Patenting Inventions or Inventing Patents? Continuation Practice at the USPTO

Cesare Righi and Timothy Simcoe*

May 18, 2022

Abstract

Continuations allow inventors to add new claims to old patents, leading to concerns about unintended infringement and holdup. We study how continuations are used in standard essential patent (SEP) prosecution. Difference in differences estimates suggest that continuation filings increase by 80-121 percent after a standard is published. This effect is larger for applicants with licensing-based business models and for patent examiners with a higher allowance rate. Claim language is more similar for SEPs filed after standard publication, and late-filing is positively correlated with litigation. These findings suggest widespread use of continuations to draft patents that are infringed by already-published standards.

JEL Codes: K11; L15; O34; O38
Keywords: patents, standards, standard essential patents, continuations

---

*Cesare Righi: Universitat Pompeu Fabra and Barcelona School of Economics. E-mail address: cesare.righi@upf.edu. Timothy Simcoe: Boston University Questrom School of Business and NBER. E-mail address: tsimcoe@bu.edu. We thank Allan Collard-Wexler (editor), two anonymous referees, Arman Aksoy, Justus Baron, Rudi Bekkers, Lorenz Brachtendorf, Iain Cockburn, Jorge Contreras, Thomas Cotter, Charles deGrazia, Gaetan de Rassenfosse, Michael Frakes, Fabian Gaessler, Jeffrey Kuhn, Mark Lemley, Helena Lenihan, Michael Meurer, Earl Nied, Jorge Padilla, Valerio Sterzi, Emanuele Tarantino, Liisa Välikangas, Andrea Vezzulli, Martin Watzinger, and Heidi Williams for helpful comments and suggestions. We thank Justus Baron for access to the SCDB data, and Evgeny Klochikhin for access to the PatentsView patent applications database. We also thank conference and seminar participants at the AOM (2021, online), ASSA (2022, online), BGSE Summer Forum (2021, online), Boston University TPRI IP day (2018 and 2021), Boston University Questrom Strategy & Innovation brown bag seminar (2020), DRUID (2021, Copenhagen), EPIP (2021, Madrid), IIOC (2021, online), Munich Summer Institute (2021, online), NBER productivity lunch (2021), TILEC Workshop on the Economics of Patents and Standards (2021, online), USPTO (2021), and UT Austin Empirical IP Law Conference (2022). Cesare Righi acknowledges financial support from the Spanish Agencia Estatal de Investigacion (AEI), through the Severo Ochoa Programme for Centres of Excellence in R&D (Barcelona School of Economics CEX2019-000915-S). Previous versions of this article circulated with the title "Patenting Inventions or Inventing Patents? Strategic Use of Continuations at the USPTO."

1 Introduction

In 2018, just over 15 percent of all U.S. patent applications were continuations.[1] A continuation application seeks protection for new claims based on the invention disclosed in a prior "parent" application, using the parent's priority date to assess novelty and obviousness. In principle, continuations encourage early disclosure by granting inventors the option to draft new claims at a later date, when they have a better understanding of the technology and its commercial embodiments. In practice, continuations are controversial because they allow applicants to tailor their patent claims to cover products and technologies developed after the original invention is disclosed.

The use of continuations to draft claims covering technology that post-dates an invention (a practice we call late claiming) is widely discussed among patent attorneys, and a frequent topic in policy debates.[2] For example, in 2003 the U.S. Federal Trade Commission proposed creating "intervening or prior user rights" to protect parties from infringing claims arising from continuations (FTC, 2003). In 2007, the U.S. Patent and Trademark Office (USPTO) proposed new rules that would sharply limit the use of continuations, but eventually withdrew the proposed changes after receiving substantial pushback from patent owners. And in 2021, the Acting Commissioner of the Food and Drug Administration sent a letter to the USPTO suggesting that misuse of the continuation process could "unduly extend market monopolies and keep drug prices high."[3]

Though policy debate has produced many examples, there is little statistical evidence on the prevalence of late claiming. The lack of systematic evidence reflects two fundamental measurement challenges: (i) it is hard to link patents to potentially infringing technologies,

[1]See Table 2 in Cotropia and Quillen (2019).

[2]For examples of the practitioner literature on continuation practice, see Michael T. Moore, "Use Strategic Continuation Practice to Monetize IP"' (Law360, April 3, 2015) or Michael Henry, "How to Slow Down Patent Prosecution with the USPTO" (https://www.henrypatentfirm.com/blog/slow-down-patent-prosecution, accessed May 8, 2020).

[3]Comments received in response to the USPTO's Proposed Rule are available at https://www.uspto.gov/patent/laws-and-regulations/comments-public/comments-regarding-continuation-practice (accessed May 8, 2020). The FDA letter is available at https://www.fda.gov/media/152086/download (accessed September 14, 2021).

and (ii) it is difficult to observe clear milestones in the development of those technologies that provide incentives for applicants to seek new claims. We address these challenges by exploiting two features of the Information and Communications Technology (ICT) standardization process. First, several large Standard Setting Organizations (SSOs) require participants to disclose patents that might be infringed by a proposed standard, creating a link between patents and potentially infringing technology. Second, the publication of a standard provides an observable proxy for the date when uncertainty about product design is resolved. This study leverages these unique features of Standard Essential Patent (SEP) prosecution to provide systematic evidence on the use of late claiming via continuations.

We find that 84% of the SEP continuations in our data (and more than half of all SEPs) are filed after publication of the relevant standard. We also estimate difference-in-differences (DID) regressions that compare the probability of filing a continuation for SEPs relative to matched controls before and after the publication of a standard. The results indicate that standardization leads to a 80-121% increase in the probability of filing a continuation. The impact of standard publication on continuation filings is stronger for parent applications assigned to more lenient examiners. The effect also varies with a SEP owner's business model, and is largest for firms that collect most of their revenue through licensing.

Given the evidence that SEP holders use continuations to draft late claims targeting industry standards, it is natural to ask whether this prosecution strategy works. It is hard to provide a definitive answer to that question, because only a court can determine infringement, and the evaluation process is generally time- and resource-intensive.[4] Nevertheless, the second half of our analysis provides three pieces of suggestive evidence. First, we show that patent examiners are more likely to issue a non-statutory double patenting rejection for claims in SEP continuations filed after standard publication. As explained below, this type of rejection signals that applicants are seeking to expand the scope of the claims in a

[4] Lemley and Simcoe (2019) find that the rate of infringement for SEPs and non-SEPs is very similar in a sample of U.S. lawsuits that reached a judgment on the merits. This finding could indicate that many SEP continuations are not infringed by the standard, but might also reflect selection into litigation or a pattern of settling stronger cases.

parent application. Second, we find that the language used in SEP claims converges after a standard is published. Specifically, we construct a sample of post-standard continuations with pre-standard parents, and show that the pairwise textual similarity of claims in the continuations is greater than the textual similarity of claims in their parent applications. Finally, we show that among SEPs, continuations are more likely than original patents to be involved in U.S. district court litigation.

Overall, our results indicate widespread use of continuations to seek new patents that are infringed by already-published standards. These findings inform, but do not resolve, a larger welfare debate. Proponents note that continuations encourage early invention disclosure, and also help parties avoid the cost of prosecuting low-value claims (Matutes et al., 1996). At the same time, late claiming creates ambiguity about the scope of patent rights, leading to concerns about holdup or inadvertent infringement by follow-on innovators. The social cost of continuations may be small if they are primarily used in response to exogenous technological uncertainty. But our results suggest that in the standard setting context, continuations are used strategically. More research is needed to determine whether this finding extends to other contexts, and to assess continuations' impact on downstream prices and innovation.

This study contributes to three broad streams of literature on patents and standardization. First, prior literature on *continuations* explains how they can undermine invention disclosure, create opportunities for hold up, and more generally reallocate rents from downstream innovators to an initial patentee (Glazier, 2003; Lemley and Moore, 2004; Lemley and Shapiro, 2005). Early empirical studies document the prevalence of continuations (Graham, 2004), the types of applicants and technologies that use them (Hegde et al., 2009), and how they fit into patterns of patent prosecution (Graham and Mowery, 2004). More recently, various authors have shown how continuations are associated with distortions in patent quality (Frakes and Wasserman, 2015) and increased litigation (Marco and Miller, 2019; Righi, 2022). Relative to this prior literature, we innovate by identifying a setting where patents can be linked to a potentially infringing technology, by proposing a strategy to identify how reduced uncertainty about infringement affects the propensity to file continuations, and by showing that late claiming is associated with more disputes.

Second, our research contributes to the literature on *strategic patenting* (Levin et al., 1987; Cohen et al., 2000; Hall and Ziedonis, 2001; Ziedonis, 2004) and specifically strategic behavior in SEP prosecution. Firms benefit from incorporating patented technology into standards because standardization eliminates competition from substitutes and lowers the cost of proving infringement (Rysman and Simcoe, 2008; Lerner and Tirole, 2015). This naturally leads to rent seeking in patent prosecution. For example, Kang and Bekkers (2015) and Kang and Motohashi (2015) show that firms often file patent applications just before standardization meetings and negotiate their inclusion into standards. Berger et al. (2012) find that a sample of declared SEPs filed at the European Patent Office (EPO) were amended more often than a set of matched control patents. Nagaoka et al. (2009) show that a significant share of U.S. SEPs related to the MPEG2, DVD, and W-CDMA standards are filed using continuations after the standards are set. Relative to this literature, our article is more focused on the use of continuations, and is the first to propose an identification strategy for estimating the impact of standard publication on continuation filing. We also employ a larger sample of standards and SEPs, and are the first to analyze non-statutory double patenting rejections, examiner leniency, and similarity in claim language.

Finally, we contribute to the literature on *patent scope* and *invention disclosure*. Menell and Meurer (2013) outline a general theory of "notice externalities" in patent prosecution, and a 2011 report by the U.S. Federal Trade Commission builds upon their work expressing similar concerns (FTC, 2011). In a series of empirical articles, Kuhn (2016), Kuhn and Thompson (2019) and Marco et al. (2019) use new data, measures and methods to investigate the determinants of patent scope, and its relation to commercial value. We show how companies use continuations not only to broaden the scope of protection, but also to increase the probability that subsequently developed technology will infringe.

In the next section of the article, we provide more information on continuations and the standardization process. Section 3 discusses the data, provides descriptive statistics on the timing of SEP filings, and describes our empirical strategy to estimate the impact of standard publication on SEP continuations. Section 4 presents the primary results, and Section 5 provides additional evidence based on examination outcomes and SEP litigation. Section 6 discusses policy implications and offers concluding remarks.

2 Continuation Applications and Standard Setting

This section describes two sets of institutions that form the backdrop for our analysis. First, because we study continuations, it is necessary to have some understanding of the rules that govern this aspect of the U.S. patent system, and the ways that inventors use them. Second, because our analysis leverages the ICT standard setting process, it helps to understand how SSOs work, and the rules they have adopted to govern the use of patented technology.

2.1 Continuations and delayed drafting of patent claims

Every patent contains a specification that describes the invention, and a set of claims that define the boundaries of the inventor's rights.[5] Patents also disclose "prior art," such as other patents, patent applications, or any public document that helps establish a threshold for assessing the novelty and non-obviousness of the claimed invention.

Inventors want patents that are valid yet broad, meaning they will withstand legal challenge and also cover as many uses of the invention as possible. To achieve these goals at reasonable cost, the basic strategy is to file early and delay claim drafting as long as possible. Filing early creates a favorable priority date. This date is key because it defines the relevant prior art. An examiner cannot reject claims based on technology disclosed after the priority date. Delayed claim drafting has several advantages. First, because most patent offices charge by the claim, the option to abandon low-value claims can reduce costs

[5]Claims are synonymous with scope because a patentee's exclusive right to make, use or sell extends only to whatever is specifically described in the claims of their patent (35 U.S.C. §100 and §112).

(Harhoff, 2016). Second, when there is uncertainty about how an invention will be used, delay allows the applicant to strengthen their patent by drafting claims focused on the most important uses of the invention. And third, delay allows applicants to tailor their claims to cover products or technology introduced by others during the pendency of the application, thereby increasing the probability of infringement.

The U.S. patent system provides several mechanisms for delayed claim drafting. A provisional patent application establishes priority, and provides applicants with up to one year to file a non-provisional application with specific claims. Applicants can also use international applications filed under the Patent Cooperation Treaty (PCT) to amend the claims in their U.S. patent application for up to 30 months. We focus on continuation applications, which allow for much longer lags between filing and claim drafting. A continuation contains new claims on the invention disclosed in its parent application and benefits from the original priority date.[6]

Applicants can file a continuation at any time during the pendency of a parent application or during the pendency of that parent's previous children. Thus, by filing a "chain" of continuations, an inventor may seek new claims many years after the original disclosure of their invention, while keeping the benefit of the parent's priority date.[7] There are three main limitations on the use of this tactic. First, each claim in a continuation must be supported by the disclosure in its parent. Specifically, the parent application must provide enough information for a "person having ordinary skill in the art" (PHOSITA) to make and use the claimed invention.[8] Second, continuations have a shorter useful life, based on the statutory patent term of 20 years from the parent's priority date. And third, each continuation costs

[6]Applicants may also seek a continuation-in-part, which also claims new subject matter that is not entitled to the earlier priority. Delay can also be achieved through reissuance and divisional applications. Reissuance allows the patent owner to correct mistakes in an issued patent and to enlarge the scope of its claims if filed within two years of the original grant date, but requires the surrender of the original patent and is relatively rare. Divisionals are primarily used in response to "restriction requirements" issued by the patent examiner when an application discloses more than one invention.

[7]Among utility patents filed after 2000, the 99$^{\text{th}}$ percentile of the time-lag between priority date and continuation filing is 15 years.

[8]In patent law, this is called the "enablement" requirement: 35 U.S.C. §112(a).

roughly $6,500 to prosecute.[9]

Continuations are used in several ways. Some applicants use them to delay claim drafting so they can achieve a better understanding of their invention. This practice can encourage early invention disclosure, and allow inventors to focus on drafting high-value claims. Other applicants use continuations to lock-in gains during negotiation with a patent examiner. In particular, if the examiner accepts some claims in a parent application, but rejects others, the applicant can allow the former set to issue as a quick but narrow patent and continue seeking protection for the latter.[10] Continuations can be used to amend claims in response to changes in patent law, for example, by working around or exploiting changes in patent eligibility. Finally, applicants may use continuations to draft claims that cover new uses of an invention that emerge after its priority date, provided the original invention disclosure is broad enough to support those claims. This opens the door to strategic use of continuations. For example, in *Kingsdown Medical Consultants v. Hollister* (863 F.2d 867, Fed. Cir. 1988) the court writes, "there is nothing improper, illegal or inequitable in... amend[ing] or insert[ing] claims intended to cover a competitor's product the applicant's attorney has learned about during the prosecution of a patent application."[11]

From a welfare perspective, the impact of continuations on patent system performance is not clear. Providing applicants with an option to delay claim drafting makes patents more valuable, which can stimulate innovation. This option should be especially helpful to start-ups, research-intensive organizations, and producers of pioneering inventions with high initial uncertainty or long lags between invention and commercialization. Continuations may encourage earlier invention disclosure in light of technical uncertainty (Matutes et al., 1996).[12] And they can help the USPTO conserve resources by avoiding examination of claims

[9]The precise cost of filing a continuation will depend on a number of factors, but several web sites suggest that attorney's fees will range from $3,000 to $6,000, and USPTO fees will amount to roughly $2,000.

[10]Marco et al. (2019) show that narrower patents are typically processed more quickly by the patent office.

[11]See also *Gentry Gallery, Inc. v. Berkline Corp.* (134 F.3d 1473, Fed. Cir. 1998)

[12]This incentive may be reduced following the U.S. move to a first-inventor-to-file system under the America Invents Act (AIA, effective on March 16, 2013). When multiple applicants claim the same invention, this system gives patent rights to the first person to file a patent application, thereby providing strong incentives to disclose early.

that turn out to have little value in light of future technology and market developments.

On the other hand, continuations contribute to the growth of patent thickets, leading to greater uncertainty and higher costs for new entrants that cannot leverage large patent portfolios in negotiations (Lemley and Shapiro, 2005; Hegde et al., 2009). Continuations may allow applicants to "wear down" patent examiners by repeatedly filing claims that were initially rejected, consuming the resources of the USPTO and ultimately leading to issuance of overly-broad patents.[13] And perhaps most importantly, continuations exacerbate the problem of patent notice (Menell and Meurer, 2013), creating uncertainty about the real scope of patent protection that can reduce follow-on innovators' incentives to invent around or build upon a pending application.

The importance of notice failures will depend crucially on the effectiveness of individual patent examiners. In principle, a PHOSITA should be able to forecast every claim that emerges from a parent application. In practice, however, the written description of the invention in many applications employs vague or opaque language, and provides little hard technical information that could be used to predict the ultimate scope of the claims (Roin, 2005; Seymore, 2009). Many observers also question whether patent examiners consistently grant only claims supported by the original disclosure (FTC, 2003; Glazier, 2003; Chiang, 2010; Freilich, 2020).[14] This leads some scholars, such as Hovenkamp and Bohannan (2011), to argue that continuations are presumptively harmful because only anticipated uses of the invention — which applicants *could* claim as of the priority date — contribute to *ex ante* innovation incentives.

This study does not seek to resolve the debate over continuations' impact on social

[13]In private conversation, some observers have suggested to us that examiners are more generous with claims in continuations because they like handling them. In particular, when a continuation is assigned to the examiner who handled its parent, it often means less work than a new original application, but receives the same credit in the USPTO's count-based system for evaluating examiner productivity.

[14]The PHOSITA's claim-forecasting problem was especially severe before the American Inventor Protection Act (AIPA, 1999), which instituted publication of pending patent applications after 18 months. Prior research also indicates that patent offices lacking access to SSO records struggle to identify relevant prior art (Bekkers et al., 2020), and that some SSO participants have successfully patented ideas introduced by others (Granstrand, 1999).

welfare. Instead, we provide evidence that continuations are used to draft late claims in one important context: standardization.

2.2 Standardization and the incentive to tailor patent claims

In order to study late claiming via continuations, it is necessary to link patents to potentially infringing technologies, and to observe clear milestones in technology adoption that create the incentive to seek new claims. We solve these two measurement challenges by studying patents that are declared essential to SSOs.

In the ICT sector, SSOs provide a forum where parties coordinate their R&D efforts and seek consensus on the design of standards that promote product interoperability. To avoid holdup problems when standards incorporate patented technology, most SSOs have policies that encourage or require participants to disclose patents that might be infringed by a proposed standard, and to license their essential patents on terms that are fair, reasonable, and non-discriminatory, or FRAND (Shapiro, 2001; Lemley, 2002; Bekkers et al., 2017). We use these disclosures to link patent applications to a potentially infringing technology.

This link is not perfect. SSOs do not attempt to assess the essentiality of disclosed SEPs, and it is well-known that some disclosed patents are not truly essential, whereas other truly essential patents are not disclosed. Mis-measurement can occur for several reasons. A patent application that is disclosed because its claims would be infringed by a draft standard may ultimately prove non-essential due to changes in either the standard or the patent application. Participants in some SSOs have incentives to "over declare" patents because non-disclosure renders true SEPs unenforceable, whereas disclosure of non-essential patents generates no real penalty. Firms may also seek to inflate their declared SEPs counts in order to increase bargaining power in licensing negotiations. At the same time, some essential patents are not disclosed because their owners do not participate in an SSO. And there are some SSOs that allow "blanket disclosure," in which a firm commits to FRAND licensing without providing a list of possibly essential patents or pending applications.

It is nevertheless reasonable to assume that most SSO participants would like their patents to become essential, because it provides a number of benefits in both licensing and implementation. For licensing, essentiality provides a large addressable market and a simple way to prove infringement (i.e., by charting the patent against the standard). For implementation, using homegrown technology in the standard can yield lower costs and product development lead times. Previous research shows that citation and litigation rates – two common proxies for patent value – increase after SEPs are disclosed to an SSO (Rysman and Simcoe, 2008; Simcoe et al., 2009).

The second part of our measurement strategy is to use the formal publication of a standard as a key observable milestone in technology development that provides incentives for applicants to tailor their patent claims via continuations. Publication is a key event in the standard setting process. Reaching consensus on a specific technical solution typically takes years. Before SSO participants agree on a particular design, different technologies compete for incorporation into a standard. Publication occurs after a draft specification has become stable and is formally approved by the SSO, signaling to implementers that they can safely commit to that design in their products (Layne-Farrar, 2011; Simcoe, 2012).

In practice, some of the uncertainty about a new standard gets resolved in technical meetings and with the circulation of draft standards that predate formal publication. Thus, we might expect SSO participants to respond to standardization starting several months before formal publication.[15] Nevertheless, if one looks over a multi-year period, publication provides a reasonable proxy for the moment when the standard locks in to a particular design, producing a sharp drop in uncertainty for both implementers and companies looking to obtain essential patents. As a result, if companies use continuations to file late claims over evolving technology, standard publication marks the moment when we expect to see a substantial increase in continuation filings.

