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ABSTRACT

Continuations allow inventors to claim technology developed after the original filing date of their patent, leading to concerns about inadvertent infringement and hold-up. We use the link between patents and standards created by the disclosure of standard essential patents (SEPs) to analyze the relationship between standard publication - a key observable milestone in technology development - and continuations. More than half of the SEPs in our data are filed after standard publication. Consistent with opportunistic behavior by patentees, there is a large increase in continuations immediately after standard publication. Keywords in the claims of SEPs linked to the same standard also become more similar after that standard is published.

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1 Introduction

An inventor who plans to seek patent protection faces a dynamic trade-off. She can file her application immediately to gain priority, or she can delay filing to strengthen her claims and extend the period of exclusivity. Continuations are a unique feature of the U.S. patent system that relaxes this tradeoff by allowing applicants to file early, but delay the drafting of claims that define the legal scope of their invention.[1]

Every continuation is the "child" of a previous patent application that protects the same invention disclosed in its "parent" but adds new claims. Importantly, the U.S. Patent and Trademark Office (USPTO) evaluates these new claims using the priority date of the parent application. In principle, this option encourages early disclosure of the underlying invention, and allows inventors to draft new claims when they have a better understanding of the technology and its commercial embodiments. In practice, continuations are controversial because they allow inventors to tailor their patent claims to cover products or technologies developed by others *after* the original disclosure.

Opportunistic use of continuations is widely discussed among patent attorneys and a frequent topic in patent policy debates. 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 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.[2]

Although these policy debates produced many examples, there is little statistical evidence on the opportunistic use of continuations. The lack of systematic evidence reflects two fundamental measurement challenges: (i) it is hard to link patents to potentially infringing technologies, and (ii) it is difficult to observe clear milestones in the development of those technologies that provide incentives for patent 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) encourage or require participants to disclose patents that might be infringed by a proposed standard, creating a link between patents and potentially infringing technology.

[1] 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).

[2] Comments received by the USPTO are available at https://www.uspto.gov/patent/laws-and-regulations/comments-public/comments-regarding-continuation-practice (accessed May 8, 2020). 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).

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 assemble data on the prosecution history of SEPs and similar technologies. In these data, 46% of SEPs are filed as continuations, and more than half of all SEPs are filed *after* the relevant standard was published. 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. This impact of standard publication on continuation filings varies with the SEP owner's business model and is largest for firms that collect most of their revenue through licensing of Intellectual Property (IP).

We interpret our DID results as evidence that patent applicants use continuations to opportunistically draft claims that cover industry standards. Unfortunately, we cannot easily compare these new claims to the text of the relevant standards. In the final step of our analysis, however, we examine claim-similarity among continuations that share a common standard. Specifically, we construct a sample of post-standard continuations with pre-standard parents and then show that the pairwise textual similarity of claims in the continuations is greater than the textual similarity of claims in their parent applications. We take this convergence in claim language as further evidence that applicants are using the delays provided by the continuation process to tailor their claims to cover related standards.

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 & Moore 2004, Lemley & Shapiro 2005). Early empirical studies document the prevalence of continuations (Graham 2004), the types of applicants and technologies that use them (Hegde, Mowery & Graham 2009), and how they fit into patterns of patent prosecution (Graham & Mowery 2004). More recently, various authors have shown how continuations are associated with distortions in patent quality (Frakes & Wasserman 2015) and increased litigation (Marco & Miller 2019, Righi 2019). Relative to this prior literature, we innovate by identifying a setting where patents can be linked to a potentially infringing technology, and by proposing a strategy to identify how reduced uncertainty about infringement affects the propensity to file continuations.

This study also contributes to a literature on strategic patenting (Levin, Klevorick, Nelson, Winter, Gilbert & Griliches 1987, Cohen, Nelson & Walsh 2000, Hall & 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 (Rysman & Simcoe 2008, Lerner & Tirole 2015). This naturally leads to rent seeking in patent prosecution. Kang & Bekkers (2015) and Kang & Motohashi (2015) show that firms often file patent applications just before standardization meetings and negotiate their inclusion into standards. Berger, Blind & Thumm (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, Tsukada & Shimbo (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 paper 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 employ a larger sample of standards and SEPs, and are also the first to examine similarity in claim language.

