodology, Writing - original draft, Writing - review & editing. Arianna Martinelli: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing - original draft, Writing - review & editing. Federico Tamagni: Conceptualization, Data curation, Formal analysis, Investigation, Software, Validation, Funding acquisition, Writing - original draft, Writing - review & editing. Declaration of Competing Interest

Authors declare that they have no conflict of interest.

Acknowledgments

We want to thank Michel Goudelis, Yann Ménière, Francesco Zaccà, Domenico Golzio, and Ilja Rudyk, all at the European Patent Office, for discussing their organization’s policy on prior art and standardization and for the feedback they provided. We are also grateful to Dietmar Harhoff for sharing EPO Office Actions Data, and Val Kidd and Cynthia Little for proofreading the manuscript. We also acknowledge useful comments and suggestions on earlier versions of this paper at the following conferences: IPSDM 2015, IEEE SIT 2015, Schumpeter 2016, DRUID 2016, EMAEE 2017, EPIP 2017, and the First Annual Empirical Research Conference on Standardization in 2019 at Northwestern University, Chicago.

Appendix A. Descriptives

<table>
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<th>Variable</th>
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<th>Mean</th>
<th>Std. Dev.</th>
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<th>Max</th>
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Table A.2
Sample average outcomes by patent office, technological areas, pre- vs. post-policy.

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<td>0.626</td>
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<td>[0.484]</td>
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<td>0.117</td>
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<tr>
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<td>[0.065]</td>
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<td>[0.036]</td>
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</table>

<table>
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<th>POST_POLICY = 1</th>
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</thead>
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</tr>
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<td>[2.47]</td>
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<td>USPTO</td>
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<td>[1.88]</td>
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<td>[3.19]</td>
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<td>[0.036]</td>
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</tbody>
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Note: Standard deviation is shown in brackets.

References


EPO, 2016b. The PATSTAT product line - Key Facts about PATSTAT. European Patent Office, Munich, Germany.


Melbourne Institute of Applied Economic and Social Research, The University of Melbourne.