Several court cases suggest firms are aware that continuations provide an opportunity

[15] One strategy for measuring the amount of new information released via standard publication would be to study stock-price reactions to new releases. We leave this as an interesting avenue for future research.

to draft late claims that read on ICT standards. The most famous example is Rambus, a company that used continuations of application 07/510,898 to cover advancements in computer memory that were incorporated into standards published by JEDEC. Rambus was sued by the Federal Trade Commission, but eventually collected royalties from several chipmakers after a long patent enforcement campaign.[16] A more recent example involves the non-practicing-entity Wi-LAN, which filed a long chain of continuations of patent 6,925,068 to track the developments of the Long Term Evolution wireless broadband standards, and asserted its patent rights against several wireless carriers and manufactures of mobile devices and laptops. In one of those cases, LG Electronics argued that Wi-LAN's US patent 8,787,924 (filed in 2012, but claiming priority to 1999) was anticipated by Release 8 of the 3GPP LTE Standard (published in December 2008). The court denied LG's motion based on the early priority date, and the parties eventually entered into a license agreement.[17]

Although our empirical application is focused on SEPs, one can find similar examples in other industries. For instance, Chiron filed a patent application covering monoclonal antibodies in 1984 and used a string of continuations to expand its claims to cover types and uses that were not understood at that time. It eventually asserted a patent based on a continuation application filed in 1999.[18] More recently, the pharmaceutical firm AbbVie was accused of using continuations (including one chain of 22 applications based on a single parent) to build an entry-deterring patent thicket around its blockbuster drug Humira.[19] The point of these examples is not that continuations are bad. As noted above, welfare effects are hard to untangle. Rather, these examples show that firms are aware of the opportunity

[16]In our data, application 07/510,898 has 40 continuations. The last one was filed on October 27, 2004, roughly 14 years after the original filing date. For details on the Rambus case, see *Rambus, Inc. v. FTC* (522 F.3d 456, D.C. Cir. 2008) and Jaffe and Lerner (2004).

[17]In our data, 32 continuations, filed over 18 years, claim priority to the 6,925,068 patent. Twelve of the resulting patents are involved in litigation. For details see *Wi-LAN Inc. v. LG Elecs., 421 F. Supp. 3d 911 (S.D. Cal. 2019)* and "WiLAN Signs Wireless License with LG" http://www.wilan.com/news/news-releases/news-release-details/2019/WiLAN-Signs-Wireless-License-with-LG/default.aspx (accessed October 13, 2021).

[18]See *Chiron Corp. v. Genentech, Inc., 268 F. Supp. 2d 1148 (E.D. Cal. 2002).*

[19]*Fraternal Order of Police, Miami Lodge 20, et al. vs. AbbVie, Inc.*, para. 90-95 (available at https://www.girardsharp.com/assets/htmldocuments/Humira%20Linked.pdf, accessed January 4, 2021).

for late claiming. Our empirical analysis sheds new light on the prevalence of this practice.

3 Data and Methods

3.1 Data sources and sample construction

Our main data source for information on SEPs is the Searle Center Database on technology standards and standard setting organizations (SCDB) (Baron and Gupta, 2018; Baron and Pohlmann, 2018; Baron and Spulber, 2018). This database contains patents and patent applications declared essential to seventeen SSOs and thirteen patent pools.[20] For data on application characteristics, we use the 2017 release of the Patent Examination Research Dataset (Patex) (Graham et al., 2018), which provides information on the applications in the Public Patent Application Information Retrieval system (Public PAIR) and covers filing activity through July 2018. We keep in our sample only utility patent applications.

Licensing commitments to SSOs usually cover all the members of a patent family (i.e., all applications sharing a common priority filing). We therefore define as SEPs the 22,869 U.S. utility patent applications from Patex that match to the SCDB dataset, along with all of their domestic family members, for a total of 31,943 applications. We link each family to a standard using the best match between disclosure letters and standards provided by Baron and Pohlmann (2018).[21] This yields complete information on the standard publication date (year and month) for 23,609 SEPs. Our sample for the analysis of the timing of SEP filings is restricted to SEPs filed in the post-AIPA period, which represents roughly 90% of the matches with a standard publication date. To identify the business model of the company making a SEP disclosure, we use company names to match these data to the

[20]The SSOs covered by the SCDB are ANSI, ARIB, ATIS, Broadband Forum, CEN, DMTF, ECMA, ETSI, IEC, IEEE, IETF, ISO, ITUR, ITUT, OASIS, OMA and TIA. The patent pools include 3GPP-GERAN, AMRWB+, ATSC, AVC, BluRay, DVB-T, DVB-T2, DVD, MPEG DASH, MPEG Visual, SIPRO, VC1, and displayport.

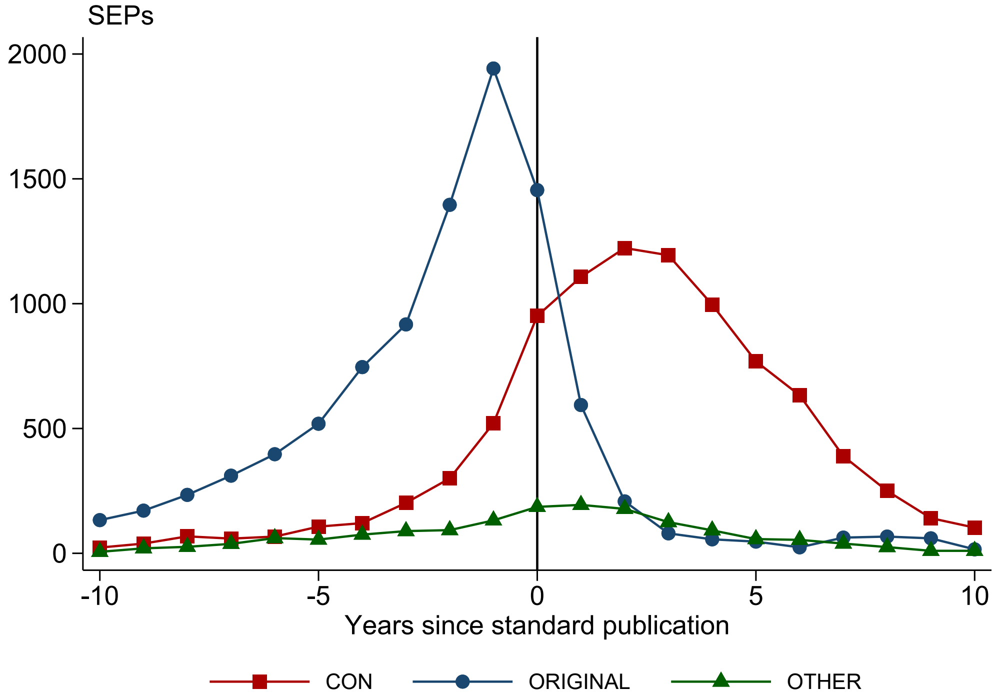
[21]The link between patents and standards documents is described in detail in Section 3.3 of Baron and Pohlmann (2018). They provide both a document ID and a version number, because SSOs often publish several iterations of a given technical specification.

Disclosed Standard Essential Patents (dSEP) Database (Bekkers et al., 2017). We also retrieve information on the claims of applications published between 2001 and 2014 from the Patent Claims Research Dataset (Marco et al., 2019) and the text of the claims from the PatentsView patent application database, which provides information on published applications as of July 15, 2016. Finally, we use the Office Action Research Dataset for Patents (Lu et al., 2017) to identify the applications that receive a non-statutory double patenting rejection during the examination process, and Lex Machina to identify the patents that are litigated in U.S. district courts in the period 2000-2018.

3.2 Descriptive statistics

Figures 1 and 2 provide an initial look at the relationship between standards and continuations in our dataset. To create these figures, we divide all SEPs into three groups based on the type of application: continuations (CON); applications that are not continuations, continuations-in-part, divisionals, or reissues of another filing (Original); and a residual category (Other) for continuations-in-part, divisionals, and reissues. Figure 1 plots the number of SEPs in each category according to the lag between the earliest standard publication date associated with the SEP's patent family and the filing date of the SEP. The graph shows that original applications grow quickly in the years leading up to standardization, peaking one year before the standard is published and declining sharply thereafter. Continuation filings, on the other hand, do not peak until 2-3 years after publication of the standard. These patterns are consistent with the idea that patent applicants often file original applications just before standard publication to establish an early priority, and later tailor the claims of continuations to the content of the standard.

Figure 1: Frequency and timing of SEP continuations, years since standard publication

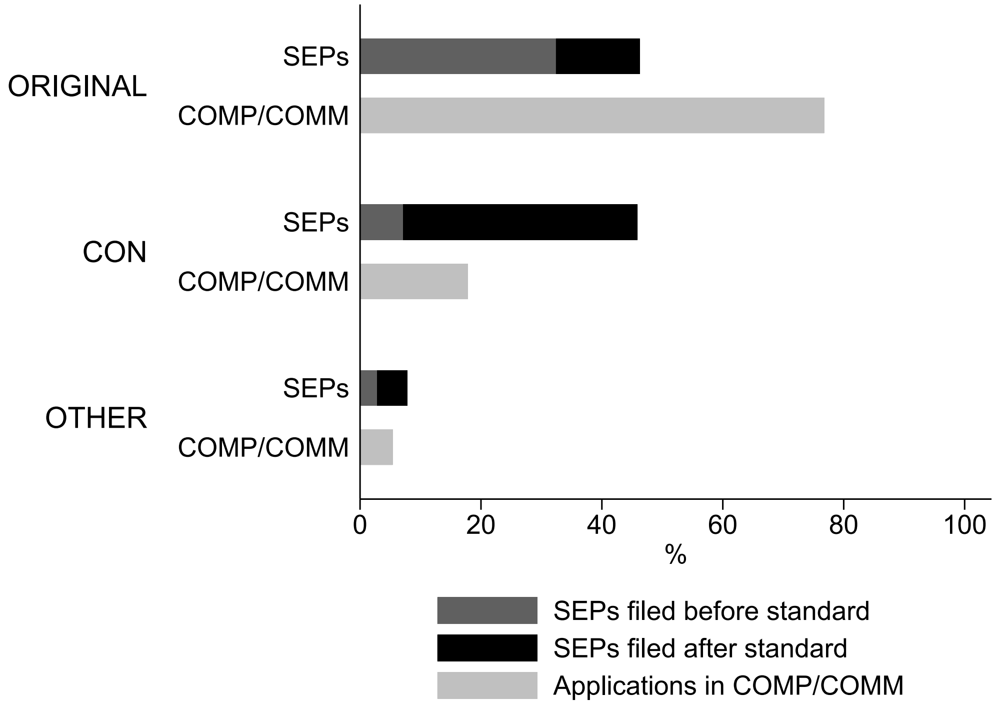


Notes. The sample contains 21,199 SEPs filed on or after November 29, 2000. SEPs include U.S. utility patent applications declared essential for a standard, as well as all their parent and child applications. For each type of application, we plot the number of SEPs by year since standard publication, where year bins are based on the difference between the application filing month-year and the publication month-year of the earliest standard linked to a family of SEPs. We plot the data for a 21-year window centered around standard publication. This time window contains about 96% of the SEPs in our sample.

To create Figure 2, we collapse SEPs in each category into two groups — those filed before versus after publication of the standard. As a point of comparison, we also calculate the Original, CON, and Other shares for all non-SEP applications examined by the USPTO's Computers and Communication area (Technology Centers 2100, 2400 and 2600), which examine roughly 90% of the SEPs in our sample.[22]

[22] Applications with a complex priority chain may be classified in more than one group. When an application is a continuation and a divisional, a continuation and a continuation-in-part, or a continuation and a reissue, we classify it as a continuation. Continuations that are also divisionals, continuations-in-part, or reissues are respectively 6.2% of the SEPs and 2.3% of the applications in the Computers and Communications area of the USPTO used for Figure 2.

Figure 2: Frequency and timing of SEP continuations



Notes. The sample contains utility patent applications filed on or after November 29, 2000. Percentages based on 21,199 SEPs and 1,447,286 (non-SEP) applications processed by Technology Centers 2100, 2400 and 2600. SEPs include U.S. utility patent applications declared essential for a standard, as well as all their parent and child applications. Pre- and post-standard SEPs defined using the earliest standard linked to a family of SEPs. Non-SEP applications are U.S. utility patent applications that are not in the patent family of a declared SEP.

Figure 2 reveals two important facts. First, SEPs are more likely to be continuations than a typical computer/communication application. Specifically, 46% of the SEPs are continuations, compared to only 18% of the reference group. One explanation for this difference is that standardization creates opportunities for strategic continuation filing that do not necessarily exist for non-SEPs. The second fact is that a large fraction of all SEPs are filed after standard publication. For SEPs filed as continuations, 84% post-date standard publication. For Original applications, 30% are filed after the standard is published, indicating substantial use of provisional and PCT applications or of the 12-month grace period between invention disclosure and application filing allowed by U.S. law. Overall, 58% of SEPs are filed after the relevant standard is published.[23]

Figure A2 in the appendix shows the percentage of SEPs filed after standard publication (or filed as continuations) for all companies in our sample that own at least 100 SEPs.[24] We find substantial variation in late claiming behavior by individual firms, with the share of SEPs filed after standard publication ranging from 27% to almost 80%. Many of the large SEP holders in our data file more than half of their SEPs after publication of the standard.

3.3 Empirical strategy

The first part of our empirical analysis estimates the impact of standard publication on continuation filing. In an experimental setting, one might randomly match pending patent applications with standards to ensure that potential outcomes are uncorrelated with SEP status. In practice, SEPs are not randomly chosen. SEPs are highly concentrated in ICT-related fields (Baron and Pohlmann, 2018) and also selected for *ex ante* quality (Rysman and Simcoe, 2008). Because more valuable patents are associated with larger families and more complex prosecution histories, this creates concerns about omitted variable bias in a simple regression of continuation filing on SEP status (Putnam, 1996; Harhoff et al., 2003). To address these concerns, we use a combination of matching and DID regression.

We begin by identifying the earliest U.S. utility patent application in each family of SEPs, and keep only those U.S. families with at least one filing (the earliest and/or one of its children) still under examination in the quarter of publication of the earliest standard linked to the family. To construct a control group, we start with all non-SEP applications filed in the same quarter as a SEP identified at the previous step, excluding any application that claims priority to a previous U.S. utility patent application. To identify applications that cover similar technology to SEPs, we exploit the technological specialization of art-units

[23]We explored the robustness of Figure 2 to several changes in the sample of SEPs and controls. In particular, we obtain similar results for (a) an alternative definition of SEP that includes only the patents and patent applications that are specifically mentioned in SSO disclosure letters (Figure A1 in the appendix), (b) a sample that includes only granted patents, or (c) a 1-to-1 match between SEPs and control applications on filing month and technology center.

[24]These companies collectively own about 90% of the SEPs in our sample.

and patent examiners within the USPTO. Specifically, we stratify on filing-quarter, art-unit and examiner, retaining all applications in any group with at least one SEP and one control application.[25] This procedure leaves us with 53,112 applications (5,487 SEPs and 47,625 controls).

Applicants can file continuations as long as their original application or any of its children are pending. So, for each application in our sample, we retain information on continuations between its filing quarter and the latest disposal quarter of an application in its U.S. patent family (using data until the end of year 2016 to minimize truncation concerns related to delays in publication). This leaves a total of 959,733 application-quarter observations, in which the mean probability of continuation filing is 1.2%.[26] About 14% of the applications in this sample have one or more continuations during the sample period. The mean number of continuations per application is 0.77 for the SEPs and 0.18 for the controls.

In addition to this baseline sample, we create a second matched control sample where the number of continuation filings prior to standard publication is the same for SEPs and controls by construction. This ensures that SEPs and controls have the same pre-publication outcome levels and trends, but comes at the cost of discarding data. To create this second matched sample, for each SEP we randomly select a single control application in the same filing-quarter-art-unit-examiner group having (i) at least one filing in the U.S. patent family still under examination, and (ii) the same cumulative number of continuations filed in the quarter before standard publication.[27] We match almost 93% of the SEPs with a control, discarding 398 SEPs. Relatively few SEPs (9%) have continuations before standard publication, and it is difficult to find controls for SEPs with a high number of pre-standard continuations. So this procedure discards a large share of the SEPs with a continuation in the pre-standard

[25]Art-units are groups of examiners who process relatively similar technologies, and within art-units examiners often specialize in certain technological areas (Cockburn et al., 2002; Lemley and Sampat, 2012; Righi and Simcoe, 2019). Comparing applications assigned to the same art-unit and examiner also reduces the possible influence of systematic differences in examination style that may be related to SEP status (Kuhn and Thompson, 2019).

[26]Summary statistics for this sample are provide in Appendix Table A1.

[27]We match without replacement and break ties at random.

periods (arguably, the cases where we should be most concerned about selection on economic or technical importance). Specifically, we match with a control application only 37% of the SEPs with at least one continuation in the pre-standard period, and none of those with more than three.

Our baseline empirical specification is a linear probability model. For application i with filing-quarter-art-unit-examiner j we estimate

$$CON_{it} = SEP_i \times (\alpha + \beta PostStandard_{it}) + \gamma_{j(i)} + \delta_t + f(age_{it}) + \varepsilon_{it} \quad (1)$$

where the outcome CON_{it} is an indicator equal to one if application i has a continuation filed in quarter t, SEP_i is an indicator equal to one for SEPs, and $PostStandard_{it}$ is an indicator equal to one starting in the quarter of publication of the earliest standard linked to the patent family of application i.[28] When using the sample matched on pre-standard continuations, we also add the main effect of $PostStandard_{it}$ to Equation (1), using the standard publication date of the matched SEP to define this variable for each control.

We consider three variants of Equation (1). The first is a pooled cross-sectional model with calendar-quarter effects, δ_t, to control for common trends, and a full set of application-age (i.e., calendar quarter minus filing quarter) effects to control for the baseline hazard of continuation filing. In the second variant, we add art-unit-examiner-filing-quarter effects, γ_j, and because age is co-linear with filing and calendar quarter, replace the age effects with the non-linear terms of a fourth-order polynomial $f(\cdot)$ in age. The third variant replaces γ_j with a full set of application effects γ_i to control for any time-invariant differences across applications (e.g. technology value or technological field). In all of our models, we cluster the residual term, ε_{it}, by application and multiply CON_{it} by 100 for an easier interpretation of the coefficients as percentage point changes in the probability of continuation filing. In all of these models, the control sample pins down the age-effects, which measure the normal rate

[28] Although we could model the outcome as a count variable, it is extremely rare for an application to spawn multiple continuations in the same quarter.

of continuation filings (i.e., in response to information that is unrelated to standardization) over an invention's life-cycle.

Under a parallel trends assumption, the coefficient β in Equation (1) measures the impact of standard publication on the probability of filing a continuation (i.e. the average treatment effect for treated applications).[29] In order to test the parallel trends assumption on pre-standard data and examine the dynamic treatment effects, we also estimate an event study version of this DID model using the following OLS regression

$$CON_{it} = \sum_{\tau=-8}^{8} (\alpha_\tau + \beta_\tau SEP_i) + \gamma_i + \delta_t + f(age_{it}) + \varepsilon_{it} \tag{2}$$

where, using the sample matched on pre-standard continuations and assigning the standard publication date of the matched SEP to each control, the α_τ's are dummies equal to one τ quarters before/after standard publication. The coefficients β_τ measure the difference in the probability of continuation filing between SEPs and controls before ($\tau < 0$) and after ($\tau \geq 0$) standard publication. For both the α_τ's and the β_τ's, the omitted category is the quarter before standard publication ($\tau = -1$), and we focus on a seventeen-quarter window around standard publication, using a single indicator for $\tau \leq -8$ and a single indicator for $\tau \geq 8$. When we use the baseline sample to estimate this equation, we omit the α_τ's because the controls do not have an associated standard publication date. All other variables are defined above.[30]

[29] The over- and under-disclosure issues mentioned above may lead to attenuation of the link between standard publication and continuation filings. Similarly, if knowledge about the standard leaks out prior to formal publication, we expect the coefficients of our DID models to be biased downward because of both classical measurement error and anticipation effects.

[30] We estimate all models that include fixed effects using the estimator described in Correia (2016), which allows a very fast estimation of linear regressions with high-dimensional fixed effects.