Finally, we contribute to a literature on patent scope and invention disclosure. Menell & Meurer (2013) outline a general theory of "notice externalities" in patent prosecution, and a 2011 report by the U.S. Federal Trade Commission expressed many similar concerns (FTC 2011). In a series of empirical papers, Kuhn (2016), Kuhn & Thompson (2019) and Marco, Sarnoff & deGrazia (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 to increase the probability that subsequently developed technology will infringe.

In the next section of the paper, we provide more information on continuations and the standardization process. Section 3 describes 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. Sections 4 and 5 report the results of our analysis. Section 6 discusses policy implications and offers concluding remarks.

2 Institutional Setting

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 (i.e., the date a patent examiner uses to assess novelty and non-obviousness). Claims are not rejected 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 is valuable to the applicant (Harhoff 2016). Second, when there is uncertainty about how an invention will be used, delay allows the applicant to draft claims corresponding to the most important uses of the invention. 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 US patent application for up to 30 months. 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 from the original grant date. Our analysis will focus on continuations — a fourth option that allows for substantially more delay.

Applicants can file a continuation at any time during the pendency of its 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 priority date of the original invention. For example, among utility patents filed after 2000, the 99^{th} percentile of the time-lag between priority date and continuation filing is 15 years. The main limitations on this tactic are the roughly $6,500 cost of filing a continuation and the statutory patent term of 20 years from the priority date (which limits the useful life of any new claims).[3]

In principle, the USPTO will grant the claims in a continuation application only if they are 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.[4] However, many observers are skeptical of the ability of a PHOSITA to forecast all the claims that could be based on the disclosure in the parent application (FTC 2003, Glazier 2003, Chiang 2010).[5] This is because the written description of the invention on many patent applications uses ambiguous or opaque language and provides little technical information that a PHOSITA could use to predict the ultimate scope of the claims (Roin 2005, Seymore 2009).[6] When continuations lead to *unexpected* change in claim scope, they become a means for applicants to "invent patents" that read on technology developed by others. This reduces incentives to avoid infringement and creates

[3]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, while USPTO fees will amount to roughly $2,000.

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

[5]This forecasting problem was especially severe before the American Inventor Protection Act (AIPA, 1999), which instituted publication of pending patent applications after 18 months.

[6]In one famous example, 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 of antibodies that were not understood at that time. It eventually asserted a patent based on a continuation application filed in 1999. See *Chiron Corp. v. Genentech, Inc., 268 F. Supp. 2d 1148 (E.D. Cal. 2002).*

a hold-up threat that may hinder follow-on innovation.

This study will not reveal whether the USPTO is striking the optimal balance in its effort to enforce the enablement and written description requirements. Instead, we provide evidence that continuations are used opportunistically in at least one important context: standardization.

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 hold-up problems when standards incorporate patented technology, most SSOs have IP polices that either encourage or require participants to disclose patents that might be infringed by a proposed standard, and to license their essential patents on fair reasonable and non-discriminatory (FRAND) terms (Shapiro 2001, Lemley 2002, Bekkers, Catalini, Martinelli, Righi & Simcoe 2017).[7] We use these disclosures to link patent applications to a potentially infringing technology (the standard). This link is not perfect. Some disclosed patents are not truly essential, and some essential patents may not be disclosed. It is reasonable, however, 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.[8]

Formal approval and publication is a key event in the standard setting process. Publication indicates that a draft specification has become stable, and signals to implementers that they can safely commit to that design in their products (Layne-Farrar 2011, Simcoe 2012). In practice, some uncertainty will be resolved in technical meetings that predate formal publication. If one looks over a multi-year period, however, publication provides a good proxy for the moment when there is a sharp drop in uncertainty about the contents of a standard, and therefore the probability that a particular patent is essential. If SSO participants use continuations to opportunistically draft claims that cover the standard, this is when we should see a jump in that activity.

We use the term "opportunism" to describe any effort to change the scope of a patent after the formation of consensus on a standard so that later-developed technology infringes. Some readers may argue that no legal prosecution strategy can be opportunistic, or that opportunism requires any new claims to exceed the boundaries of the original disclosure. Regarding the first point, there is nothing illegal about this prosecution strategy, and indeed, some U.S. Courts even appear to view it favorably.[9] Regarding the second point, the late-

[7]Although most SEPs in our study were disclosed to the European Telecommunications Standards Institute (ETSI), which has a policy of mandatory disclosure, a number of patents were disclosed to other SSOs where it is possible to offer FRAND licensing commitments without identifying specific patents.

[8]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.