4 Standard Publication and Continuations

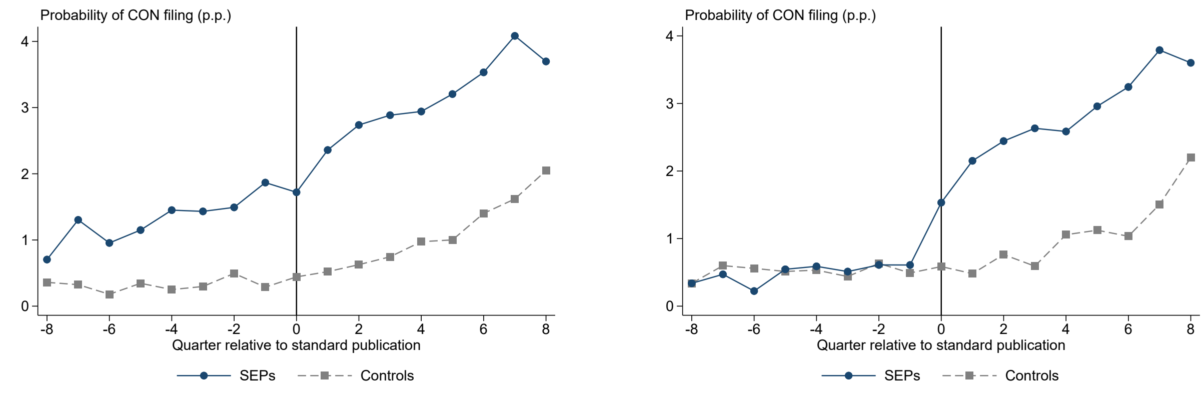
4.1 Graphical evidence

Figure 3 provides graphical evidence of the link between standard publication and continuation filing. Specifically, we plot the quarterly probability of continuation filing for both SEPs and controls in a seventeen-quarter window around standard publication. In order to assign a publication date to the controls, we match each SEP to a single control and use the publication date for the matched SEP's standard. For panel (a), we randomly match each SEP with a control filed in the same quarter and assigned to the same examiner in the same art-unit.[31] For panel (b), we use the 1-to-1 match described above, which ensures that SEPs and controls have the same cumulative number of pre-standard continuations.

Panel (a) in Figure 3 shows that the baseline probability of continuation filing increases over time for both SEPs and controls. Although SEPs are more likely to generate a continuation both before and after standardization, the difference clearly increases in the post-standard time-period. In fact, it appears that the relative rate of continuation filings for SEPs starts to increase a year or more before publication. These pre-treatment effects are consistent with the idea that design commitments actually occur prior to formal approval and publication of the standard or, alternatively, that participants in the standardization process anticipate the final design and begin to file continuations before a standard is formally approved.

[31] We match without replacement and break ties at random. We match 99.6% of the SEPs with a control, discarding only 23 SEPs.

Figure 3: Continuation filings around standard publication



(a) Controls picked randomly (b) Controls matched on continuation filings

Notes: This figure plots the average probability of continuation filing for SEPs and controls in each quarter in a 17-quarter window around standard publication (for controls, we use the publication date of the matched SEP). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The quarter of standard publication is the quarter of publication of the earliest standard linked to a family of SEPs. In panel A we use as control for each SEP an application in the same art-unit-examiner-filing-quarter group picked at random. In panel B we use as control for each SEP an application in the same art-unit-examiner-filing-quarter group with a pending family (i.e. at least one filing in the U.S. patent family is still under examination) and the same cumulative number of CONs filed in the quarter before standard publication. An application is included in the sample from its filing quarter to the latest disposal quarter of an application in its U.S. patent family, or the end of year 2016 if its family is still pending.

Panel (b) of Figure 3 shows that after matching SEPs and controls on the number of pre-standard continuations, the two groups are on the same trend before standard publication, and there is still a substantial increase in the probability of continuation filings for the SEPs after standard publication. As a result of the exclusion from this matched sample of many SEPs that generate a continuation in the pre-standard period, the SEPs have a much lower probability of continuation filing than in the previous panel. Next, we analyze these patterns in a regression framework.

4.2 Difference in differences estimates

Table 1 shows coefficient estimates from our DID models, using the two samples described above. The first column is based on a pooled cross-sectional regression. The coefficients indicate that the quarterly probability of continuation filing is 0.8 percentage points higher for SEPs before standard publication. The DID estimate indicates that standardization produces a 1.13 percentage point increase in the probability of filing a continuation, which corresponds to a 93% increase in the baseline probability. In the second column, we add art-unit-examiner-filing-quarter effects to control for technological heterogeneity and differences among cohorts, and find similar estimates. The third column adds application effects, which absorb the SEP indicator. In this specification, the DID estimate grows to 1.5 percentage points, more than doubling the baseline probability.

Columns (4) through (6) of Table 1 report estimates from similar models, using the matched sample and adding the main effect of the standard publication dummy. Recall that matching discards roughly 7% of the SEPs (typically those with one or more pre-standard continuation filings), so these estimates should be interpreted as a conditional average treatment effect for treated SEPs. The mean outcome in this sample is about 50% larger, and the coefficient on the SEP indicator is approximately zero by construction. The DID coefficient in these three specifications is between 1.7 and 1.9, which corresponds to an increase in the probability of continuation filing between 88 and 96%.[32] Overall, the DID estimates uniformly indicate that there is an economically and statistically significant increase in SEP continuations filed after standards are published.

[32] Chabé-Ferret (2017) shows that including unit fixed effects in DID models after matching on pre-treatment outcomes may introduce bias. Our estimates suggest this is not a concern in our analysis.

Table 1: Difference in differences models of continuation filing

Outcome	CON × 100					
Estimation method	OLS					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	Pooled OLS (1)	Tech & cohort FE (2)	Application FE (3)	Pooled OLS (4)	Tech & cohort FE (5)	Application FE (6)
PostStandard × SEP	1.13***	0.98***	1.48***	1.87***	1.72***	1.83***
	(0.09)	(0.09)	(0.09)	(0.11)	(0.09)	(0.11)
SEP	0.80***	0.91***		0.00	0.00	
	(0.05)	(0.05)		(0.05)	(0.04)	
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓			✓	
Age^2, age^3 & age^4		✓	✓		✓	✓
Application FE			✓			✓
PostStandard				✓	✓	✓
Observations	959,733	959,733	959,733	214,896	214,896	214,896
R-squared	0.02	0.03	0.07	0.02	0.05	0.07
Applications	53,112	53,112	53,112	10,178	10,178	10,178
Mean of outcome	1.22	1.22	1.22	1.95	1.95	1.95

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the latest disposal quarter of an application in its U.S. patent family, or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample for models (1)-(3) contains SEPs whose family is pending at standard publication and control applications in art-unit-examiner-filing-quarter groups with at least one SEP and one control. The sample for models (4)-(6) contains SEPs whose family is still pending at standard publication and control applications whose family is still pending in the quarter before standard publication matched on filing quarter, art unit, examiner and cumulative number of continuations in the quarter before standard publication. The quarter of standard publication is the quarter of publication of the earliest standard linked to a family of SEPs. Standard errors clustered by application in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

4.3 Event studies

Event study models can provide a closer look at the precise timing of the increase in SEP continuation filings. Figure 4 plots the β_τ's from four versions of Equation (2). The top row shows results for the baseline sample, using either the indicator SEP_i and a full set of age effects (panel a), or application fixed effects and an age polynomial (panel b). The bottom row graphs estimates for similar models, using the sample of SEPs and controls matched on pre-standard continuations, and adding the α_τ's to the regressions.

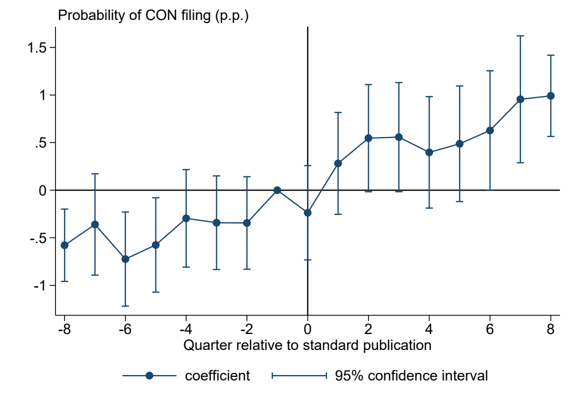
All four models show a jump in the probability of a SEP continuation filing immediately after standard publication, although this increase is more pronounced for the matched sample. Panels (a) and (b) also show an increasing trend in SEP continuations prior to standard publication, which may cause some doubts about the validity of the parallel trend assumption for the full sample. For panel (a), an F-test of the hypothesis that all pre-publication coefficients are jointly equal to zero rejects the parallel-trends assumption (p=0.055). However, we do not reject the hypothesis that the coefficients β_{-8} through β_{-2} are equal to each other (p=0.37). As described above, an increase in continuations just before standard publication could reflect the resolution of design uncertainty prior to formal approval.[33] For panel (b), both tests reject the parallel pre-trend hypothesis at the 1 percent level.

In panels (c) and (d) we match on the cumulative number of pre-publication continuations. In this sample, we cannot reject the hypothesis of parallel pre-trends.[34] Following standard publication, we find a sharp increase in the probability of a continuation filing. We interpret the matched sample event study results as evidence that applicants use the continuation procedure to seek late claims covering technology that has become essential to standards.

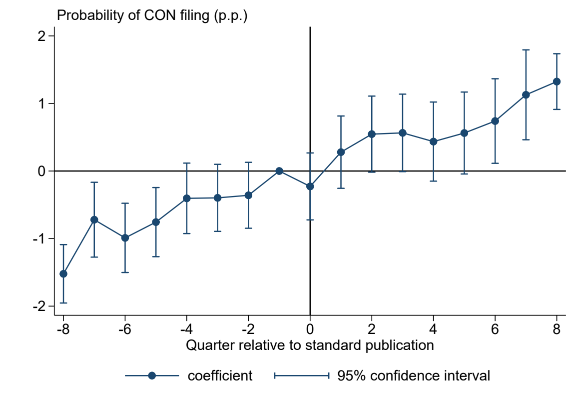
[33]To the extent that our definition of treatment (i.e., $\tau = 0$) is a little "too late" that measurement error will bias our baseline DID estimates towards zero.

[34]F-tests cannot reject the null hypothesis that the pre-standard coefficients for the SEPs are jointly equal to zero, with p-value=0.62 for panel C and p-value=0.52 for panel D.

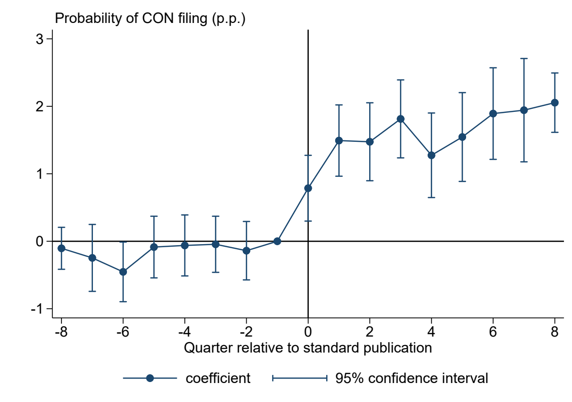
Figure 4: Continuation filings around standard publication, DID models



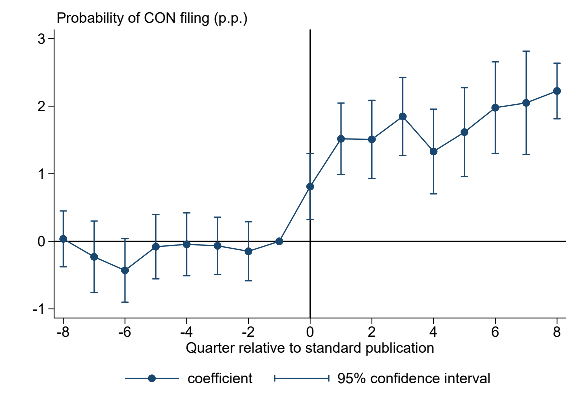
(a) SEPs and controls



(b) SEPs and controls (FE)



(c) SEPs and CON matched controls



(d) SEPs and CON matched controls (FE)

Notes. Each panel plots the β_τ's and their 95% confidence intervals from OLS regressions based on Equation 2. Models for panels (a) and (b) are estimated on the sample for models (1)-(3) in Table 1. Models for panels (c) and (d) are estimated on the sample for models (4)-(6) in Table 1. Panels (a) and (c) report the estimates for pooled cross-sectional models. Panels (b) and (d) report the estimates for the models with application fixed effects.

4.4 Examiner leniency

Although patent examiners have a uniform mandate, in practice they have substantial discretion in how to deal with an application, and prior research has found that this leads to large differences in patenting outcomes (Feng and Jaravel, 2020; Kuhn and Thompson, 2019; Lemley and Sampat, 2012; Sampat and Williams, 2019). Because patent examination involves several rounds of negotiation between applicant and examiner, we might expect that an applicant can learn something about the type of examiner on a given application, and tailor their prosecution strategy accordingly. In particular, after knowing the final product design or the most promising implementations of a technology, an applicant should be more willing to invest in additional claim drafting and file a continuation when facing a "lenient" examiner who is more likely to allow the new claims.[35] In our setting, this suggests firms will be even more likely to file a post-standard continuation when they receive a favorable draw from the distribution of examiner leniency.

To test this idea, we compute a measure of leniency based on each examiner's grant rate (Sampat and Williams, 2019). Specifically, for each application in our data, we compute the grant rate on all post-AIPA published applications that are disposed by the same examiner, excluding applications in the same family as the focal application.[36] We standardize this measure of examiner leniency (for ease of interpretation), and re-estimate the DID models adding a three-way interaction between leniency and the $PostStandard_{it} \times SEP_i$ indicator.[37] Results are in Table 2.

Across all models, the increase in continuation filings after standard publication is larger for applications assigned to more lenient examiners: a one standard deviation increase in examiner leniency is associated with a 0.68-0.78 percentage point increase in the probability of continuation filing. This increase is roughly three fourths as large as the main treatment effect in the first two models. This finding suggests that applicants are more likely to seek late

[35]This logic requires, of course, that the examiner on the parent application is also assigned to the continuation. This is often true in practice. In particular, roughly 75 percent of the post-AIPA continuations filed at the USPTO are assigned to the same examiner of the earliest application in their priority chain.

[36] Because this measure is not used as an instrumental variable, we make no assumptions about random matching between applications and examiners (Righi and Simcoe, 2019), and require only that the examiner-specific grant-rate is a valid proxy for leniency. To construct the variable, we use all post-AIPA applications disposed by an examiner because, although the leniency of an examiner is affected by time-varying factors such as experience, time available to review applications or peer effects, it tends to be very persistent over time (Frakes and Wasserman, 2016, 2017, 2021; Lemley and Sampat, 2012). Measuring leniency at a specific point in time would require arbitrary choices because examination of a single application often spans several years. We exclude from the analysis all applications where our measure of leniency is computed using less than 10 applications.

[37]We also add the relevant two-way interactions of leniency to our regressions.

claims covering a published standard when they perceive a better chance that the examiner will allow those claims to issue. To our knowledge, this is the first article to test the idea that applicants learn about examiner leniency during the examination process.

Table 2: Heterogeneous effects by examiner leniency measured as grant rate

Outcome	CON × 100					
Estimation method	OLS					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	Pooled OLS	Tech & cohort FE	Application FE	Pooled OLS	Tech & cohort FE	Application FE
	(1)	(2)	(3)	(4)	(5)	(6)
PostStandard × SEP × Leniency	0.78***	0.76***	0.74***	0.76***	0.73***	0.68***
	(0.08)	(0.08)	(0.08)	(0.10)	(0.08)	(0.10)
PostStandard × SEP	1.08***	0.98***	1.49***	1.82***	1.70***	1.83***
	(0.09)	(0.09)	(0.09)	(0.11)	(0.09)	(0.11)
SEP	0.83***	0.91***		0.00	0.00	
	(0.05)	(0.05)		(0.05)	(0.04)	
Leniency	0.30***			0.19***		
	(0.01)			(0.03)		
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓			✓	
Age^2, age^3 & age^4		✓	✓		✓	✓
Application FE			✓			✓
PostStandard				✓	✓	✓
SEP × Leniency	✓	✓		✓	✓	
PostStandard × Leniency				✓	✓	✓
Observations	959,627	959,627	959,627	214,838	214,838	214,838
R-squared	0.02	0.03	0.07	0.03	0.05	0.07
Applications	53,106	53,106	53,106	10,176	10,176	10,176
Mean of outcome	1.22	1.22	1.22	1.95	1.95	1.95

Notes. The unit of observation is an application-quarter. See Table 1 for the description of the samples. We keep in the samples the applications whose examiner disposes at least 10 applications outside the focal family that are published before grant, and keep in the sample art-unit-examiner-filing-quarter groups with at least one SEP and one control after this restriction (models (1)-(3)), and matched pairs where both applications meet this additional criterion (models (4)-(6)). Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4.5 Business models

Table 3: Heterogeneous effects by business model

Outcome	CON × 100					
Estimation method	OLS					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	Pooled OLS (1)	Tech & cohort FE (2)	Application FE (3)	Pooled OLS (4)	Tech & cohort FE (5)	Application FE (6)
PostStandard × SEP × patent holding company	2.08***	1.89***	2.97***	3.15***	3.02***	3.50***
	(0.32)	(0.28)	(0.34)	(0.29)	(0.30)	(0.35)
PostStandard × SEP × components	-1.08***	-1.19***	-0.50***	-0.56***	-0.64***	-0.38**
	(0.16)	(0.14)	(0.16)	(0.15)	(0.14)	(0.16)
PostStandard × SEP × products	1.62***	1.49***	1.90***	2.41***	2.25***	2.36***
	(0.12)	(0.11)	(0.12)	(0.13)	(0.11)	(0.14)
PostStandard × SEP × other	0.68***	0.58***	1.37***	1.26***	1.19***	1.42***
	(0.24)	(0.23)	(0.26)	(0.24)	(0.22)	(0.25)
SEP × patent holding company	1.06***	1.00***		0.10	-0.19	
	(0.24)	(0.19)		(0.16)	(0.21)	
SEP × components	0.68***	0.82***		0.00	0.09	
	(0.12)	(0.10)		(0.09)	(0.09)	
SEP × products	0.85***	0.94***		0.02	-0.01	
	(0.07)	(0.06)		(0.05)	(0.06)	
SEP × other	0.58***	0.70***		-0.15**	0.02	
	(0.14)	(0.14)		(0.08)	(0.12)	
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓			✓	
Age^2, age^3 & age^4		✓	✓		✓	✓
Application FE			✓			✓
PostStandard				✓	✓	✓
Observations	959,733	959,733	959,733	214,896	214,896	214,896
R-squared	0.02	0.03	0.07	0.03	0.05	0.07
Applications	53,112	53,112	53,112	10,178	10,178	10,178
Mean of outcome	1.22	1.22	1.22	1.95	1.95	1.95

Notes. The unit of observation is an application-quarter. See Table 1 for the description of the samples. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

If continuations are used to obtain SEPs, it is natural to ask what sort of applicants are doing so. The dSEP database classifies SEP-owner business models into nine categories. We focus on the largest three in our sample: (i) product suppliers, product vendors and system integrators (3,516 SEPs); (ii) components (942 SEPs); (iii) pure upstream knowledge developer or patent holding company (415 SEPs). We pool together all of the smaller categories, along with SEPs that we cannot match to dSEP, into a residual category (614 SEPs). We then re-estimate the models in Table 1, interacting $PostStandard_{it} \times SEP_i$ and SEP_i with a dummy for each business model category.[38] Results are in Table 3.

The estimates in columns (1) and (2) show that SEPs have a higher pre-publication rate of continuation filings than the controls across all business model types. Patent holding companies, which base their business model on licensing of IP, have the highest baseline rate of continuation filings, although we cannot reject the hypothesis that any of the baseline SEP continuation rates are equal at a 5% significance level.

Across all six models, the two groups with the highest correlation between standard publication and continuation filing are patent holding companies and product suppliers.[39] Patent holding companies have the largest DID coefficient in all models, and the difference between patent holding companies and product suppliers is statistically significant at conventional levels in models (3)-(6).[40] Patent holding companies have incentives to use continuations strategically to increase their licensing revenues. Interestingly, and perhaps surprisingly given the importance of IP to their business models, the correlation between standard publication and the probability of continuation filing is negative or not statistically different from zero for producers of components. This result suggests that different types of "upstream" players have different strategies regarding continuations. A plausible explanation for the relatively large coefficient for product suppliers is that downstream players

[38]If a SEP is associated with multiple companies, we use the business model of the first company in alphabetical order. The results are robust to excluding these 40 SEPs.

[39]Statistical tests reject the equality of those coefficients with the coefficients of standard publication for components and the residual category "other" at least at 10% in all models.

[40]The p-values for a test of the null hypothesis that the two coefficients are equal are 0.18 for model (1), 0.19 for model (2), and lower than 0.03 in the other models.

have an incentive to inflate their SEP portfolios to protect their investments from holdup risks, increase their bargaining power in cross-licensing negotiations, and obtain freedom to operate (Hall and Ziedonis, 2001; Shapiro, 2001; Ziedonis, 2004).

4.6 Robustness checks

We have argued that the DID estimates are evidence of late claiming by applicants trying to obtain SEPs. At a conceptual level, one might wonder if applicants are using continuation applications to continue prosecuting claims that were initially rejected, as opposed to drafting new claims that read on standards. We think the timing of the post-standard surge in continuations favors the latter interpretation, because there is no reason to expect rejections will arrive at the same time a standard is published. Nevertheless, we provide a few additional pieces of evidence on this point in the Appendix.

First, it is relatively unusual for applicants to file a continuation application after receiving a final or non-final rejection. Instead, most continuations are filed after the applicant receives a notice of allowance (see Table A2). Second, for a sample of SEPs filed as original applications that are eventually granted, we regress an indicator for continuation filing on two measures of change in scope during examination (Kuhn and Thompson, 2019; Marco et al., 2019). The results are small in magnitude, and point in opposite directions for the two different scope proxies (see Table A3). The results of these robustness checks reinforce our view that continuations are mostly used to delay prosecution and add new claims after a first patent is allowed, rather than to respond to rejections or changes in scope.

We have also considered a wide variety of alternative specifications for the baseline results in Table 1. Across all models, we find a robust association between standard publication and the probability of filing a SEP continuation. The next paragraph offers a brief overview, and the Appendix contains a full discussion and all results.

First, we consider an alternative definition of SEP that includes *only* patents or patent applications explicitly mentioned in a disclosure letter to an SSO (Table A4). Second, we change the outcome variable to an indicator for any type of child application — including continuations-in-part, divisionals and reissues – as opposed to just continuations (Table A5). Third, we add controls for a number of observable application characteristics that may be related to both SEP status and the propensity to file continuations (Table A6). Fourth, we estimate models that include four leads of an indicator equal to one for SEPs in the quarter of standard publication, to measure any anticipation effects (Table A7). Fifth, because continuation is a rare outcome, we estimate a series of piecewise constant hazard models, where the outcome is the probability of continuation conditional on not having any prior continuations, and applications are removed from the sample after the first observed continuation (Tables A8–A10). Sixth, we estimate models similar to those in the main analysis and in the previous robustness checks using samples that contain only SEPs filed before standard publication (Tables A11–A13). Seventh, we estimate models that control for time-varying technology-area shocks that may drive both standardization and continuation filings (Table A14). Eighth, to address concerns related to the availability of blanket disclosures at many SSOs, we divide the SEPs into two groups (Table A15): those linked to ETSI, which mandates disclosure, and those linked to other SSOs, which generally allow firms to make licensing commitments without identifying specific patents.[41]

Finally, there is a growing literature that identifies a potential bias in DID designs with heterogeneous effects and staggered treatment (Goodman-Bacon, 2021), and suggests new unbiased estimators. To address these concerns, we check the robustness of our main DID and event-study estimates using the estimators proposed by de Chaisemartin and D'Haultfœuille (2020a,b) (Table A16), Callaway and Sant'Anna (2021) (Table A17 and Figure A4), Sun and Abraham (2021) (Figure A5), and Borusyak et al. (2021) (Table A18 and Figure A6).

[41] Tables A19-A21 report robustness checks for the analysis in the next section dividing the SEPs into ETSI and non-ETSI SEPs.

5 Claim Drafting and SEP Litigation

This section provides additional evidence of late claiming based on examination outcomes, claim text, and SEP litigation rates.

5.1 Double patenting rejections

Patent examiners may reject a claim if the same inventor has disclosed "patentably indistinct" claims in a previous application.[42] This is called a non-statutory or obviousness-type double patenting rejection, and it is meant to prevent applicants from extending the term of a first patent by including similar claims in a later application. Non-statutory double patenting rejections often occur when an applicant seeks to change the scope of its earlier claims, for example expanding it by removing some limitations. We therefore take these rejections as a proxy for "claim broadening" or "claim tailoring" (as opposed to claiming new and distinct uses of the original invention).[43] If applicants use continuations to draft claims that read on standards, we would expect to see more non-statutory double-patenting rejections for SEP continuations filed after standard publication than before.

To test this hypothesis, we construct a sample of SEP and control continuations that are technologically similar and exposed to a similar examination environment. We start from the sample of SEP continuations described in section 3.2, matching each SEP continuation with a non-SEP continuation filed in the same year, and assigned to the same art unit and examiner.[44] In order to observe the full examination history of each application, which we obtain from Lu et al. (2017), we exclude all continuations filed before 2008 or disposed after June 2017. This process yields a sample of 10,588 continuation applications. Using this sample, we estimate linear probability models where the outcome is equal to one if a continuation receives a non-statutory double patenting rejection (multiplied by 100 for an

[42] See the *Manual of Patent Examination Procedure*, Title 37 Code of Federal Regulations, Section 1.78.

[43] We are indebted to Jeffrey Kuhn for suggesting this outcome variable.

[44] We perform a 1-to-1 match without replacement, breaking ties at random. We match about 93% of the SEP continuations available after the exclusions described in the main text.

easier interpretation of the coefficients). The main explanatory variables are two indicators equal to one for SEP continuations filed, respectively, before and after the month of standard publication. The results appear in Table 4.

Column (1) shows that post-standard SEP continuations are about 8 percentage points more likely than the non-SEP continuations to receive a non-statutory double patenting rejection. This is a 15% increase relative to the 50% baseline probability of a double-patenting rejection. Pre-standard SEP continuations, on the other hand, are about 5 percentage points *less* likely to receive a non-statutory double patenting rejection than the non-SEP controls.

Table 4: Regression models of non-statutory double patenting rejection

Outcome	Non-statutory double patenting rejection ×100	
Estimation method	OLS	
Model	Baseline	FE
	(1)	(2)
SEP post-standard	7.69***	7.06***
	(1.14)	(0.99)
SEP pre-standard	-4.93**	-1.13
	(2.02)	(2.00)
Art unit effects		✓
Filing year effects		✓
Examiner effects		✓
Observations	10,588	10,588
R-squared	0.01	0.25
Patent families	8,172	8,172
Mean of outcome	49.82	49.82

Notes. The unit of observation is a patent application. The sample contains continuations filed after year 2007 and disposed before July 2017. We match SEP and non-SEP continuations on art unit, filing year, and examiner. We match without replacement and break ties at random. SEPs include U.S. utility patent applications declared essential for a standard, as well as all their parent and child applications. Pre- and post-standard SEPs defined using the earliest standard linked to a family of SEPs. Non-SEP applications are U.S. utility patent applications that are not in the patent family of a declared SEP. Standard errors clustered by patent family in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In column (2), we add art unit, filing year, and examiner effects. The coefficient of the post-standard SEP continuation dummy is similar to column (1). The coefficient of the pre-standard SEP continuation dummy, however, becomes indistinguishable from zero. We interpret these estimates as further evidence that SEP applicants use continuations to modify the scope of patent protection after they know the design of a standard.[45]

5.2 Claim language convergence

In this part of the analysis, we focus on the actual text of the patent application claims. To determine whether applicants are, in fact, using continuations to draft claims that read on published standards, one could attempt to read the original disclosure, the new claims, and the relevant standards. Unfortunately, that is a very time-intensive process requiring access to the text of standards and also expertise in interpreting patent claims.[46] As an alternative, we measure the similarity of claims across pairs of applications linked to the same standard, comparing the similarity of claims filed before and after standard publication. If applicants are drafting claims that read on the standard, our hypothesis is that claim language should converge after the standard is published.[47]

Suppose k indexes pairs of continuations declared as essential for the same standard, both filed after standard publication, and each having a parent application filed before standard publication. Our measure of claim similarity is a Jaccard index (Arts et al., 2018), which equals the number of common keywords in the claims of the two applications divided by the number of total keywords, multiplied by 100. For each application pair k we define two similarity scores: J_k^{post} is the similarity of the two post-standard continuations, and J_k^{pre} is the similarity of the two pre-standard parent applications.[48] We retain all pairs where the

[45] We also construct a matched sample containing not only continuations but also other types of applications, matching SEPs and controls also on the type of application — original, continuation, or the residual category "other." The results are similar to those reported in the article. Figure A7 shows graphically that continuations, in general, have a much higher probability of receiving a non-statutory double patenting rejection than other types of applications, and that post-standard SEP continuations in particular have the highest rate of non-statutory double patenting rejections.

[46] Brachtendorf et al. (2019) pursues a similar approach based on automated text analysis.

[47] We do not have strong priors as to whether the claims in a continuation would be "broader" or "narrower" than the claims in its parent: this likely depends on the (unobserved) relationship of the original claims to the standard. For this reason, we do not analyze text-based measures of claim scope.

[48] We use all the families of SEPs in our data and adapt the procedure described in Arts et al. (2018) to extract a set of unique keywords from the claims of each application. We also use all standards in our data, but drop duplicates when the same pair is related to multiple standards.

two continuations and their parents have at least 10 keywords and drop all pairs where the two continuations claim priority to the same parent. This leaves us with a sample of 661,789 pairs.

Table 5: Regression models of Jaccard similarity

Outcome	Jaccard similarity		
Estimation method	OLS		
Model	No controls	Pair FE	Application characteristics
	(1)	(2)	(3)
Post-standard CONs	2.17***	2.17***	0.74***
	(0.01)	(0.01)	(0.06)
Pair FE		✓	✓
Claims, technology, year			✓
Observations	1,323,578	1,323,578	419,142
R-squared	0.02	0.82	0.83
Pairs	661,789	661,789	209,571
Mean of outcome	14.26	14.26	12.51

Notes. The sample contains two observations for each pair of post-standard continuations, one for the two continuations and one for their parents. The control variables for model (3) are defined at the application level, i.e. measured separately for the two applications of each observation. Controls include filing year effects, art-unit-by-examiner effects, and the natural logarithms of the number of independent claims and the number of words per independent claim. Standard errors clustered by pair in parentheses. *** p<0.01, ** p<0.05, * p<0.1

For this sample of application-pairs, the mean of J_k^{pre} is 13.17 and the mean of J_k^{post} is 15.34. Pooling together J_k^{pre} and J_k^{post}, we find that the difference in means is equal to 0.31 standard deviations of J_k (t-stat=295). We also create a sample with two observations for each pair k — one observation for the post-standard continuations and one for their pre-standard parents — and compare the Jaccard similarities using OLS regression.

The first column in Table 5 regresses Jaccard similarity against a dummy equal to one for the post-standard continuations. In the second column, we add pair fixed effects to control for all common characteristics of the pre- and post-standard applications in a pair. In the third column, we control for several observable application characteristics (independent claims, words per independent claim, art-unit-by-examiner effects, and filing-year effects), which reduces the sample size because of missing data. All three models confirm that the claims of post-standard continuations are more similar than those of their pre-standard parents. Although it is difficult to interpret the magnitude of this finding, we take the convergence in claim language as further evidence that SEP owners use continuations to draft claims that cover standards.

5.3 Litigation

The last part of our analysis examines the relationship between continuations, prosecution delay, and patent litigation. Litigation occurs when bargaining between a patent owner and an alleged infringer fails to produce agreement, and the patent owner asserts its rights in court.[49] Theoretical research highlights several mechanisms that might link late-claiming to litigation of particular patents (Cooter and Rubinfeld, 1989; Lanjouw and Lerner, 1998). Plaintiffs are more likely to assert those patents for which infringement is easily proved. For SEPs, infringement is typically argued by comparing the patent claims to the standard, and as we have argued, continuations allow applicants to tailor their claims to the content of an already published specification. Litigation is also more likely when the stakes are higher, and patent owners may be more likely to invest in late claim drafting for their more valuable inventions.

For this analysis, we use a sample of SEPs filed after AIPA came into effect, that are eventually granted, and for which we have information on the standard publication date. We estimate linear probability models where the outcome is equal to one if a SEP is litigated at least once in a U.S. district court before the end of 2018 (multiplied by 100 for an easier interpretation of the coefficients). The key explanatory variables are an indicator for SEPs filed as a continuation application and two measures of prosecution delay: (i) an indicator equal to one for SEPs filed after the month of standard publication, and (ii) the difference,

[49]Litigation can also occur when an alleged infringer files a declaratory judgment case to have a patent declared invalid or not infringed, but these cases are relatively rare and are typically triggered by the threat of a patent infringement lawsuit.

in years, between the filing month of the SEP and the month of standard publication.[50] All of the regressions include issue-year effects to control for differences in the time at risk of litigation, as well as filing-year effects, art-unit effects, and examiner effects to control for differences across filing cohorts, technology areas, and examination styles.

The estimates in the first column of Table 6 show that SEPs filed after standard publication are 0.87 percentage points (or 42%) more likely to be litigated than pre-standard SEPs. Column (2) shows that the probability of SEP litigation increases by 0.25 percentage points with each year of filing lag relative to the date of standard publication.

Table 6: Filing lag and litigation

Outcome	Litigation × 100			
Estimation method	OLS			
Sample	SEPs		SEPs, original and CONs	
Model	Post standard	Filing lag	Post standard & CON	Filing lag & CON
	(1)	(2)	(3)	(4)
Post-standard	0.87***		0.66*	
	(0.30)		(0.39)	
Filing lag		0.25***		0.26***
		(0.06)		(0.06)
CON			1.23**	0.69**
			(0.54)	(0.34)
Post-standard × CON			-0.20	
			(0.66)	
Filing lag × CON				-0.04
				(0.11)
Observations	16,213	16,213	14,894	14,894
R-squared	0.16	0.16	0.16	0.16
Patent families	9,004	9,004	8,721	8,721
Mean of outcome	2.05	2.05	2.03	2.03

Notes. The unit of observation is a SEP. The sample contains the SEPs filed on or after November 29, 2000 that are granted. SEPs include U.S. utility patent applications declared essential for a standard, as well as all their parent and child applications. The sample for models (3) and (4) contains only SEPs from original applications and CONs. All models include effects for filing year, issue year, art unit and examiner. Standard errors clustered by patent family in parentheses. *** p<0.01, ** p<0.05, * p<0.1

[50] The latter measure takes negative values for SEPs filed before standard publication.

The third and fourth columns in Table 6 try to disentangle the role of delayed filing from the use of continuation applications. For these models, we drop SEPs based on continuations-in-part, divisionals, and reissues and keep only SEPs filed as an original or continuation application. The results in column (3) show that SEPs from continuations are more likely to be litigated than SEPs based on original applications. We cannot, however, reject the hypothesis that litigation rates are equal for continuations filed before versus after publication of the standard. Indeed, the relatively large standard errors in this specification reflect the fact that 83% of SEPs based on continuation applications are filed after publication, making it difficult to separate the two effects.

The model in column (4) replaces the post-publication dummy with a continuous measure of the lag between standard publication and filing date. As in column (2) the coefficient on filing-lag indicates that delays increase the probability of litigation by around 0.25 percentage points per year. Moreover, after conditioning on the filing-lag, SEPs based on continuations remain 0.69 percentage points (34%) more likely to be litigated than SEPs based on original applications. Overall, these results illustrate a strong positive association between late claiming and litigation. We also find that SEPs from continuations are more likely to be litigated, even after conditioning on the timing of the application. The latter result could be causal (e.g. if continuations are particularly effective for obtaining essential claims) or a selection effect, whereby applicants file continuations on their more valuable inventions.[51]

6 Conclusion

This article shows how continuation applications are used to obtain protection for technology developed after a patent application is filed. Although the practice is well-known among patent attorneys and policymakers, empirical evidence on the incidence of late-claiming was limited due to measurement challenges. We exploit the disclosure of SEPs during the ICT

[51] Table A22 uses similar regression models and data from Kogan et al. (2017) to show that delays in claim drafting relative to standard publication are positively correlated with their measure of patent value (which is based on stock-price event studies around patent issuance).

standardization process to link patents with a potentially infringing technology, and then measure the association between resolution of uncertainty (i.e. standard publication) and the use of continuation applications.

We find that more than half of the SEPs in our sample are filed after standard publication, typically via continuation applications. Moreover, there is a large increase in continuation filings immediately after a standard is published. This effect is larger for more lenient examiners, and for applicants that seek to license their SEP portfolios. We show that keywords in SEP claims become more similar after a standard is published, and that post-standard continuations are more likely to receive non-statutory double patenting rejections. Finally, we find that continuation applications and delays in patent filing relative to standard publication are associated with more litigation.

From a welfare perspective, continuations present a complex tradeoff. By helping applicants obtain broader or stronger patents at reasonable cost, continuations can increase innovation incentives. The option to abandon some claims and refine others is especially valuable to applicants facing high levels of uncertainty, such as startups or inventors of very novel technologies. At the same time, continuations increase uncertainty about the actual scope of patent protection. Unexpected changes in patent scope increase the likelihood of accidental infringement, reduce incentives to invent around patents, and create a holdup threat that can increase the costs of technology adoption.

Our findings highlight the potential for opportunistic use of continuations. Proponents of continuation practice would argue that opportunism requires any new claims to exceed the boundaries of the original invention disclosure, and that it is the examiner's job to enforce that boundary. On the other hand, that argument begs the question of whose idea was embodied in the new claims, and why they were not part of the parent application? In a highly collaborative context, such as an SSO, continuations filed after publication of a standard might easily claim ideas for which others deserve at least a share of the credit. Moreover, some SSOs (including ETSI, the largest in our sample) encourage early disclosure of patents and specify procedures for removing or designing around patented technology when a FRAND commitment cannot be obtained. Such policies suggest that SSOs would prefer more clarity about claim scope during the specification drafting process — a goal that is undermined by continuations filed after standards are published.

Looking forward, the main challenge for assessing welfare effects is to quantify how continuations reallocate rents between generations of innovators, along with the consequences for innovation and competition. Whether continuations increase the costs of implementation and follow-on innovation, and whether those costs outweigh any benefits from earlier invention disclosure or greater *ex ante* investment is ultimately an empirical question that we leave for future research.

Nevertheless, there are several policy options that might be used to limit the downsides of opportunistic continuation practice without completely removing an applicant's option to delay claim drafting. For example, the USPTO could adjust its fee schedule or adopt a rule to limit the use of lengthy continuation "chains." The FTC has previously espoused intervening-user rights that protect infringers who can show that they adopted the claimed technology before a continuation application was filed. U.S. courts can guard against opportunism by relying on the doctrine of prosecution laches, which renders a patent unenforceable if a patentee's delay in prosecution was "unreasonable and inexcusable under the totality of circumstances."[52] With respect to SEPs, moreover, SSOs could adopt similar rules as part of their intellectual property policies.

Although we believe such proposals have merit, we also acknowledge that it is not easy to predict the behavior of patentees or standards developers under counter-factual policies meant to limit opportunistic continuation practice. We might see original applications containing a multitude of vague claims, or a surge in last-minute applications filed just before standards are finalized. On the other hand, if patent scope were more predictable, standards developers would have stronger incentives to consider infringement when making design de-

[52]The legal standard for prosecution laches is spelled out in *Cancer Research Technology Ltd. v. Barr Laboratories, Inc* (625 F.3d 724, Fed. Cir. 2010).

cisions instead of (as some observers claim) leaving the entire problem for patent litigators to sort out long after the standards are adopted.

Finally, it is important to recognize that continuations are not the only way to delay claim drafting and issuance. U.S. applicants can use other tools, such as provisional applications or requests for continued examination. In jurisdictions where continuations are not available, applicants can use divisionals or deferred examination. Further research is needed to understand how inventors use all of these tools, individually and in combination, to manage the tradeoff between filing early to obtain priority and delaying in order to draft stronger claims.

References

Arts, S., Cassiman, B., and Gomez, J. C. (2018). Text matching to measure patent similarity. *Strategic Management Journal*, 39(1):62–84.

Baron, J. and Gupta, K. (2018). Unpacking 3GPP standards. *Journal of Economics and Management Strategy*, 27(3):433–461.

Baron, J. and Pohlmann, T. (2018). Mapping standards to patents using declarations of standard-essential patents. *Journal of Economics and Management Strategy*, 27(3):504–534.

Baron, J. and Spulber, D. (2018). Technology standards and standard setting organizations: Introduction to the Searle Center Database. *Journal of Economics and Management Strategy*, 27(3):462–503.

Bekkers, R., Catalini, C., Martinelli, A., Righi, C., and Simcoe, T. (2017). Disclosure rules and declared essential patents. *NBER Working Paper 23627*.

Bekkers, R., Martinelli, A., and Tamagni, F. (2020). The impact of including standards-related documentation in patent prior art: Evidence from an EPO policy change. *Research Policy*, 49(7):104007.

Berger, F., Blind, K., and Thumm, N. (2012). Filing behaviour regarding essential patents in industry standards. *Research Policy*, 41(1):216–225.

Borusyak, K., Jaravel, X., and Spiess, J. (2021). Revisiting event study designs: Robust and efficient estimation. *Working Paper*.

Brachtendorf, L., Gaessler, F., and Harhoff, D. (2019). Approximating the standard essentiality of patents – a semantics-based analysis. *Working Paper*.

Callaway, B. and Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics*, 225(2):200–230.

Chabé-Ferret, S. (2017). Should we combine difference in differences with conditioning on pre-treatment outcomes? *Working Paper*.

Chiang, T.-J. (2010). Fixing patent boundaries. *Michigan Law Review*, 108(4):523–576.

Cockburn, I. M., Kortum, S., and Stern, S. (2002). Are all patent examiners equal? The impact of examiner characteristics. *NBER Working Paper 8980*.

Cohen, W. M., Nelson, R. R., and Walsh, J. P. (2000). Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not). *NBER Working Paper 7552*.

Cooter, R. D. and Rubinfeld, D. L. (1989). Economic analysis of legal disputes and their resolution. *Journal of Economic Literature*, 27(3):1067–1097.

Correia, S. (2016). Linear models with high-dimensional fixed effects: An efficient and feasible estimator. *Working Paper*.