[9]For example, in *Kingsdown Medical Consultants v. Hollister* (863 F.2d 867, Fed. Cir. 1988) the court

claiming behavior we document below establishes a necessary but not sufficient condition under that stricter definition of opportunism.[10] All of these arguments, however, beg the question of whose idea was embodied in the new claims, and why those claims were not part of the original application? In a highly collaborative context, such as an SSO, it seems likely that continuations filed after publication of a standard often claim ideas for which others deserve at least a share of the credit. Moreover, some SSOs (including ETSI) 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.

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 & Gupta 2018, Baron & Pohlmann 2018, Baron & Spulber 2018). This database contains patents and patent applications declared essential to seventeen SSOs and thirteen patent pools.[11] For data on application characteristics, we use the 2017 release of the Patent Examination Research Dataset (Patex) (Graham, Marco & Miller 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

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." See also *Gentry Gallery, Inc. v. Berkline Corp.* (134 F.3d 1473, Fed. Cir. 1998) or *Rambus, Inc. v. FTC* (522 F.3d 456, D.C. Cir. 2008) where this prosecution tactic was employed in the standard-setting context.

[10] It is not clear how we could measure whether a new claim was unanticipated, short of a case by case review. Prior research indicates that patent offices lacking access to SSO records struggle to identify relevant prior art (Bekkers, Martinelli & Tamagni 2020), and that some SSO participants have successfully patented ideas introduced by others (Granstrand 1999, p. 204). These findings do not speak directly to enablement, but do raise further questions about SEP validity and opportunism.

[11] 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.

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 & Pohlmann (2018).[12] This yields complete information on the standard publication date (year and month) for 23,609 SEPs. Our analysis sample 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 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.

3.2 Descriptive statistics

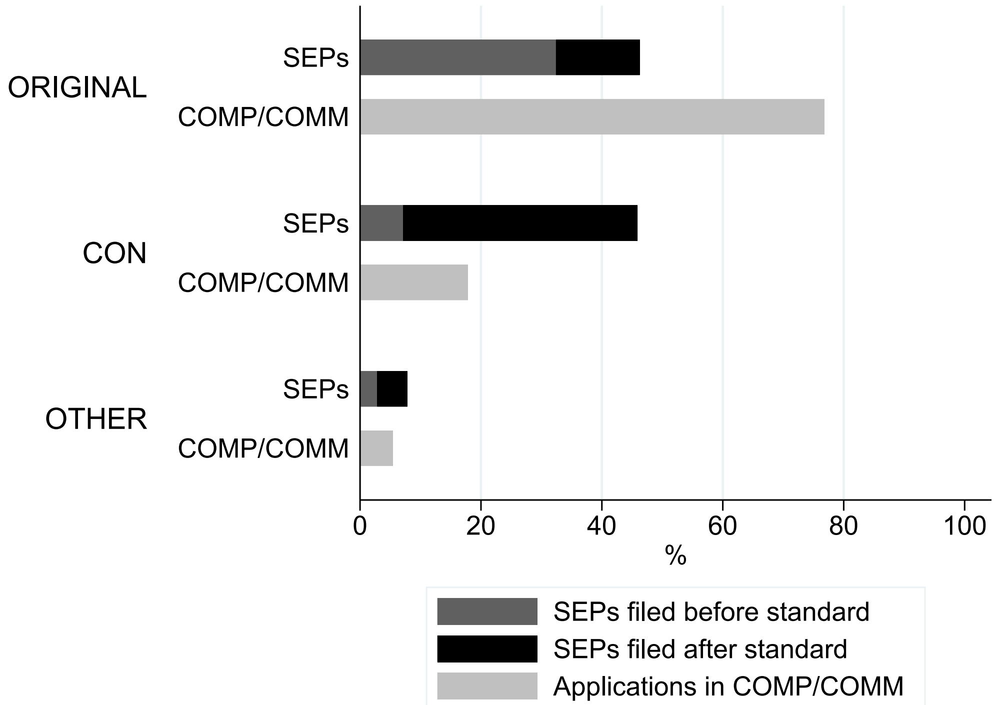
Figure 1 provides an initial look at the relationship between standards and continuations in our dataset. To create the figure, we divide all SEPs into three groups based on the type of application: continuations (CON); applications that are not continuations, continuations-in-part, divisionals or reissues of another filing (Original); and a residual category (Other) for continuations-in-part, divisionals and reissues.[13] Within each group, we also divide the SEPs into those filed before versus after the earliest standard publication date associated with their patent family. Finally, as a point of comparison, we show the relative size of the three groups for all non-SEP applications examined by the Computers and Communication area of the USPTO. These three Technology Centers (2100, 2400 and 2600) examine roughly 90% of the SEPs in our sample.