Cotropia, C. and Quillen, C. (2019). Continuing patent applications and performance of the U.S. patent and trademark office as of fiscal year 2018. *Richmond School of Law Intellectual Property Institute Research Paper*, No. 2019-01.

de Chaisemartin, C. and D'Haultfœuille, X. (2020a). Difference-in-differences estimators of intertemporal treatment effects. *Working Paper*.

de Chaisemartin, C. and D'Haultfœuille, X. (2020b). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review*, 110(9):2964–96.

Feng, J. and Jaravel, X. (2020). Crafting intellectual property rights: Implications for patent assertion entities, litigation, and innovation. *American Economic Journal: Applied Economics*, 12(1):140–81.

Frakes, M. D. and Wasserman, M. F. (2015). Does the US patent and trademark office grant too many bad patents: Evidence from a quasi-experiment. *Stanford Law Review*, 67(3):613–676.

Frakes, M. D. and Wasserman, M. F. (2016). Patent office cohorts. *Duke Law Journal*, 65(8):1601–1655.

Frakes, M. D. and Wasserman, M. F. (2017). Is the time allocated to review patent applications inducing examiners to grant invalid patents? evidence from microlevel application data. *Review of Economics and Statistics*, 99(3):550–563.

Frakes, M. D. and Wasserman, M. F. (2021). Knowledge spillovers, peer effects, and telecommuting: Evidence from the US Patent Office. *Journal of Public Economics*, 198:104425.

Freilich, J. (2020). The replicability crisis in patent law. *Indiana Law Journal*, 95(2):431–483.

FTC (2003). To promote innovation: a proper balance of competition and patent law and policy. Report, U.S. Federal Trade Commission.

FTC (2011). The evolving IP marketplace: Aligning patent notice and remedies with competition. Technical report, U.S. Federal Trade Commission.

Glazier, S. C. (2003). *Patent Strategies for Business*. LBI Law & Business Institute, Washington D.C.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2):254–277.

Graham, S. J. (2004). Behind the patent's veil: Innovators' uses of patent continuation practice, 1975-2002. *Working Paper*.

Graham, S. J., Marco, A. C., and Miller, R. (2018). The USPTO patent examination research dataset: A window on patent processing. *Journal of Economics & Management Strategy*, 27(3):554–578.

Graham, S. J. and Mowery, D. C. (2004). Submarines in software? continuations in US software patenting in the 1980s and 1990s. *Economics of Innovation and New Technology*, 13(5):443–456.

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

Hall, B. H. and Ziedonis, R. H. (2001). The patent paradox revisited: an empirical study of patenting in the US semiconductor industry, 1979-1995. *RAND Journal of Economics*, 32(1):101–128.

Harhoff, D. (2016). Patent quality and examination in europe. *American Economic Review: Papers & Proceedings*, 106(5):193–97.

Harhoff, D., Scherer, F. M., and Vopel, K. (2003). Citations, family size, opposition and the value of patent rights. *Research Policy*, 32(8):1343–1363.

Hegde, D., Mowery, D. C., and Graham, S. J. (2009). Pioneering inventors or thicket builders: Which US firms use continuations in patenting? *Management Science*, 55(7):1214–1226.

Hovenkamp, H. and Bohannan, C. (2011). *Creation without Restraint: Promoting Liberty and Rivalry in Innovation*. Oxford University Press.

Jaffe, A. B. and Lerner, J. (2004). *Innovation and its discontents : how our broken patent system is endangering innovation and progress, and what to do about it*. Princeton University, Princeton, NJ.

Kang, B. and Bekkers, R. (2015). Just-in-time patents and the development of standards. *Research Policy*, 44(10):1948–1961.

Kang, B. and Motohashi, K. (2015). Essential intellectual property rights and inventors' involvement in standardization. *Research Policy*, 44(2):483–492.

Kogan, L., Papanikolaou, D., Seru, A., and Stoffman, N. (2017). Technological innovation, resource allocation, and growth. *Quarterly Journal of Economics*, 132(2):665–712.

Kuhn, J. M. (2016). Property rights and frictions in the sale of patents. *Working Paper*.

Kuhn, J. M. and Thompson, N. C. (2019). How to measure and draw causal inferences with patent scope. *International Journal of the Economics of Business*, 26(1):5–38.

Lanjouw, J. O. and Lerner, J. (1998). The enforcement of intellectual property rights: a survey of the empirical literature. *Annales d'Economie et de Statistique*, 49/50:223–246.

Layne-Farrar, A. (2011). Assessing IPR disclosure within standard setting: An ICT case study. *Working Paper*.

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

Lemley, M. A. and Moore, K. A. (2004). Ending abuse of patent continuations. *Boston University Law Review*, 84(1):63–123.

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

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

Lemley, M. A. and Simcoe, T. (2019). How essential are standard-essential patents? *Cornell Law Review*, 104:607–641.

Lerner, J. and Tirole, J. (2015). Standard-essential patents. *Journal of Political Economy*, 123(3):547–586.

Levin, R. C., Klevorick, A. K., Nelson, R. R., Winter, S. G., Gilbert, R., and Griliches, Z. (1987). Appropriating the returns from industrial research and development. *Brookings papers on economic activity*, 1987(3):783–831.

Lu, Q., Myers, A., and Beliveau, S. (2017). USPTO patent prosecution research data: Unlocking office action traits. *Working Paper*.

Malani, A. and Reif, J. (2015). Interpreting pre-trends as anticipation: Impact on estimated treatment effects from tort reform. *Journal of Public Economics*, 124:1–17.

Marco, A. C. and Miller, R. (2019). Patent examination quality and litigation: Is there a link? *International Journal of the Economics of Business*, 26(1):65–91.

Marco, A. C., Sarnoff, J. D., and deGrazia, C. (2019). Patent claims and patent scope. *Research Policy*, 48(9):103790.

Matutes, C., Regibeau, P., and Rockett, K. (1996). Optimal patent design and the diffusion of innovations. *RAND Journal of Economics*, 27(1):60–83.

Menell, P. and Meurer, M. (2013). Notice failure and notice externalities. *Journal of Legal Analysis*, 5(1):1–59.

Nagaoka, S., Tsukada, N., and Shimbo, T. (2009). The structure and the emergence of essential patents for standards: Lessons from three IT standards. In Cantner, U., Gaffard, J.-L., and Nesta, L., editors, *Schumpeterian Perspectives on Innovation, Competition and Growth*, pages 435–450. Springer, Berlin Heidelberg.

Putnam, J. (1996). The value of international patent protection. *Unpublished Ph. D. Dissertation, Yale University*.

Righi, C. (2022). Continuation patents and litigation. *Working Paper*.

Righi, C. and Simcoe, T. (2019). Patent examiner specialization. *Research Policy*, 48(1):137–148.

Roin, B. N. (2005). The disclosure function of the patent system (or lack thereof). *Harvard Law Review*, 118(6):2007–2028.

Rysman, M. and Simcoe, T. (2008). Patents and the performance of voluntary standard-setting organizations. *Management Science*, 54(11):1920–1934.

Sampat, B. and Williams, H. L. (2019). How do patents affect follow-on innovation? evidence from the human genome. *American Economic Review*, 109(1):203–236.

Seymore, S. B. (2009). The teaching function of patents. *Notre Dame Law Review*, 85(2):621–669.

Shapiro, C. (2001). Navigating the patent thicket: Cross licenses, patent pools, and standard setting. In Jaffe, A. B., Lerner, J., and Stern, S., editors, *Innovation Policy and the Economy*, volume 1, pages 119–150. MIT press, Cambridge, MA.

Simcoe, T. (2012). Standard setting committees: Consensus governance for shared technology platforms. *American Economic Review*, 102(1):305–36.

Simcoe, T. S., Graham, S. J., and Feldman, M. P. (2009). Competing on standards? entrepreneurship, intellectual property, and platform technologies. *Journal of Economics & Management Strategy*, 18(3):775–816.

Sun, L. and Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, 225(2):175–199.

Wuchty, S., Jones, B. F., and Uzzi, B. (2007). The increasing dominance of teams in production of knowledge. *Science*, 316(5827):1036–1039.

Ziedonis, R. H. (2004). Don't fence me in: Fragmented markets for technology and the patent acquisition strategies of firms. *Management Science*, 50(6):804–820.

Online Appendix

This Appendix reports a number of supplemental results and robustness checks.

A.1 Descriptive statistics

Here we provide additional information on our data. Figures A1 and A3 show results similar to those in Figures 2 and A2 using an alternative definition of SEP that includes only the patents and patent applications that are specifically mentioned in SSO disclosure letters (i.e. excluding undeclared U.S. family members of declared SEPs). Unreported versions of Figure 2 that use only granted patents or a 1-to-1 match between SEPs and control applications on filing month and technology center are almost identical to the figure reported in the text. For the latter version, we do not limit the control group to patents in Computers and Communications and pick a control at random if multiple controls are available. Unreported versions of Figure 2 that use only either SEPs linked to ETSI or SEPs linked to other SSOs are also very similar.

A.2 Patent examination and continuations

Do patent applicant file continuations to respond to rejections? Or do applicants rather use continuations to obtain additional claims after they receive a first patent? To study these questions, we analyze a sample of SEPs and controls matched on art unit, examiner, and filing year (all filed as original applications), and compute some simple statistics on examination and continuation filings. We focus on three important office actions issued by the patent examiners: the first non-final rejection, the first final rejection, and the first notice of allowance. We also use information only on the first continuation of an application.

For each office action, we report three statistics. First, we compute the percentage of applications that receive the office action. Second, conditional on receiving the office action, we compute the probability of filing the first continuation within six months from the date of the office action.[1] Third, conditional on generating a continuation, we compute the probability that the first continuation is filed within six months from the date of the office action. We report these statistics for the SEPs and the matched controls in Table A2.

Most patent applications receive a non-final rejection, and more than half receive a final rejection. However, as Table A2 clearly shows, the probability that an applicant files the first continuation after a rejection is relatively low. Even if SEPs are more likely than the controls to have a continuation after a rejection, the differences are small. The Table also shows that the probability of filing a continuation is much higher after a notice of allowance, and it is particularly high for SEPs. SEPs are also more likely to be granted by the patent office, a result probably due to the importance or innovativeness of the underlying technology or to higher investments in prosecution. Finally, the SEPs are less likely than the controls to have their first continuation after the first notice of allowance. There are several potential explanations. As we saw above, the SEPs are more likely to generate

[1] We use a six-month window because applicants have three months to reply to a rejection, and can obtain up to three more months paying a fee. Failure to reply to rejections within the specified period implies the abandonment of the application.

continuations after rejections. Moreover, the first continuation may be filed immediately after the publication of the relevant standard, without waiting for the end of the examination of the parent application. Furthermore, SEPs are also more likely to generate other types of child applications (e.g. continuations-in-part or divisionals) and the first continuation may follow one of these filings.[2]

These results suggest that the primary use of continuations is to prolong the prosecution of an application after a first patent is allowed. Then, it is natural to ask whether applicants use continuations when the examiner grants a patent but also narrows significantly the claims throughout examination. We analyze this question focusing on a sample of SEPs filed as original applications that are eventually granted. Table A3 reports the results of two linear probability models in which we regress an indicator equal to one if a SEP generates a continuation (multiplied by 100) against two measures of patent scope change from the published application to the granted patent: (i) the change in the number of independent claims (Marco et al., 2019), and (ii) the change in the length of the first independent claim (Kuhn and Thompson, 2019). The regressions also control for filing year, issue year, art unit, and examiner effects.

We do not find a clear relationship between claim narrowing and continuations. On the one hand, the first regressions shows that an increase in the number of independent claims (i.e. an increase in scope) is negatively correlated with the probability of continuation filing. On the other hand, the results of the second model indicate that an increase in the length of the first independent claim (i.e. a decrease in scope) is negatively correlated with the probability of continuation filing.

Overall, these results suggest that the primary use of continuations is to add new claims after the allowance of a first patent, rather than to respond to rejections or to react to claim narrowing.

A.3 Difference in differences models

The following discussion provides further details regarding estimation of the robustness checks described in Section 4.6 of the article, with results presented below in Tables A4 through A18 and Figures A4 through A6.

In Table A4, we consider an alternative sample. Instead of defining SEPs to include all U.S. family members (i.e. applications sharing a common priority) of any patent declared to an SSO, we limit the definition of SEP to include *only* patents or patent applications explicitly mentioned in a disclosure letter to an SSO. Our main results also keep applications in the sample until the last member of their U.S. patent family is pending, so applications with more children are at risk of continuation for longer. In the robustness check, we use only the focal application's pendency at the patent office to define the time at risk of continuations, discarding the pendency of its children. Similarly, we use only the pendency of the earliest

[2] Unreported regressions that control for art unit, examiner, and filing year confirm that, conditional on receiving the relevant office action, SEPs are more likely to generate a continuation than the controls. The magnitude of the coefficients is similar to the difference between the percentages reported in Table A2. We also estimate two linear probability models, for the SEPs and the controls separately, that estimate the correlation between receiving the three office actions and continuation filing, controlling for art unit, examiner, and filing year. In both models, receiving a notice of allowance has by far the largest coefficient.

filing of each non-SEP patent family for the control group. In this alternative sample, the coefficients on $PostStandard_{it} \times SEP_i$ are similar to those in our main results.

In Table A5, we re-estimate the main DID models using information on all types of child applications, i.e. including also continuations-in-part, divisionals, and reissues. In general, these applications also provide opportunities for strategic behavior, although they are used less frequently, in different ways, or do not protect exactly the same invention claimed in the original filing. Nevertheless, we find similar results when we use also information for these other types of child applications for the analysis.

In Table A6, we control for a number of observable application characteristics that may be related to SEP status and to the propensity to file continuations. Continuations are a relatively rare outcome, so the application fixed effects and matching on pre-standard continuations may not capture well differences among applications in terms of value or prosecution strategies. In order to address this concern at least partially, we re-estimate the cross-sectional models in the main analysis and the previous robustness checks adding to the specifications control variables for the scope of the application (number of independent claims and average length of the independent claims), number of inventors (which is correlated with invention quality (Wuchty et al., 2007)), dummies for applications that claim priority to provisional and PCT applications (which should partially capture investments in prosecution prior to the filing date of the focal application), as well as dummies for applications filed by small entities and those that claim priority to foreign applications (to control for the type of applicant).[3] Table A6 shows that the results for these models are similar to those reported previously.

In Tables A7, instead of matching on pre-standard trends, we control for the anticipation effects of standard publication. Specifically, we include in our regressions four leads of an indicator equal to one for the SEPs in the quarter of standard publication. Under the assumption that standard publication is exogenous, these leads capture the anticipation effects (Malani and Reif, 2015). The results show that, although there are relatively large anticipation effects in the quarter before standard publication, the coefficients on $PostStandard_{it} \times SEP_i$ are similar to those in our main analysis.

Tables A8–A10 consider an alternative specification based on a piecewise constant hazard model, using samples similar to those for the main analysis and for the previous robustness checks. In these regressions, the outcome is the probability of continuation conditional on not having any prior continuations, and an application is removed from the sample after the first period in which any continuation is filed. We also repeat this exercise using information on all child applications.[4] In all models (Tables A8–A10), SEPs have a higher baseline hazard of continuation or child application, and standard publication has a positive and large correlation with the probability of filing the first continuation or the first child application.

[3]The USPTO defines as small entities independent inventors, companies with less than 500 employees and nonprofit organizations. These applicants have substantial discounts on various USPTO fees.

[4]The samples for Table A8 and Table A10 are constructed using the definition of SEP used in the main analysis, and contains all SEPs filed before the quarter of standard publication and controls in the same art-unit-examiner-filing-quarter group of the SEPs. We keep applications in the sample until the earliest of (i) the filing of the first continuation (Table A8) or child application (Table A10), (ii) family disposal, or (iii) the end of year 2016. The sample for Table A9 is similar but, as in Table A4, uses the narrower definition of SEP and information on standards and pendency of the earliest application in each family.

Tables A11 through A13 provide results based on models similar to those in the main analysis and in the previous robustness checks using samples that contain only SEPs filed before standard publication. That is, we discard the control group and estimate models that are identified based on variation in the timing of standard publication within the SEP sample. The coefficients of $PostStandard_{it}$ are smaller in magnitude and sometimes estimated less precisely than those in the rest of the analysis. Nevertheless, standard publication is associated with an increase in continuation filings statistically significant at conventional levels in all but two of these specifications. The results for the models of child application are similar but the coefficients are generally smaller and estimated less precisely. This may be due simply to the lower opportunities for strategic use of continuations-in-part, divisionals, and reissues.

We also estimate models that control for time-varying technology-area shocks that may drive both standardization and continuation filings. Table A14 shows the results of models similar to those in Table 1 where we interact the calendar quarter indicators with art-unit, art-unit-by-filing-quarter, or art-unit-by-filing-quarter-by-examiner effects to capture time-varying shocks that may affect groups of similar technologies. The results are similar to those in the main analysis.

To check whether the availability of blanket disclosures at many SSOs affects our results, in Table A15 we analyze our data dividing the SEPs into two groups: those linked to ETSI and those linked to other SSOs. ETSI is by far the largest SSO in our data and has a policy of mandatory disclosure, whereas the other SSOs in our sample usually demand licensing commitments without the need of identifying specific patents. The results for ETSI are very similar to those in the main analysis. This is not surprising, because most SEPs in our sample are linked to ETSI standards. The results for the non-ETSI SEPs are qualitatively similar, although less precise, probably because of the small sample size.

We also check the robustness of our main results with a set of models that address the concerns related to the potential problems of difference-in-differences designs with variation in treatment timing when treatment effects are heterogeneous (Goodman-Bacon, 2021).

de Chaisemartin and D'Haultfœuille (2020b) show that the classic difference-in-differences model estimated with a linear regression with period and group fixed effects may produce negative weights for some group-periods, leading to biased estimates if the treatment effect is not constant across groups or periods. To understand how serious this problem is in our analysis, we compute the weights attached to our main two-way-fixed-effects regressions (columns 3 and 6 of Table 1) using the tool provided by de Chaisemartin and D'Haultfœuille (2020b).

Because calculating the weights produced by the regression on our full sample of SEPs and controls is computationally very demanding, for the first set of weights we use the 1 to 1 matched sample where each SEP is matched with a control picked at random in the same art-unit-examiner-filing-quarter. We re-estimate the regression in column (3) of Table 1 using this sample and find that a significant share (18%) of the weights is negative. On the other hand, only 4% of the weights produced by the regression in column (6) of Table 1 are negative. Next, we re-estimate these models using the estimator proposed by de Chaisemartin and D'Haultfœuille (2020b), which is valid even if the treatment effect is heterogeneous over time or across groups. The results are in columns (1) and (3) of Table A16. Under a common trends assumption, these models estimate the instantaneous effect of standard publication on continuation filings, and produce coefficients very similar to those of our main event study specifications for the period of standard publication. In columns (2) and (4), we also estimate placebo effects for the pre-standard period, as well as dynamic effects using the estimator proposed by de Chaisemartin and D'Haultfœuille (2020a). These specifications are demanding to estimate, therefore we only estimate placebos for the year preceding standard publication and dynamic effects up to four quarters after standard publication. The results are again similar to those in the main analysis.

Callaway and Sant'Anna (2021) propose an estimator of the group-time average treatment effects for staggered difference-in-differences designs that can be used to construct more aggregated parameters. Implementing the Callaway and Sant'Anna (2021) estimator with our large sample is computationally difficult, hence for this piece of analysis we use two random subsamples of 500 matched SEP-control pairs from our two main analysis samples. In Table A17 we report the weighted average of all group-time average treatment effects (with weights proportional to group size) obtained with this new estimator. The estimated effects of standard publication are even larger in magnitude than those in the main analysis. To check the robustness of our event study, in Figure A4 we plot the average effects across different lengths of exposure to the treatment for a seventeen quarter window centered around standard publication. The results are similar to those in the main analysis, although the estimates of the dynamic effects are less precise because of the smaller samples used.[5]

Sun and Abraham (2021) show that, when there is variation in treatment timing and effects are heterogeneous, the estimates for a given time period from the standard event study specification may be contaminated by effects from other periods. They also propose an estimator that is free from contamination. We use this estimator to check the robustness of our event-study specifications in Figure 4 and report the results in Figure A5. The estimates are similar.

Finally, we check the robustness of the results by implementing the "imputation estimator" proposed by Borusyak et al. (2021). In Table A18 we report the results of the models in Table 1 estimated with the imputation estimator. The estimates are similar to those in the main analysis. We also estimate event study specifications similar to those for Figure 4 where instead of the β_τ's we estimate the pre-trends and the horizons in a window of seventeen quarters centered around standard publication. We plot these estimates in Figure A6. The results are similar to those in the main analysis, although the pre-standard increase in continuations estimated by the imputation estimator is more marked when we use the application fixed effects in the full sample of SEPs and controls.

A.4 Other results for ETSI vs. other SSOs

Tables A19-A21 re-estimate the models in Section 5 dividing the SEPs into those linked to ETSI and those linked to other SSOs. As above, the results for ETSI are very similar to those in the main analysis. Relatively few SEPs are linked to other SSOs. As a result, the estimates for these subsamples are much less precise.

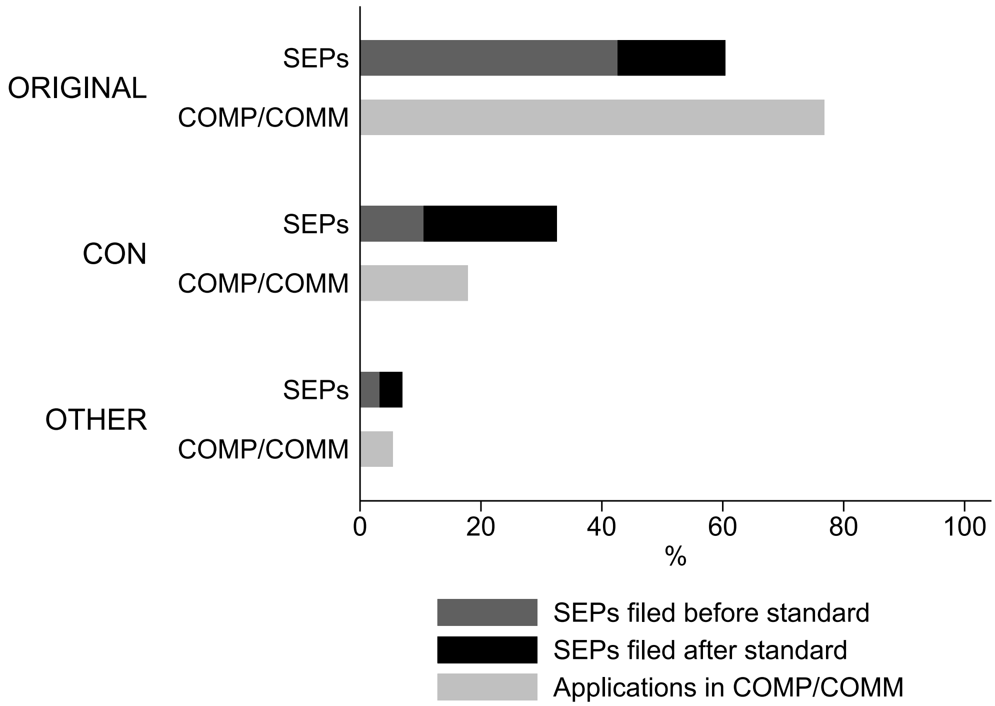
[5] We use the "doubly robust" approach to compute the group-time average treatment effects and the "never treated" as the control group. We do not include controls for age or post-standard periods in these models because the software to implement the Callaway and Sant'Anna (2021) estimator is particularly sensitive to collinearity issues.

A.5 Filing lag and patent private value

In Table A22, we report the results of an analysis of the relationship between patent value estimates based on stock market event studies and the timing of SEP filing relative to standard publication. For this analysis, we match our data on SEPs with the June 8, 2021 update of the Kogan et al. (2017) data, which contains information up to year 2020. The specifications are analogous to those we use for the litigation analysis, but use the natural logarithm of real patent value as outcome variable. The results are consistent with the idea that delays in claim drafting, and continuations in particular, are positively correlated with an increase in the private value of patents.

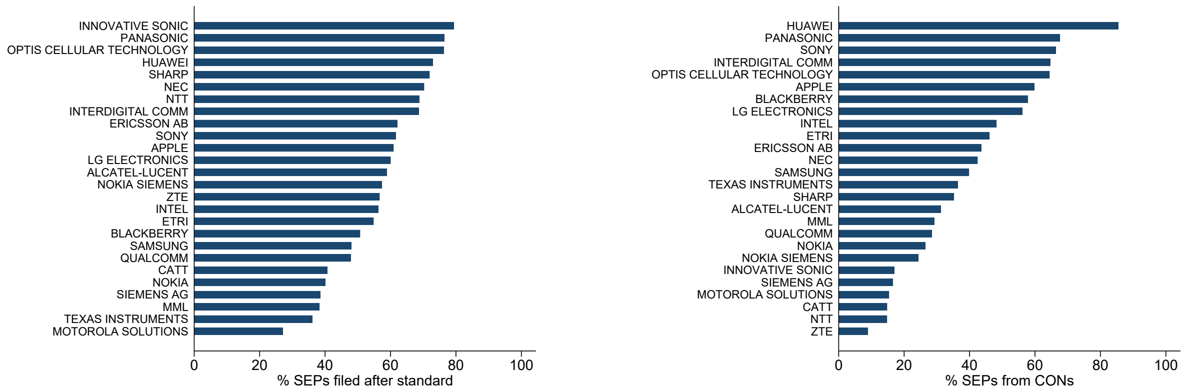
Columns (1) and (2) show that SEPs filed after standard publication are more valuable than those filed before: the value of post-standard SEPs is 18% higher, and a one-year change in the application filing lag relative to standard publication is associated with an increase in patent value of 8%. Columns (3) and (4) compare SEPs from original applications and SEPs from continuations, adding a continuation indicator and its interactions with the measures of timing of filing relative to standard publication. As in the analogous models for the litigation analysis, it is hard to disentangle the relationship between patent value, use of continuations, and filing delays, because most continuations are filed after standard publication. Nevertheless, post-standard continuations have a higher value, and the increase in patent value associated with filing lags relative to standard publication is higher for continuations.

Figure A1: Frequency and timing of SEP continuations, narrower definition of SEP



Notes. The sample contains utility patent applications filed on or after November 29, 2000. Percentages based on 15,695 SEPs and 1,447,286 (non-SEP) applications processed by Technology Centers 2100, 2400 and 2600. SEPs include U.S. utility patent applications declared essential for a standard. Pre- and post-standard SEPs defined using the earliest standard linked to a SEP. Non-SEP applications are U.S. utility patent applications that are not in the patent family of a declared SEP.

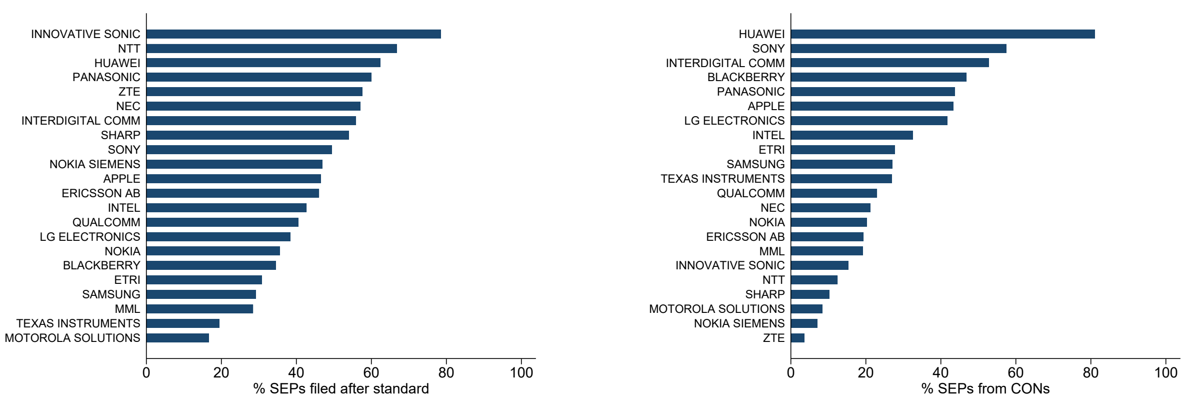
Figure A2: Owners of SEPs (declared SEPs and their family members)



(a) SEPs filed after standard (b) SEPs filed as CONs

Notes. The figure reports the percentage of SEPs owned by each company that are filed after standard publication (panel a) or that are filed as continuations (panel b). The sample contains utility patent applications filed on or after November 29, 2000. SEPs include U.S. utility patent applications declared essential for a standard, as well as all their parent and child applications. Pre- and post-standard SEPs defined using the earliest standard linked to a family of SEPs. The figure reports only companies with at least 100 SEPs.

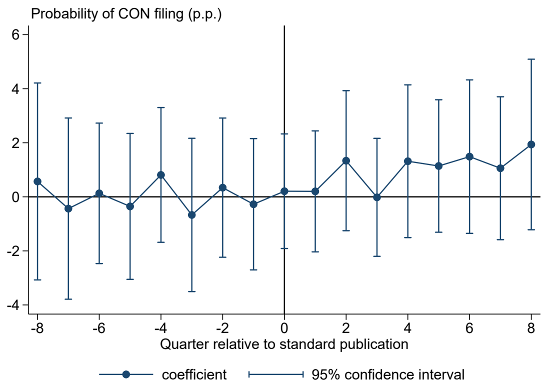
Figure A3: Owners of SEPs (only declared SEPs)



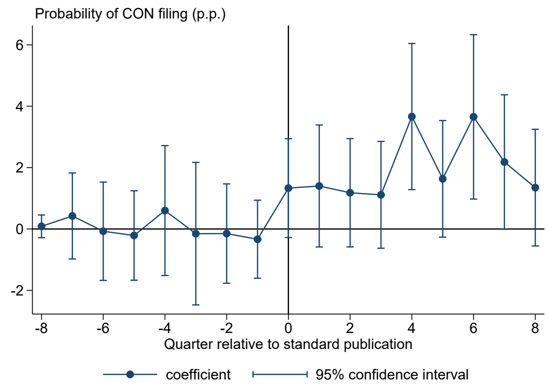
(a) SEPs filed after standard (b) SEPs filed as CONs

Notes. The figure reports the percentage of SEPs owned by each company that are filed after standard publication (panel a) or that are filed as continuations (panel b). The sample contains utility patent applications filed on or after November 29, 2000. SEPs include U.S. utility patent applications declared essential for a standard. Pre- and post-standard SEPs defined using the earliest standard linked to a SEPs. The figure reports only companies with at least 100 SEPs.

Figure A4: Continuation filings around standard publication, Callaway and Sant'Anna (2021)



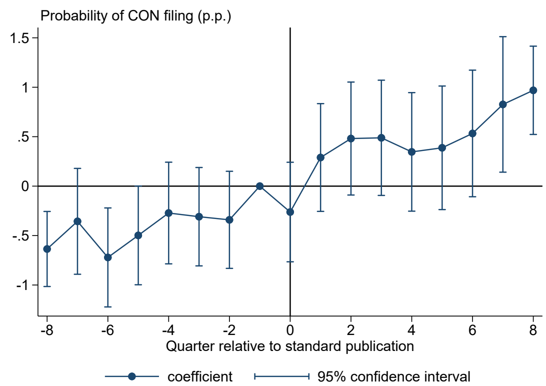
(a) SEPs and random controls



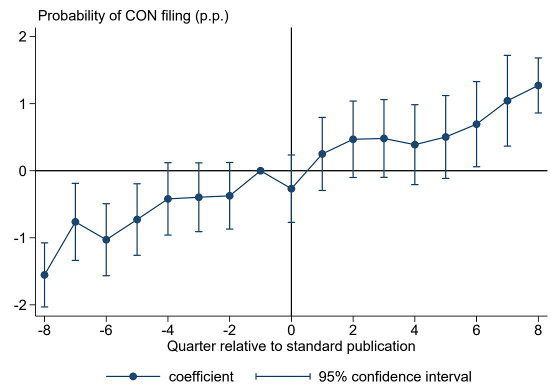
(b) SEPs and CON matched controls

Notes. Each panel plots the dynamic effects of standard publication and their 95% confidence intervals estimated using the method proposed by Callaway and Sant'Anna (2021) in a seventeen quarter window centered around standard publication. Panel (a) uses the estimates from model (1) in Table A17. Panel (b) uses the estimates for model (2) in Table A17.

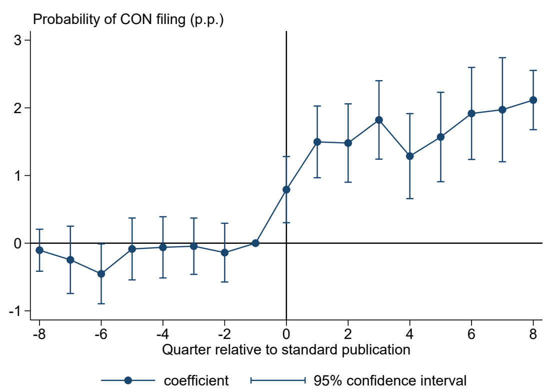
Figure A5: Continuation filings around standard publication, Sun and Abraham (2021)



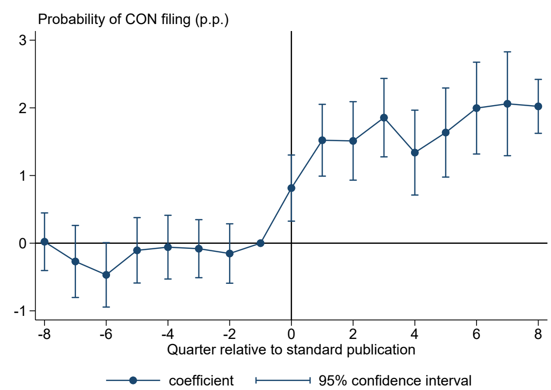
(a) SEPs and random controls



(b) SEPs and random controls (FE)



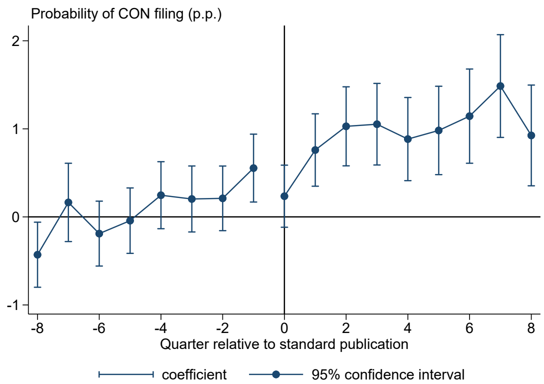
(c) SEPs and CON matched controls



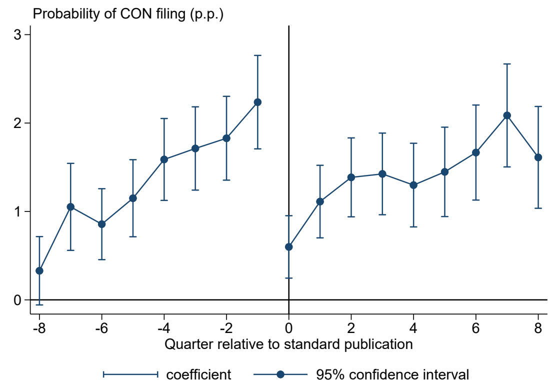
(d) SEPs and CON matched controls (FE)

Notes. Each panel plots the β_τ's and their 95% confidence intervals from an event study based on Equation 2 estimated using the method proposed by Sun and Abraham (2021). Models for panels (a) and (b) are estimated on a 1 to 1 matched subsample of the sample for models (1)-(3) in Table 1 where each SEP is matched with a control in the same art-unit-examiner-filing-quarter picked at random. Models for panels (c) and (d) are estimated on the sample for models (4)-(6) in Table 1. Panels (a) and (c) report the estimates for pooled cross-sectional models. Panels (b) and (d) report the estimates for the models with application fixed effects.

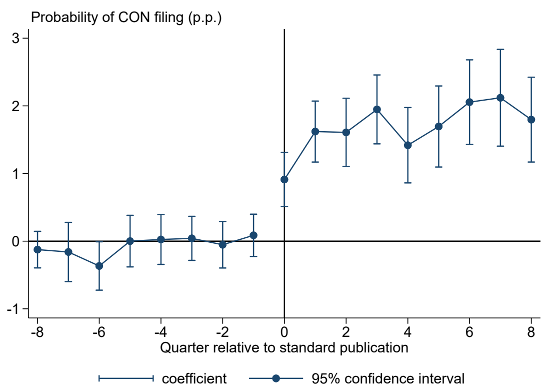
Figure A6: Continuation filings around standard publication, Borusyak et al. (2021)



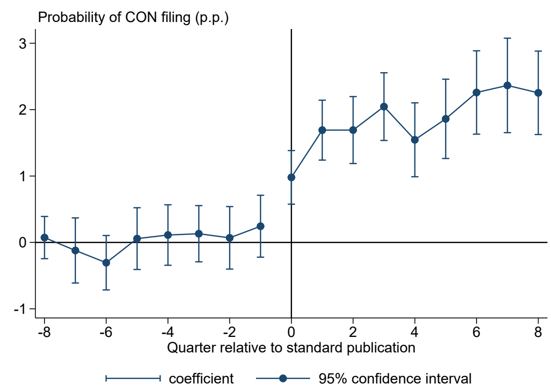
(a) SEPs and controls



(b) SEPs and controls (FE)



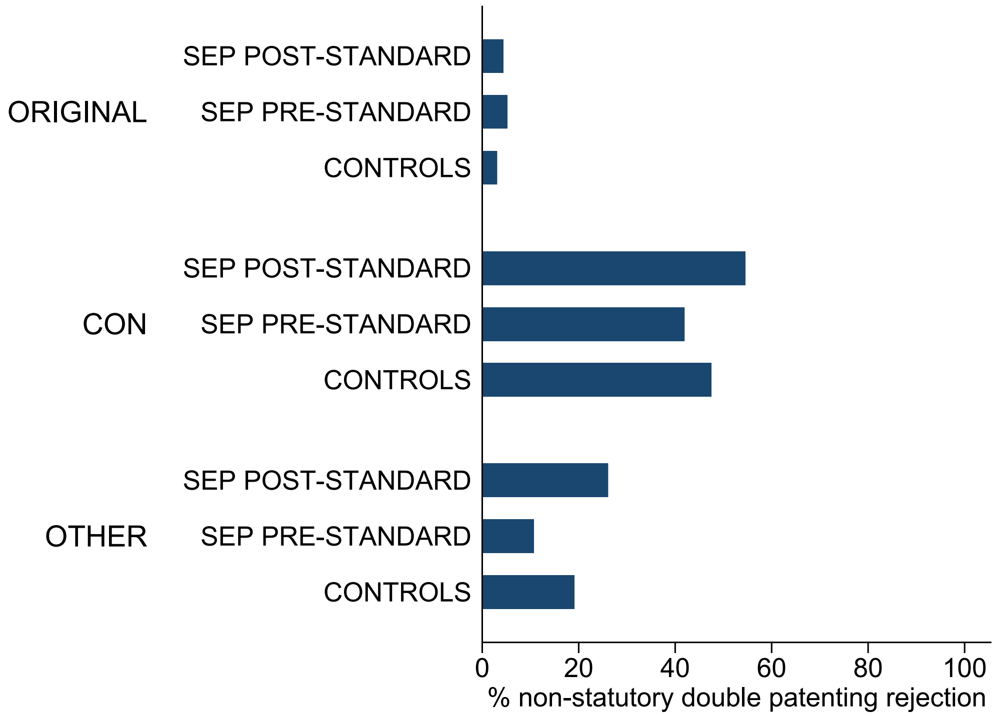
(c) SEPs and CON matched controls



(d) SEPs and CON matched controls (FE)

Notes. Each panel plots the dynamic effects of standard publication and their 95% confidence intervals from an event study estimated using the method proposed by Borusyak et al. (2021). We estimate models similar to Equation 2 but, instead of the β_τ's, we estimate the pre-trends and the horizons in a seventeen quarter window centered around standard publication. Models for panels (a) and (b) are estimated on the sample for models (1)-(3) in Table 1. Models for panels (c) and (d) are estimated on the sample for models (4)-(6) in Table 1. Panels (a) and (c) report the estimates for pooled cross-sectional models. Panels (b) and (d) report the estimates for the models with application fixed effects.

Figure A7: Non-statutory double patenting rejections



Notes. The sample contains 22,204 utility patent applications filed after year 2007 and disposed before July 2017. We match SEPs and non-SEPs ("controls") on art unit, examiner, filing year and type of application (CON, original, or the residual category "other"). SEPs include U.S. utility patent applications declared essential for a standard, as well as all their parent and child applications. Pre- and post-standard SEPs defined using the earliest standard linked to a family of SEPs. Non-SEP applications are U.S. utility patent applications that are not in the patent family of a declared SEP. We match one-to-one, without replacement and breaking ties at random, matching 94% of the SEPs in the sample period with information on the standard publication date. The final sample contains 10,588 CONs (4,548 post-standard SEPs, 746 pre-standard SEPs and 5,294 controls), 10,476 original applications (1,765 post-standard SEPs, 3,473 pre-standard SEPs and 5,238 controls), and 1,140 applications in the residual category "other" (402 post-standard SEPs, 168 pre-standard SEPs and 570 controls).

Table A1: Summary statistics for SEPs and controls in the main analysis sample

	N	Mean	SD	Min	1^{st} Q	Median	3^{rd} Q	Max
CON	959,733	0.012	0.110	0.000	0.000	0.000	0.000	1.000
CONs	959,733	0.013	0.166	0.000	0.000	0.000	0.000	98.000
PostStandard × SEP	959,733	0.086	0.281	0.000	0.000	0.000	0.000	1.000
SEP	959,733	0.137	0.343	0.000	0.000	0.000	0.000	1.000
Age	959,733	10.425	8.580	0.000	4.000	9.000	15.000	64.000
Ind. claims	884,347	3.937	2.879	0.000	2.000	3.000	4.000	76.000
Words per ind. claim	883,852	115.338	85.697	7.000	75.833	101.200	136.500	4,535.000
Inventors	959,733	2.722	1.706	1.000	1.000	2.000	4.000	22.000
Provisional	959,733	0.263	0.440	0.000	0.000	0.000	1.000	1.000
PCT	959,733	0.197	0.398	0.000	0.000	0.000	0.000	1.000
Small entity	959,733	0.097	0.296	0.000	0.000	0.000	0.000	1.000
Foreign priority	959,733	0.352	0.477	0.000	0.000	0.000	1.000	1.000
Leniency (grant rate)*	959,627	0.749	0.134	0.026	0.682	0.780	0.850	1.000

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the latest disposal quarter of an application in its U.S. patent family, or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample contains SEPs whose family is still pending in the quarter of publication of the earliest standard linked to the family and control applications in art-unit-examiner-filing-quarter groups with at least one SEP and one control. The sample contains 53,112 applications (5,487 SEPs and 47,625 controls). *Statistics reported for the sample in Table 2.