Figure 1 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 Computers and Communications reference group. One explanation is that standardization creates opportunities for strategic continuation filing that do not necessarily exist for non-SEPs. Second, many SEPs are filed after standard

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

[13] Continuations-in-part are applications that contain new claims on the invention disclosed in the parent application but also disclose new subject matter. Divisionals are applications filed because the original filing discloses more than one invention. 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 1.

Figure 1: 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.

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 patent application filing allowed by U.S. patent law. Overall, 58% of SEPs are filed after the relevant standard is published.

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.[14] We find substantial variation in "late filing" 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.[15]

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

[15]Figures A1 and A3 show similar results using an alternative definition of SEP that includes only the

3.3 Empirical strategy

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 & Pohlmann 2018) and also selected for *ex ante* quality (Rysman & 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, Scherer & Vopel 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 whose U.S. patent family is 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 and patent examiners within the USPTO. Specifically, we retain all applications in any filing-quarter-art-unit-examiner *strata* with at least one SEP and one control application.[16] 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 quarter of disposal of 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%. 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

patents and patent applications that are specifically mentioned in SSO disclosure letters (i.e. excluding undeclared U.S. family members of declared SEPs). Different versions of Figure 1 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.

[16] Art-units are groups of examiners who process relatively similar technologies, and within art-units examiners often specialize in certain technological areas (Cockburn, Kortum & Stern 2002, Lemley & Sampat 2012, Righi & 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 the eventual inclusion of a technology into a standard (Kuhn & Thompson 2019).

number of continuation filings prior to standard publication is the same for SEPs and controls by construction. Specifically, for each SEP we randomly select a single control application in the same filing-quarter-art-unit-examiner *stratum* having a pending family with the same cumulative number of continuations filed in the quarter before standard publication.[17]

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

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

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. 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.[18]

We consider three variants of Equation (1). The first variant 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).[19] In all of our models, we cluster the residual term, ε_{it}, by application and we multiply CON_{it} by 100 so the coefficient α represents a percentage point change in the probability of continuation filing.

Under a parallel trends assumption, the coefficient α in Equation (1) measures the impact of standard publication on the probability of filing a continuation. 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

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

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

[18] 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.

[19] In principle, CON_{it} is a repeated outcome, so the true DID model with application effects is identified. In practice, most applications have no continuations, and very few have more than one. That is the primary reason why we consider models that make greater use of the cross-sectional variation.

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 α_τ's and the β_τ's, the omitted category is the quarter before standard publication ($\tau = -1$), and we focus on a four-year 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.[20]

4 Results

4.1 Graphical evidence

Figure 2 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 four-year 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.[21] For panel (b), we use the 1-to-1 match described above, which ensures that SEPs and control have the same cumulative number of pre-standard continuations.

Panel (a) in Figure 2 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, consistent with the idea that key design commitments actually occur prior to formal approval and publication of the standard. Participants in the standardization process may also anticipate the final design and begin to file continuations before a standard is formally approved.

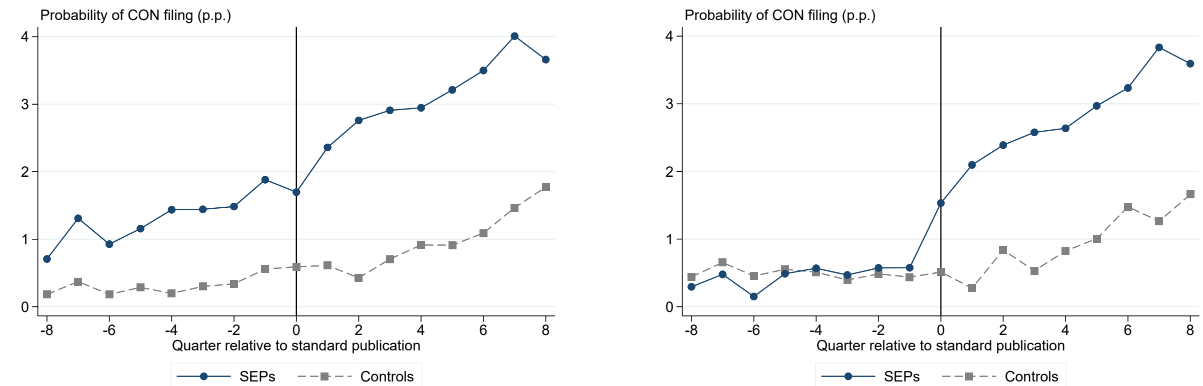
Panel (b) of Figure 2 shows that after matching SEPs and controls on the number of pre-standard continuations, the two groups are on the same trend before standard publication, and there is still a substantial increase in the probability of continuation filings for the SEPs after standard publication. Next, we analyze these patterns in a regression framework.