Table A2: Patent examination and continuations

Group	SEPs (1)	Controls (2)
Non-final rejection		
Pr(non-final rejection)	91%	91%
Pr(CON after non-final rejection | non-final rejection)	3%	1%
Pr(CON after non-final rejection | CON)	7%	5%
Final rejection		
Pr(final rejection)	57%	52%
Pr(CON after final rejection | final rejection)	3%	1%
Pr(CON after final rejection | CON)	6%	6%
Notice of allowance		
Pr(notice of allowance)	85%	74%
Pr(CON after notice of allowance | notice of allowance)	28%	13%
Pr(CON after notice of allowance | CON)	72%	78%

Notes. The unit of observation is a patent application. The sample contains 22,850 original patent applications filed on or after November 29, 2000, 11,425 SEPs and 11,425 controls matched on art unit, examiner and filing year.

Table A3: Patent scope change and continuation filing

Outcome	CON × 100	
Estimation method	OLS	
Measure of patent scope	Number of claims	Length 1st ind claim
	(1)	(2)
Change in ind claims	-1.88***	
	(0.73)	
Change in length 1st ind claim		-2.56***
		(0.65)
Observations	6,051	6,048
R-squared	0.18	0.18
Mean of outcome	37.96	37.96

Notes. The unit of observation is a SEP. The sample contains the SEPs filed on or after November 29, 2000 that are filed as original applications and are granted. SEPs include U.S. utility patent applications declared essential for a standard, as well as all their parent and child applications. All models include effects for filing year, issue year, art unit and examiner. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A4: Difference in differences models of continuation filing, declared SEPs and controls

Outcome	CON × 100					
Estimation method	OLS					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	Pooled OLS (1)	Tech & cohort FE (2)	Application FE (3)	Pooled OLS (4)	Tech & cohort FE (5)	Application FE (6)
PostStandard × SEP	1.73***	1.66***	2.09***	1.77***	1.81***	2.29***
	(0.08)	(0.08)	(0.12)	(0.09)	(0.10)	(0.14)
SEP	-0.01	0.11***		0.00	-0.00	
	(0.03)	(0.04)		(0.02)	(0.04)	
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓			✓	
Age^2, age^3 & age^4		✓	✓		✓	✓
Application FE			✓			✓
PostStandard				✓	✓	✓
Observations	758,930	758,930	758,930	171,412	171,412	171,412
R-squared	0.01	0.02	0.08	0.02	0.05	0.08
Applications	46,919	46,919	4,6919	9,564	9,564	9,564
Mean of outcome	0.90	0.90	0.90	1.32	1.32	1.32

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the quarter of disposal or the end of year 2016 if still pending. A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample for models (1)-(3) contains SEPs that are mentioned in patent disclosure letters and are pending in the quarter of publication of the earliest standard linked to the application, and control applications in art-unit-examiner-filing-quarter groups with at least one SEP and one control. The sample for models (4)-(6) contains SEPs that are mentioned in patent disclosure letters and are pending in the quarter of publication of the earliest standard linked to the application, and controls pending in the quarter before standard publication matched on filing quarter, art unit, examiner and cumulative number of continuations in the quarter before standard publication. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A5: Difference in differences models of child application filing

Outcome	Child × 100					
Estimation method	OLS					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	Pooled OLS (1)	Tech & cohort FE (2)	Application FE (3)	Pooled OLS (4)	Tech & cohort FE (5)	Application FE (6)
PostStandard × SEP	0.87***	0.68***	1.67***	2.10***	1.97***	2.25***
	(0.11)	(0.10)	(0.11)	(0.12)	(0.10)	(0.13)
SEP	1.14***	1.31***		-0.00	0.00	
	(0.08)	(0.07)		(0.06)	(0.05)	
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓			✓	
Age^2, age^3 & age^4		✓	✓		✓	✓
Application FE			✓			✓
PostStandard				✓	✓	✓
Observations	959,733	959,733	959,733	209,440	209,440	209,440
R-squared	0.02	0.03	0.07	0.02	0.05	0.07
Applications	53,112	53,112	53,112	9,988	9,988	9,988
Mean of outcome	1.72	1.72	1.72	2.46	2.46	2.46

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the latest disposal quarter of an application in its U.S. patent family, or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample for models (1)-(3) contains SEPs whose family is pending at standard publication and control applications in art-unit-examiner-filing-quarter groups with at least one SEP and one control. The sample for models (4)-(6) contains SEPs whose family is still pending at standard publication and control applications whose family is still pending in the quarter before standard publication matched on filing quarter, art unit, examiner and cumulative number of child applications in the quarter before standard publication. The quarter of standard publication is the quarter of publication of the earliest standard linked to a family of SEPs. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A6: Difference in differences models controlling for application characteristics

Estimation method	OLS											
Outcome	CON × 100								Child × 100			
Sample	Info on entire family, all		Info on entire family, matched on pre-trend		Info on first application in family, all		Info on first application in family, matched on pre-trend		Info on entire family, all		Info on the entire family, matched on pre-trend	
Model	Pooled OLS	Tech & cohort FE	Pooled OLS	Tech & cohort FE	Pooled OLS	Tech & cohort FE	Pooled OLS	Tech & cohort FE	Pooled OLS	Tech & cohort FE	Pooled OLS	Tech & cohort FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
PostStandard × SEP	1.22***	1.07***	1.91***	1.76***	1.78***	1.73***	1.85***	1.89***	1.01***	0.83***	2.12***	2.01***
	(0.09)	(0.09)	(0.11)	(0.09)	(0.08)	(0.08)	(0.09)	(0.10)	(0.11)	(0.10)	(0.12)	(0.10)
SEP	0.79***	0.89***	0.02	0.04	0.02	0.13***	0.00	0.03	1.05***	1.21***	0.00	-0.01
	(0.05)	(0.05)	(0.05)	(0.05)	(0.03)	(0.04)	(0.03)	(0.05)	(0.08)	(0.07)	(0.06)	(0.06)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓		✓		✓		✓		✓		✓	
AU-E-FQ FE		✓		✓		✓		✓		✓		✓
Age^2, age^3 & age^4		✓		✓		✓		✓		✓		✓
Observations	865,911	865,911	193,195	193,195	691,645	691,645	155,799	155,801	865,911	865,911	188,593	188,593
R-squared	0.02	0.03	0.02	0.05	0.01	0.02	0.02	0.05	0.02	0.03	0.03	0.05
Applications	47,730	47,730	9,154	9,154	42,416	42,416	8,636	8,636	47,730	47,730	8,992	8,992
Mean of outcome	1.19	1.19	1.91	1.91	0.88	0.88	1.30	1.30	1.69	1.69	2.42	2.42

Notes. The unit of observation is an application-quarter. Models (1)-(4) estimated on the samples for Table 1. Models (5)-(8) estimated on the samples for Table A4. Models (9)-(12) estimated on the samples for Table A5. All models include control variables for the characteristics of the earliest U.S. utility patent application of a family. These include indicators for applications that claim priority to provisional applications, PCT applications or foreign applications, an indicator for applications filed by small entities, and the natural logarithms of the number of independent claims, the number of words per independent claim, and the number of inventors. Models in columns (1), (2), (5), (6), (9) and (10) estimated after dropping applications with missing values for the control variables and keeping only examiner-art-unit-filing-quarter groups with at least one SEP and one control. Models in columns (3), (4), (7), (8), (11) and (12) estimated keeping only matched pairs with complete information for the control variables for both applications. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A7: Difference in differences models, anticipation

Estimation method	OLS											
Outcome	CON × 100								Child × 100			
Sample	Info on entire family				Info on first application in family				Info on entire family			
Model	Pooled OLS	Tech & cohort FE	Controls	Appl. FE	Pooled OLS	Tech & cohort FE	Controls	Appl. FE	Pooled OLS	Tech & cohort FE	Controls	Appl. FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
PostStandard × SEP	1.17***	1.05***	1.18***	1.99***	1.74***	1.64***	1.73***	2.08***	0.84***	0.66***	0.86***	2.26***
	(0.10)	(0.09)	(0.09)	(0.12)	(0.08)	(0.08)	(0.09)	(0.15)	(0.13)	(0.13)	(0.12)	(0.15)
Standard $(t-1)$ × SEP	0.57***	0.59***	0.62***	1.28***	0.67***	0.60***	0.57***	0.60***	0.22	0.19	0.24	1.38***
	(0.19)	(0.19)	(0.19)	(0.21)	(0.15)	(0.15)	(0.15)	(0.18)	(0.22)	(0.22)	(0.22)	(0.23)
Standard $(t-2)$ × SEP	0.23	0.25	0.31*	0.92***	-0.07	-0.13	-0.09	-0.10	-0.03	-0.07	0.07	1.07***
	(0.18)	(0.18)	(0.18)	(0.20)	(0.08)	(0.09)	(0.09)	(0.12)	(0.22)	(0.22)	(0.23)	(0.23)
Standard $(t-3)$ × SEP	0.23	0.26	0.34*	0.88***	-0.06	-0.12	-0.12	-0.10	-0.00	-0.03	0.09	1.02***
	(0.19)	(0.19)	(0.19)	(0.20)	(0.08)	(0.09)	(0.09)	(0.11)	(0.23)	(0.23)	(0.23)	(0.24)
Standard $(t-4)$ × SEP	0.28	0.30	0.29	0.85***	-0.16**	-0.22***	-0.21***	-0.22**	0.31	0.27	0.26	1.22***
	(0.19)	(0.19)	(0.19)	(0.21)	(0.06)	(0.07)	(0.07)	(0.09)	(0.25)	(0.25)	(0.25)	(0.26)
SEP	0.66***	0.75***	0.71***		-0.07***	0.08**	0.09**		1.08***	1.27***	1.13***	
	(0.06)	(0.06)	(0.06)		(0.03)	(0.04)	(0.04)		(0.10)	(0.10)	(0.10)	
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓				✓				✓			
AU-E-FQ FE		✓	✓			✓	✓			✓	✓	
Age^2, age^3 & age^4		✓	✓	✓		✓	✓	✓		✓	✓	✓
Controls			✓				✓				✓	
Application FE				✓				✓				✓
Observations	927,567	927,567	838,603	927,567	742,204	742,204	678,532	742,204	927,567	927,567	838,603	927,567
R-squared	0.02	0.03	0.03	0.07	0.01	0.02	0.02	0.08	0.02	0.03	0.03	0.07
Applications	53,112	53,112	47,730	53,112	46,919	46,919	42,416	46,919	53,112	53,112	47,730	53,112
Mean of outcome	1.12	1.12	1.09	1.12	0.85	0.85	0.82	0.85	1.60	1.60	1.56	1.60

Notes. The unit of observation is an application-quarter. Models (1)-(4) estimated on the samples for Table 1. Models (5)-(8) estimated on the samples for Table A4. Models (9)-(12) estimated on the samples for Table A5. Control variables for the characteristics of the earliest U.S. utility patent application of a family include indicators for applications that claim priority to provisional applications, PCT applications or foreign applications, an indicator for applications filed by small entities, and the natural logarithms of the number of independent claims, the number of words per independent claim, and the number of inventors. Models (3), (7) and (11) estimated after dropping applications with missing values for the control variables and keeping only examiner-art-unit-filing-quarter groups with at least one SEP and one control. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A8: Hazard models of continuation filing

Outcome	CON × 100					
Estimation method	OLS					
Models	Myopic			Quasi-myopic		
Model	Pooled OLS	Tech & cohort FE	Controls	Pooled OLS	Tech & cohort FE	Controls
	(1)	(2)	(3)	(4)	(5)	(6)
PostStandard × SEP	1.02***	1.09***	1.15***	1.11***	1.20***	1.27***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Standard $(t-1)$ × SEP				0.66***	0.74***	0.70***
				(0.17)	(0.17)	(0.17)
Standard $(t-2)$ × SEP				0.47***	0.54***	0.55***
				(0.17)	(0.17)	(0.17)
Standard $(t-3)$ × SEP				0.35**	0.42**	0.44**
				(0.17)	(0.17)	(0.17)
Standard $(t-4)$ × SEP				0.15	0.19	0.18
				(0.16)	(0.16)	(0.16)
SEP	0.49***	0.53***	0.54***	0.36***	0.38***	0.39***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓	✓		✓	✓
Age^2, age^3 & age^4		✓	✓		✓	✓
Controls			✓			✓
Observations	1,071,574	1,071,574	959,984	1,052,185	1,052,186	944,361
R-squared	0.01	0.02	0.02	0.01	0.02	0.02
Applications	65,486	65,486	58,261	65,486	65,486	58,261
Mean of outcome	0.81	0.81	0.79	0.78	0.78	0.75

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the earliest of the filing quarter of its first continuation, the latest disposal quarter of an application in its U.S. patent family or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample contains SEPs filed before the quarter of publication of the earliest standard linked to their family and control applications in art-unit-examiner-filing-quarter groups with at least one SEP and one control. Control variables for the characteristics of the earliest U.S. utility patent application of a family include indicators for applications that claim priority to provisional applications, PCT applications or foreign applications, an indicator for applications filed by small entities, and the natural logarithms of the number of independent claims, the number of words per independent claim, and the number of inventors. Models (3) and (6) estimated after dropping applications with missing values for the control variables and keeping only examiner-art-unit-filing-quarter groups with at least one SEP and one control. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A9: Hazard models of continuation filing, declared SEPs and controls

Outcome	CON × 100					
Estimation method	OLS					
Models	Myopic			Quasi-myopic		
Model	Pooled OLS (1)	Tech & cohort FE (2)	Controls (3)	Pooled OLS (4)	Tech & cohort FE (5)	Controls (6)
PostStandard × SEP	1.17***	1.24***	1.29***	1.23***	1.33***	1.40***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)
Standard $(t-1)$ × SEP				0.77***	0.86***	0.82***
				(0.18)	(0.18)	(0.18)
Standard $(t-2)$ × SEP				0.34**	0.42***	0.47***
				(0.16)	(0.16)	(0.17)
Standard $(t-3)$ × SEP				0.32*	0.39**	0.38**
				(0.16)	(0.17)	(0.17)
Standard $(t-4)$ × SEP				0.11	0.15	0.17
				(0.15)	(0.15)	(0.16)
SEP	0.44***	0.50***	0.52***	0.32***	0.35***	0.36***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓	✓		✓	✓
Age^2, age^3 & age^4		✓	✓		✓	✓
Controls			✓			✓
Observations	1,004,990	1,004,995	904,014	988,569	988,570	891,139
R-squared	0.01	0.02	0.02	0.01	0.02	0.02
Applications	63,158	63,158	56,386	63,158	63,158	56,386
Mean of outcome	0.83	0.83	0.81	0.79	0.79	0.77

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the earliest of the filing quarter of its first continuation, the quarter of disposal or the end of year 2016 if it is still pending. A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample contains SEPs that are mentioned in patent disclosure letters and are filed before the quarter of publication of the earliest standard linked to the application, and control applications in art-unit-examiner-filing-quarter groups with at least one SEP and one control. Control variables for the characteristics of the earliest U.S. utility patent application of a family include indicators for applications that claim priority to provisional applications, PCT applications or foreign applications, an indicator for applications filed by small entities, and the natural logarithms of the number of independent claims, the number of words per independent claim, and the number of inventors. Models (3) and (6) estimated after dropping applications with missing values for the control variables and keeping only examiner-art-unit-filing-quarter groups with at least one SEP and one control. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A10: Hazard models of child application filing

Outcome	Child × 100					
Estimation method	OLS					
Models	Myopic			Quasi-myopic		
Model	Pooled OLS (1)	Tech & cohort FE (2)	Controls (3)	Pooled OLS (4)	Tech & cohort FE (5)	Controls (6)
PostStandard × SEP	1.14***	1.20***	1.25***	1.17***	1.26***	1.32***
	(0.09)	(0.09)	(0.09)	(0.10)	(0.10)	(0.10)
Standard ($t-1$) × SEP				0.56***	0.63***	0.59***
				(0.20)	(0.20)	(0.20)
Standard ($t-2$) × SEP				0.40**	0.45**	0.48**
				(0.20)	(0.20)	(0.20)
Standard ($t-3$) × SEP				0.21	0.25	0.28
				(0.19)	(0.20)	(0.20)
Standard ($t-4$) × SEP				0.17	0.19	0.16
				(0.20)	(0.20)	(0.20)
SEP	0.67***	0.80***	0.76***	0.57***	0.68***	0.63***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓	✓		✓	✓
Age^2, age^3 & age^4		✓	✓		✓	✓
Controls			✓			✓
Observations	1,017,784	1,017,788	913,169	1,001,621	1,001,621	900,503
R-squared	0.01	0.02	0.02	0.01	0.02	0.02
Applications	65,486	65,486	58,261	65,486	65,486	58,261
Mean of outcome	1.21	1.21	1.18	1.17	1.17	1.13

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the earliest of the filing quarter of its first child application, the latest disposal quarter of an application in its U.S. patent family or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample contains SEPs filed before the quarter of publication of the earliest standard linked to their family and control applications in art-unit-examiner-filing-quarter groups with at least one SEP and one control. Control variables for the characteristics of the earliest U.S. utility patent application of a family include indicators for applications that claim priority to provisional applications, PCT applications or foreign applications, an indicator for applications filed by small entities, and the natural logarithms of the number of independent claims, the number of words per independent claim, and the number of inventors. Models (3) and (6) estimated after dropping applications with missing values for the control variables and keeping only examiner-art-unit-filing-quarter groups with at least one SEP and one control. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A11: Difference in differences and hazard models of continuation filing, only SEPs

Outcome	CON × 100													
Estimation method	OLS													
	DID, myopic				DID, quasi-myopic				Hazard, myopic			Hazard, quasi-myopic		
Model	Pooled OLS	Tech & cohort FE	Controls	Appl. FE	Pooled OLS	Tech & cohort FE	Controls	Appl. FE	Pooled OLS	Tech & cohort FE	Controls	Pooled OLS	Tech & cohort FE	Controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PostStandard	0.26***	0.20*	0.19	0.19	0.33***	0.47***	0.47***	0.52***	0.15*	0.39***	0.39***	0.21**	0.67***	0.67***
	(0.10)	(0.12)	(0.12)	(0.12)	(0.10)	(0.15)	(0.15)	(0.16)	(0.09)	(0.13)	(0.13)	(0.09)	(0.17)	(0.17)
Standard $(t-1)$					0.39**	0.58***	0.58***	0.61***				0.31*	0.54***	0.53**
					(0.18)	(0.20)	(0.20)	(0.21)				(0.17)	(0.20)	(0.21)
Standard $(t-2)$					0.07	0.27	0.30	0.31				0.20	0.45**	0.44**
					(0.17)	(0.19)	(0.19)	(0.19)				(0.17)	(0.20)	(0.20)
Standard $(t-3)$					0.17	0.38**	0.39**	0.42**				0.20	0.43**	0.43**
					(0.17)	(0.20)	(0.20)	(0.20)				(0.17)	(0.19)	(0.19)
Standard $(t-4)$					0.18	0.36*	0.33*	0.41**				-0.03	0.14	0.13
					(0.18)	(0.19)	(0.19)	(0.19)				(0.16)	(0.17)	(0.17)
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓				✓				✓			✓		
AU-E-FQ FE		✓	✓			✓	✓			✓	✓		✓	✓
Age^2, age^3 & age^4		✓	✓	✓		✓	✓	✓		✓	✓		✓	✓
Controls			✓				✓				✓			✓
Application FE				✓				✓						
Observations	162,126	161,936	156,927	162,126	153,354	153,168	148,379	153,354	131,348	131,211	127,289	128,008	127,872	124,069
R-squared	0.02	0.06	0.06	0.07	0.02	0.06	0.06	0.07	0.02	0.08	0.08	0.02	0.08	0.08
Applications	7,019	7,012	6,798	7,019	7,019	7,012	6,798	7,019	7,019	7,003	6,791	7,019	7,003	6,791
Mean of outcome	2.67	2.67	2.67	2.67	2.44	2.44	2.44	2.44	1.80	1.80	1.80	1.73	1.72	1.72