[20]We estimate all models that include fixed effects using the estimator described in Correia (2016).
[21]We match without replacement and break ties at random.

Figure 2: 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 4-year 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 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 quarter of family disposal or the end of year 2016 if its family is still pending.

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. 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 all three specifications is roughly 2, which corresponds to an increase in the probability of a continuation filing by about 100%.[22] Overall, the DID estimates uniformly indicate that there is an economically and statistically significant increase in SEP continuations filed after standards are published.

Table 1: Difference in differences models of continuation filing

Outcome Specification	CON × 100 OLS					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	pooled cross-section (1)	tech & cohort (2)	FE (3)	pooled cross-section (4)	tech & cohort (5)	FE (6)
PostStandard × SEP	1.13*** (0.09)	0.98*** (0.09)	1.48*** (0.09)	2.03*** (0.11)	1.90*** (0.09)	1.97*** (0.11)
SEP	0.80*** (0.05)	0.91*** (0.05)		0.00 (0.05)	0.00 (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	211,265	211,265	211,265
R-squared	0.02	0.03	0.07	0.02	0.05	0.07
Applications	53,112	53,112	53,112	10,050	10,050	10,050
Mean of outcome	1.22	1.22	1.22	1.91	1.91	1.91

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the quarter of family disposal or the end of year 2016 if its family 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 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. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

[22]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.

4.3 Event studies

Event study models can provide a closer look at the precise timing of the increase in SEP continuation filings. Figure 3 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.

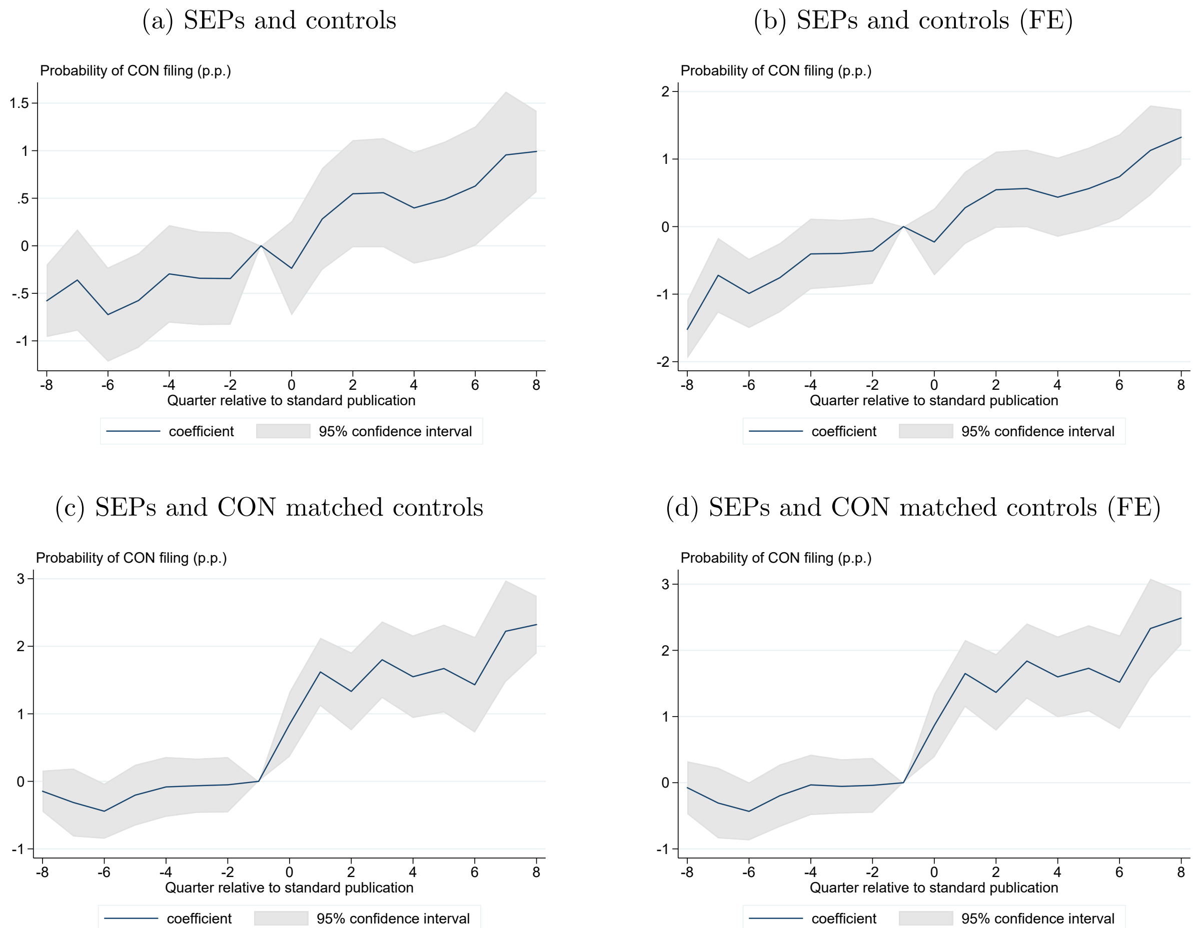
All four models show a sharp jump in the probability of a SEP continuation filing immediately after standard publication. Panels (a) and (b) also show a clear increasing trend in the probability of SEP continuations prior to standard publication. Indeed, an F-test of the hypothesis that the pre-publication coefficients are jointly equal to zero rejects the parallel-trends assumption for both models (p-values equal to 0.05 and 0.00, respectively). As we described above, this may reflect the resolution of some uncertainty about the design of the standard prior to publication.