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the latest disposal quarter of an application in its U.S. patent family, or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination) in columns (1)-(8), and to the earliest of the filing quarter of its first continuation, the latest disposal quarter of an application in its U.S. patent family or the end of year 2016 if its family is still pending in columns (9)-(14). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. The sample contains SEPs filed before the quarter of publication of the earliest standard linked to their family. Control variables for the characteristics of the earliest U.S. utility patent application of a family include indicators for applications that claim priority to provisional applications, PCT applications or foreign applications, an indicator for applications filed by small entities, and the natural logarithms of the number of independent claims, the number of words per independent claim, and the number of inventors. Standard errors clustered by application in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A12: Difference in differences and hazard models of continuation filing, only declared SEPs

Outcome	CON × 100													
Estimation method	OLS													
	DID, myopic				DID, quasi-myopic				Hazard, myopic			Hazard, quasi-myopic		
Model	Pooled OLS	Tech & cohort FE	Controls	Appl. FE	Pooled OLS	Tech & cohort FE	Controls	Appl. FE	Pooled OLS	Tech & cohort FE	Controls	Pooled OLS	Tech & cohort FE	Controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PostStandard	0.22**	0.41***	0.40***	0.38***	0.27***	0.72***	0.71***	0.77***	0.15*	0.49***	0.48***	0.19**	0.80***	0.78***
	(0.09)	(0.13)	(0.13)	(0.14)	(0.09)	(0.17)	(0.18)	(0.21)	(0.09)	(0.14)	(0.14)	(0.09)	(0.18)	(0.18)
Standard $(t-1)$					0.37**	0.71***	0.69***	0.74***				0.35**	0.70***	0.69***
					(0.18)	(0.21)	(0.21)	(0.23)				(0.18)	(0.21)	(0.22)
Standard $(t-2)$					0.07	0.39**	0.42**	0.44**				0.02	0.39**	0.41**
					(0.16)	(0.19)	(0.20)	(0.20)				(0.16)	(0.19)	(0.20)
Standard $(t-3)$					0.12	0.40**	0.38*	0.45**				0.12	0.45**	0.41**
					(0.17)	(0.19)	(0.19)	(0.20)				(0.17)	(0.19)	(0.19)
Standard $(t-4)$					-0.07	0.18	0.19	0.22				-0.09	0.16	0.17
					(0.16)	(0.18)	(0.18)	(0.18)				(0.16)	(0.17)	(0.18)
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓				✓				✓			✓		
AU-E-FQ FE		✓	✓			✓	✓			✓	✓		✓	✓
Age^2, age^3 & age^4		✓	✓	✓		✓	✓	✓		✓	✓		✓	✓
Controls			✓				✓				✓			✓
Application FE				✓				✓						
Observations	125,427	125,427	122,103	125,427	122,606	122,608	119,392	122,608	121,914	121,907	118,643	119,324	119,319	116,157
R-squared	0.02	0.07	0.07	0.08	0.02	0.08	0.08	0.09	0.02	0.08	0.08	0.02	0.08	0.08
Applications	6,834	6,834	6,638	6,834	6,834	6,834	6,638	6,834	6,834	6,827	6,632	6,834	6,827	6,632
Mean of outcome	1.93	1.93	1.93	1.93	1.84	1.84	1.84	1.84	1.86	1.85	1.85	1.76	1.76	1.76

Notes. The unit of observation is an application-quarter. Applications included in the sample from their filing quarter to the quarter of disposal or the end of year 2016 if still pending in columns (1)-(8), and to the earliest of the filing quarter of their first continuation, the quarter of disposal or the end of year 2016 if censored in columns (9)-(14). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. The sample contains SEPs that are mentioned in patent disclosure letters and are filed before the quarter of publication of the earliest standard linked to the application. Control variables for the characteristics of the earliest U.S. utility patent application of a family include indicators for applications that claim priority to provisional applications, PCT applications or foreign applications, an indicator for applications filed by small entities, and the natural logarithms of the number of independent claims, the number of words per independent claim, and the number of inventors. Standard errors clustered by application in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A13: Difference in differences and hazard models of child application filing, only SEPs

Outcome	Child × 100													
Estimation method	OLS													
	DID, myopic				DID, quasi-myopic				Hazard, myopic			Hazard, quasi-myopic		
Model	Pooled OLS	Tech & cohort FE	Controls	Appl. FE	Pooled OLS	Tech & cohort FE	Controls	Appl. FE	Pooled OLS	Tech & cohort FE	Controls	Pooled OLS	Tech & cohort FE	Controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PostStandard	0.12	0.20	0.20	0.16	0.16	0.53***	0.54***	0.55***	0.03	0.45***	0.43***	0.07	0.92***	0.88***
	(0.12)	(0.13)	(0.14)	(0.14)	(0.13)	(0.17)	(0.17)	(0.20)	(0.11)	(0.16)	(0.16)	(0.11)	(0.21)	(0.21)
Standard ($t-1$)					0.23	0.58**	0.54**	0.58**				0.21	0.84***	0.80***
					(0.20)	(0.23)	(0.23)	(0.23)				(0.20)	(0.24)	(0.24)
Standard ($t-2$)					0.03	0.38*	0.43*	0.39*				0.13	0.75***	0.73***
					(0.20)	(0.23)	(0.23)	(0.23)				(0.20)	(0.23)	(0.24)
Standard ($t-3$)					0.07	0.40*	0.41*	0.41*				0.04	0.61***	0.59***
					(0.21)	(0.23)	(0.23)	(0.23)				(0.20)	(0.22)	(0.23)
Standard ($t-4$)					0.32	0.55**	0.48**	0.62***				0.02	0.45**	0.41*
					(0.23)	(0.24)	(0.24)	(0.24)				(0.20)	(0.22)	(0.22)
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓				✓				✓			✓		
AU-E-FQ FE		✓	✓			✓	✓			✓	✓		✓	✓
Age^2, age^3 & age^4		✓	✓	✓		✓	✓	✓		✓	✓		✓	✓
Controls			✓				✓				✓			✓
Application FE				✓				✓						
Observations	162,126	161,936	156,927	162,126	153,354	153,168	148,379	153,354	121,222	121,179	117,752	118,700	118,657	115,332
R-squared	0.02	0.06	0.06	0.07	0.02	0.06	0.06	0.07	0.02	0.09	0.09	0.02	0.09	0.09
Applications	7,019	7,012	6,798	7,019	7,019	7,012	6,798	7,019	7,019	6,987	6,775	7,019	6,987	6,775
Mean of outcome	3.41	3.40	3.38	3.41	3.17	3.16	3.14	3.17	2.44	2.42	2.41	2.34	2.32	2.32

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the latest disposal quarter of an application in its U.S. patent family, or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination) in columns (1)-(8), and to the earliest of the filing quarter of its first child application, the latest disposal quarter of an application in its U.S. patent family or the end of year 2016 if its family is still pending in columns (9)-(14). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. The sample contains SEPs filed before the quarter of publication of the earliest standard linked to their family. Control variables for the characteristics of the earliest U.S. utility patent application of a family include indicators for applications that claim priority to provisional applications, PCT applications or foreign applications, an indicator for applications filed by small entities, and the natural logarithms of the number of independent claims, the number of words per independent claim, and the number of inventors. Standard errors clustered by application in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A14: Difference in differences models of continuation filing, technology area shocks

Outcome	CON × 100											
Estimation method	OLS											
Sample	SEPs and controls						SEPs and controls matched on pre-standard CONs					
Model	Pooled OLS			Application FE			Pooled OLS			Application FE		
Technology area	AU	AU-FQ	AU-FQ-E	AU	AU-FQ	AU-FQ-E	AU	AU-FQ	AU-FQ-E	AU	AU-FQ	AU-FQ-E
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
PostStandard × SEP	1.02***	1.05***	1.04***	1.48***	1.60***	1.66***	1.75***	1.73***	1.58***	1.77***	1.83***	1.75***
	(0.09)	(0.09)	(0.08)	(0.09)	(0.10)	(0.09)	(0.10)	(0.10)	(0.09)	(0.11)	(0.11)	(0.12)
SEP	0.82***	0.78***	0.72***				0.00	0.00	0.00			
	(0.05)	(0.05)	(0.05)				(0.04)	(0.04)	(0.02)			
Age FE	✓						✓					
Age^2, age^3 & age^4				✓						✓		
AU-CQ FE	✓			✓			✓			✓		
AU-FQ-CQ FE		✓			✓			✓			✓	
AU-FQ-E-CQ FE			✓			✓			✓			✓
PostStandard							✓	✓	✓	✓	✓	✓
Application FE				✓	✓	✓				✓	✓	✓
Observations	958,195	950,886	937,891	958,195	950,886	937,891	212,606	203,694	186,163	212,606	203,694	186,163
R-squared	0.04	0.12	0.22	0.09	0.17	0.26	0.07	0.25	0.45	0.11	0.29	0.48
Applications	53,112	53,112	53,112	53,112	53,112	53,112	10,178	10,178	10,178	10,178	10,178	10,178
Mean of outcome	1.22	1.20	1.14	1.22	1.20	1.14	1.93	1.83	1.49	1.93	1.83	1.49

Notes. The unit of observation is an application-quarter. See Table 1 for the description of the samples. Models (1), (4), (7), and (10) include art-unit-by-calendar-quarter effects. Models (2), (5), (8), and (11) include art-unit-by-filing-quarter-by-calendar-quarter effects. Models (3), (6), (9), and (12) include art-unit-by-filing-quarter-by-examiner-by-calendar-quarter effects. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A15: Difference in differences models of continuation filing, ETSI vs. other SSOs

Outcome	CON × 100											
Estimation method	OLS											
SSOs	ETSI						Other					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs			SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	Pooled OLS	Tech & cohort FE	Appl. FE	Pooled OLS	Tech & cohort FE	Appl. FE	Pooled OLS	Tech & cohort FE	Appl. FE	Pooled OLS	Tech & cohort FE	Appl. FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
PostStandard × SEP	1.14***	0.98***	1.48***	1.88***	1.72***	1.82***	0.65	0.56	1.39***	1.45**	1.41***	2.25***
	(0.09)	(0.09)	(0.10)	(0.11)	(0.09)	(0.12)	(0.48)	(0.45)	(0.50)	(0.68)	(0.53)	(0.62)
SEP	0.82***	0.92***		0.00	0.00		0.52**	0.53**		-0.00	0.00	
	(0.06)	(0.05)		(0.05)	(0.05)		(0.22)	(0.21)		(0.27)	(0.18)	
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓			✓			✓			✓		
AU-E-FQ FE		✓			✓			✓			✓	
Age^2, age^3 & age^4		✓	✓		✓	✓		✓	✓		✓	✓
Application FE			✓			✓			✓			✓
PostStandard				✓	✓	✓				✓	✓	✓
Observations	932,719	932,719	932,719	208,736	208,736	208,736	28,886	28,886	28,886	6,156	6,160	6,160
R-squared	0.02	0.03	0.07	0.02	0.05	0.07	0.02	0.02	0.05	0.04	0.05	0.06
Applications	51,814	51,814	51,814	9,948	9,948	9,948	1,382	1,382	1,382	230	230	230
Mean of outcome	1.23	1.23	1.23	1.97	1.97	1.97	0.91	0.91	0.91	1.35	1.35	1.35

Notes. The unit of observation is an application-quarter. See Table 1 for the description of the samples. Columns (1)-(6) are estimated using only SEPs linked to ETSI and control patent applications. Columns (7)-(12) are estimated using only SEPs linked to SSOs different from ETSI and control patent applications. Standard errors clustered by application in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A16: Difference in differences models of continuation filing, De Chaisemartin and D'Haultfoeuille (2020a, 2020b)

Outcome	CON × 100			
Sample	SEPs and controls picked randomly		SEPs and controls matched on pre-standard CONs	
Estimator	DID_M (1)	DID_l (2)	DID_M (3)	DID_l (4)
PostStandard × SEP effects				
$Effect_0$	-0.23	-0.23	0.84***	0.84***
	(0.25)	(0.25)	(0.25)	(0.25)
$Effect_1$		0.29		1.39***
		(0.29)		(0.27)
$Effect_2$		0.51*		1.60***
		(0.29)		(0.26)
$Effect_3$		0.53*		1.68***
		(0.31)		(0.29)
$Effect_4$		0.48		1.46***
		(0.30)		(0.29)
PreStandard × SEP placebos				
$Placebo_{-1}$		0.43*		0.07
		(0.26)		(0.18)
$Placebo_{-2}$		0.11		0.08
		(0.27)		(0.19)
$Placebo_{-3}$		0.14		-0.02
		(0.28)		(0.19)
$Placebo_{-4}$		0.28		-0.06
		(0.30)		(0.21)
PostStandard			✓	✓

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the latest disposal quarter of an application in its U.S. patent family, or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample for models (1)-(2) contains SEPs whose family is pending at standard publication and control applications matched on filing quarter, art unit and examiner. The sample for models (3)-(4) contains SEPs whose family is still pending at standard publication and control applications whose family is still pending in the quarter before standard publication matched on filing quarter, art unit, examiner and cumulative number of continuations in the quarter before standard publication. The quarter of standard publication is the quarter of publication of the earliest standard linked to a family of SEPs. All models include the non-linear terms of a four degree polynomial of age. Columns (1) and (3) use the estimator proposed by de Chaisemartin and D'Haultfœuille (2020b). Columns (2) and (4) use the estimator proposed by de Chaisemartin and D'Haultfœuille (2020a). Bootstrapped standard errors (500 repetitions) clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A17: Difference in differences models of continuation filing, Callaway and Sant'Anna (2021)

Outcome	CON × 100	
Estimator	Callaway and Sant'Anna (2021)	
Sample	SEPs and controls picked randomly	SEPs and controls matched on pre-standard CONs
	(1)	(2)
PostStandard × SEP	2.69***	3.82***
	(0.51)	(0.56)
Observations	21,057	20,398
Applications	1,000	1,000
Mean of outcome	1.98	2.02

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the latest disposal quarter of an application in its U.S. patent family, or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample for model (1) contains 500 pairs (selected at random) of SEPs whose family is pending at standard publication and control applications matched on filing quarter, art unit and examiner. The sample for model (2) contains 500 pairs (selected at random) of SEPs whose family is still pending at standard publication and control applications whose family is still pending in the quarter before standard publication matched on filing quarter, art unit, examiner and cumulative number of continuations in the quarter before standard publication. The quarter of standard publication is the quarter of publication of the earliest standard linked to a family of SEPs. Bootstrapped standard errors (500 repetitions) clustered by application in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A18: Difference in differences models of continuation filing, Borusyak et al. (2021)

Outcome	CON × 100					
Estimator	Borusyak et al. (2021)					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	Pooled OLS (1)	Tech & cohort FE (2)	Application FE (3)	Pooled OLS (4)	Tech & cohort FE (5)	Application FE (6)
PostStandard × SEP	1.22***	1.16***	2.01***	1.94***	2.12***	2.27***
	(0.10)	(0.09)	(0.09)	(0.12)	(0.10)	(0.11)
SEP	✓	✓		✓	✓	
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓			✓	
Age^2, age^3 & age^4		✓	✓		✓	✓
Application FE			✓			✓
PostStandard				✓	✓	✓
Observations	959,730	959,733	959,733	214,896	214,896	214,896
Applications	53,112	53,112	53,112	10,178	10,178	10,178
Mean of outcome	1.22	1.22	1.22	1.95	1.95	1.95

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the latest disposal quarter of an application in its U.S. patent family, or the end of year 2016 if its family is still pending (i.e. at least one filing in the U.S. patent family is still under examination). A SEP is the earliest U.S. utility patent application of a domestic patent family that contains at least one U.S. utility patent application declared essential for a standard. A control application is the earliest U.S. utility patent application of a domestic patent family that does not contain any U.S. utility patent applications declared essential for a standard. The sample for models (1)-(3) contains SEPs whose family is pending at standard publication and control applications in art-unit-examiner-filing-quarter groups with at least one SEP and one control. The sample for models (4)-(6) contains SEPs whose family is still pending at standard publication and control applications whose family is still pending in the quarter before standard publication matched on filing quarter, art unit, examiner and cumulative number of continuations in the quarter before standard publication. The quarter of standard publication is the quarter of publication of the earliest standard linked to a family of SEPs. Standard errors clustered by application in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A19: Regression models of non-statutory double patenting rejection, ETSI vs. other SSOs

Outcome	Non-statutory double patenting rejection ×100			
Estimation method	OLS			
SSOs	ETSI		Other	
Model	Baseline	FE	Baseline	FE
	(1)	(2)	(3)	(4)
SEP post-standard	8.29***	7.52***	-7.83	-3.82
	(1.13)	(0.99)	(7.93)	(6.74)
SEP pre-standard	-4.59**	0.14	-4.40	-23.34**
	(2.06)	(2.01)	(10.61)	(9.76)
Art unit effects		✓		✓
Filing year effects		✓		✓
Examiner effects		✓		✓
Observations	10,258	10,258	332	332
R-squared	0.01	0.25	0.01	0.47
Patent families	7,984	7,984	243	243
Mean of outcome	50.02	50.02	42.17	42.17

Notes. The unit of observation is a patent application. See Table 4 for the description of the samples. Columns (1) and (2) are estimated using only SEPs linked to ETSI and control patent applications. Columns (3) and (4) are estimated using only SEPs linked to SSOs different from ETSI and control patent applications. Standard errors clustered by patent family in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A20: Regression models of Jaccard similarity, ETSI vs. other SSOs

Outcome	Jaccard similarity				
Estimation method	OLS				
SSOs	ETSI			Other	
Model	No controls	Pair FE	Application characteristics	No controls	Pair FE
	(1)	(2)	(3)	(4)	(5)
Post-standard CONs	2.16***	2.16***	0.74***	8.90***	8.90***
	(0.01)	(0.01)	(0.06)	(1.28)	(1.28)
Pair FE		✓	✓		✓
Claims, technology, year			✓		
Observations	1,323,252	1,323,252	418,898	326	326
R-squared	0.02	0.82	0.83	0.07	0.76
Pairs	661,626	661,626	209,449	163	163
Mean of outcome	14.26	14.26	12.51	19.35	19.35

Notes. The samples contain two observations for each pair of post-standard continuations, one for the two continuations and one for their parents. The control variables for model (3) are defined at the application level, i.e. measured separately for the two applications of each observation. Controls include filing year effects, art-unit-by-examiner effects, and the natural logarithms of the number of independent claims and the number of words per independent claim. Columns (1)-(3) are estimated using only SEPs linked to ETSI. Columns (4) and (5) are estimated using only SEPs linked to SSOs different from ETSI. Standard errors clustered by pair in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A21: Filing lag and litigation, ETSI vs. other SSOs

Outcome	Litigation × 100							
Estimation method	OLS							
SSOs	ETSI				Other			
Sample	SEPs		SEPs, original and CONs		SEPs		SEPs, original and CONs	
Model	Post standard	Filing lag	Post standard & CON	Filing lag & CON	Post standard	Filing lag	Post standard & CON	Filing lag & CON
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post-standard	0.82***		0.72*		5.44		-0.14	
	(0.30)		(0.40)		(4.35)		(7.35)	
Filing lag		0.25***		0.30***		0.12		-0.08
		(0.06)		(0.06)		(0.47)		(0.48)
CON			1.12**	0.47			-0.52	3.31
			(0.54)	(0.34)			(5.10)	(3.77)
Post-standard × CON			-0.28				6.70	
			(0.66)				(8.17)	
Filing lag × CON				-0.06				-0.07
				(0.12)				(0.35)
Observations	15,564	15,564	14,352	14,352	472	472	379	379
R-squared	0.14	0.14	0.14	0.14	0.59	0.59	0.71	0.71
Patent families	8,664	8,664	8,407	8,407	202	202	176	176
Mean of outcome	1.90	1.90	1.92	1.92	6.78	6.78	6.07	6.07

Notes. The unit of observation is a SEP. See Table 6 for the description of the samples. Columns (1)-(4) are estimated using only SEPs linked to ETSI. Columns (5)-(8) are estimated using only SEPs linked to SSOs different from ETSI. All models include effects for filing year, issue year, art unit and examiner. Standard errors clustered by patent family in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A22: Filing lag and patent private value

Outcome	Log(value)			
Estimation method	OLS			
Sample	SEPs		SEPs, original and CONs	
Model	Post standard	Filing lag	Post standard & CON	Filing lag & CON
	(1)	(2)	(3)	(4)
Post-standard	0.18***		-0.17**	
	(0.06)		(0.07)	
Filing lag		0.08***		0.03***
		(0.01)		(0.01)
CON			0.07	0.14**
			(0.10)	(0.07)
Post-standard × CON			0.55***	
			(0.12)	
Filing lag × CON				0.09***
				(0.01)
Observations	9,975	9,975	9,372	9,372
R-squared	0.37	0.38	0.38	0.39
Patent families	5,603	5,603	5,473	5,473
Mean of outcome	-0.46	-0.46	-0.55	-0.55

Notes. The unit of observation is a SEP. The sample contains the SEPs filed on or after November 29, 2000 that are granted and have data on patent value. SEPs include U.S. utility patent applications declared essential for a standard, as well as all their parent and child applications. The sample for models (3) and (4) contains only SEPs from original applications and CONs. All models include effects for filing year, issue year, art unit and examiner. Standard errors clustered by patent family in parentheses. *** p<0.01, ** p<0.05, * p<0.1