In panels (c) and (d) we remove the divergent pre-trends by matching on the cumulative number of pre-publication continuations (which, in practice, is typically zero or one). For this sample, we cannot reject the hypothesis of parallel pre-trends.[23] Following standard publication, we continue to find a sharp increase in the probability of a continuation filing. We interpret the matched sample event study results as strong evidence of opportunistic use of the continuation procedure to seek claims covering technology that has been included in a standard. Our findings do not, however, imply that this prosecution strategy works. Indeed, Lemley & 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.[24]

[23]F-tests cannot reject the null hypothesis that the pre-standard coefficients for the SEPs are jointly equal to zero, with p-value=0.47 for panel C and p-value=0.52 for panel D.

[24]There are several ways to reconcile the two papers' findings including selection into litigation, assertion of patents that cover optional features within a standard, or implementations that are not 100% compliant.

Figure 3: Continuation filings around standard publication, DID models



Notes. Each panel plots the β_τ's (solid line) and their 95% confidence intervals (shaded area) 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 Business models

If continuations are used to obtain SEPs, it is natural to ask what sort of patent 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. The results are in Table 2.[25]

The results 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 four models, the two groups with the highest correlation between standard publication and continuation filing are patent holding companies and product suppliers.[26] 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).[27] 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 have an incentive to inflate their SEP portfolios to protect their investments from hold-up risks, increase their bargaining power in cross-licensing negotiations, and obtain freedom to operate (Hall & Ziedonis 2001, Shapiro 2001, Ziedonis 2004).

[25]If a SEP is associated with multiple companies, we use the business model of the first company in alphabetical order. There are only 40 SEPs potentially associated with multiple companies, and the results are robust to excluding these observations.

[26]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.

[27]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 0.02 in the other models.

Table 2: Heterogenous effects by business model

Outcome Specification	CON × 100 OLS					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	pooled cross-section	tech & cohort	FE	pooled cross-section	tech & cohort	FE
	(1)	(2)	(3)	(4)	(5)	(6)
PostStandard × SEP × patent holding company	2.08*** (0.32)	1.89*** (0.28)	2.97*** (0.34)	3.29*** (0.29)	3.24*** (0.29)	3.61*** (0.34)
PostStandard × SEP × components	-1.08*** (0.16)	-1.19*** (0.14)	-0.50*** (0.16)	-0.41*** (0.15)	-0.45*** (0.14)	-0.23 (0.16)
PostStandard × SEP × products	1.62*** (0.12)	1.49*** (0.11)	1.90*** (0.12)	2.57*** (0.13)	2.43*** (0.11)	2.50*** (0.13)
PostStandard × SEP × other	0.68*** (0.24)	0.58*** (0.23)	1.37*** (0.26)	1.40*** (0.24)	1.33*** (0.22)	1.52*** (0.25)
SEP × patent holding company	1.06*** (0.24)	1.00*** (0.19)		0.12 (0.16)	-0.26 (0.21)	
SEP × components	0.68*** (0.12)	0.82*** (0.10)		0.01 (0.09)	0.12 (0.08)	
SEP × products	0.85*** (0.07)	0.94*** (0.06)		0.02 (0.05)	0.02 (0.06)	
SEP × other	0.58*** (0.14)	0.70*** (0.14)		-0.16** (0.07)	-0.18 (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	211,265	211,265	211,265
R-squared	0.02	0.03	0.07	0.03	0.05	0.07
Applications	53,112	53,112	53,112	10,050	10,050	10,050
Mean of outcome	1.22	1.22	1.22	1.91	1.91	1.91

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

4.5 Robustness checks

We conduct a series of robustness checks, reporting all results in the appendix. First, we consider an alternative way to define the sample (Table A2). 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 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.

Second, instead of matching on pre-standard trends, we control for the anticipation effects of standard publication, using the baseline samples of SEPs and controls for Tables 1 and A2. 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 & Reif 2015). The results are in Table A3, and show that, while 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.

Third, because continuations are a rare outcome — many applications have zero or one continuation — we estimate a series of piecewise constant hazard regressions on samples similar to that for the main analysis and for Table A2. In these regressions, the outcome is the probability of continuation conditional on not having any prior continuations.[28] In all models, SEPs have a higher baseline hazard of continuation and standard publication has a positive and large correlation with the probability of filing the first continuation.

Fourth, we estimate all models in the main analysis and in the previous robustness checks using samples that contain only SEPs filed before standard publication (Tables A6 and A7). 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

[28] The sample for Table A4 is contructed 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, (ii) family disposal, or (iii) the end of year 2016. The sample for Table A5 is similar but, as in Table A2, uses the narrower definition of SEP and information on standards and pendency of the earliest application in each family.

$PostStandard_{it}$ 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 one of these specifications.

5 Claim language convergence

Up to this point, our evidence that patent applicants are using continuations opportunistically is based on the timing of those applications. Ideally, one might read the original disclosure, the new claims and the relevant standards to see whether there is evidence of opportunistic claiming. Unfortunately, that is a very time-intensive process requiring access to the text of standards and also expertise in interpreting patent claims.[29] As an alternative, we measure the similarity of claims across pairs of applications linked to the same standard, and compare the similarity of claims filed before versus 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.[30]

Suppose k indexes pairs of continuations essential for the same standard, both continuations are filed after standard publication, and each has a parent application filed before standard publication. Our measure of claim similarity is a Jaccard index (Arts, Cassiman & Gomez 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.[31] We retain all pairs where the 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.

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 regressions.

[29] Brachtendorf, Gaessler & Harhoff (2019) pursues a similar approach based on automated text matching.

[30] 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.

[31] 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.

Table 3: Regression models of Jaccard similarity

Outcome	Jaccard similarity		
Specification	OLS		
Model	no controls	pair FE	application characteristics
	(1)	(2)	(3)
Post-standard CONs	2.17***	2.17***	0.61***
	(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, number of independent claims and number of words per independent claim. Standard errors clustered by pair in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The first column in Table 3 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.

6 Conclusion

We study the strategic use of continuations to patent technologies developed after the original filing date of a patent. Although continuations have featured prominently in patent policy debates, empirical evidence of this behavior was limited due to measurement challenges. We exploit the disclosure of SEPs during the ICT standardization process to link patents with standards, and to measure the association between the resolution of uncertainty on standard design and the use of continuations. Consistent with the idea that companies use continuations to cover standards after consensus forms around a specific design, we find that a large share of SEPs are continuations filed after standard publication, and that there is a large increase in the continuations of SEPs immediately after a standard is published. We also show that claims in continuations filed post-standard are more similar to each other than the claims of their pre-standard parent applications.

From a patent policy perspective, continuations present a complex tradeoff. 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. On the other hand, continuations are problematic because they increase uncertainty about the actual scope of patent protection. Unexpected changes in patent scope increase the likelihood of inadvertent infringement, reduce incentives to invent around patents, and create a hold-up threat that can increase the costs of technology adoption.

The USPTO could address the downsides of continuation practice by increasing fees, restricting the use of lengthy continuation "chains" (e.g. by capping the number of links), or by creating intervening-user rights that reduce incentives for opportunistic claiming. With respect to SEPs, SSOs could adopt similar rules as part of their intellectual property policies. It is not easy, however, to predict the behavior of patentees and standards developers under these counterfactual policies. Without continuations, we might see more 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 decisions instead of (as some observers claim) leaving the entire problem for patent attorneys to sort out *ex post*.

A full accounting of the costs and benefits of continuation lies beyond the scope of this paper, and presents an interesting topic for future research. Moreover, 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 might study 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.

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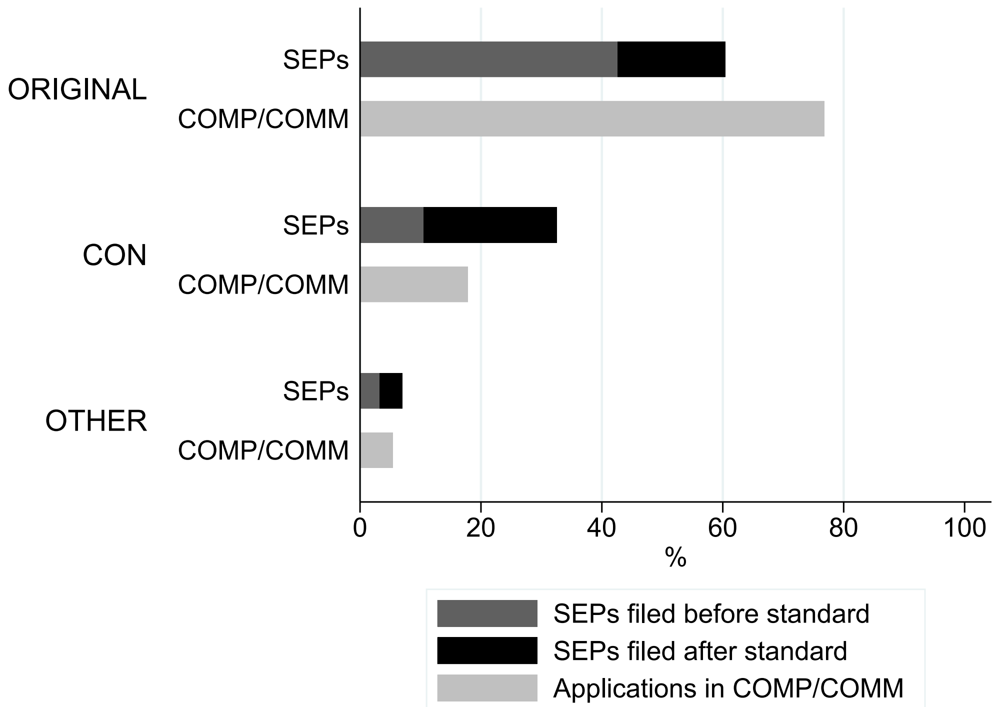
Appendix

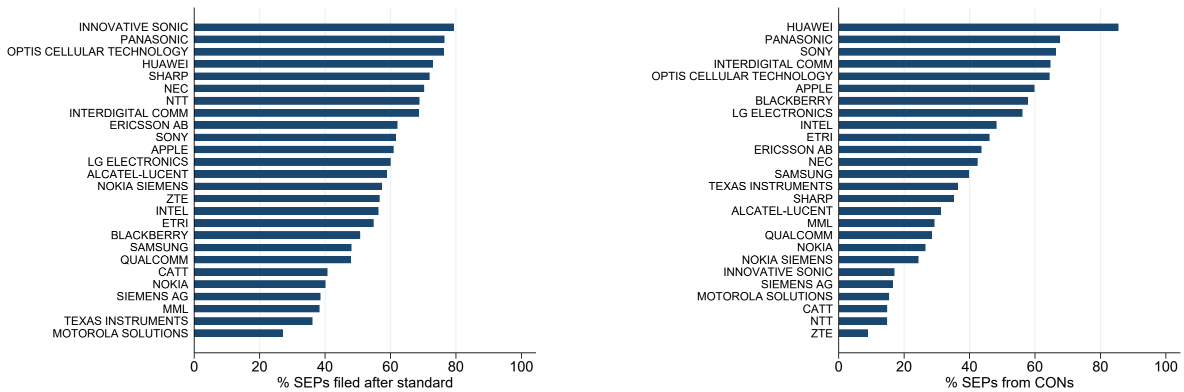
Figure A1: Frequency and timing of SEP continuations, narrower definition of SEP



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)

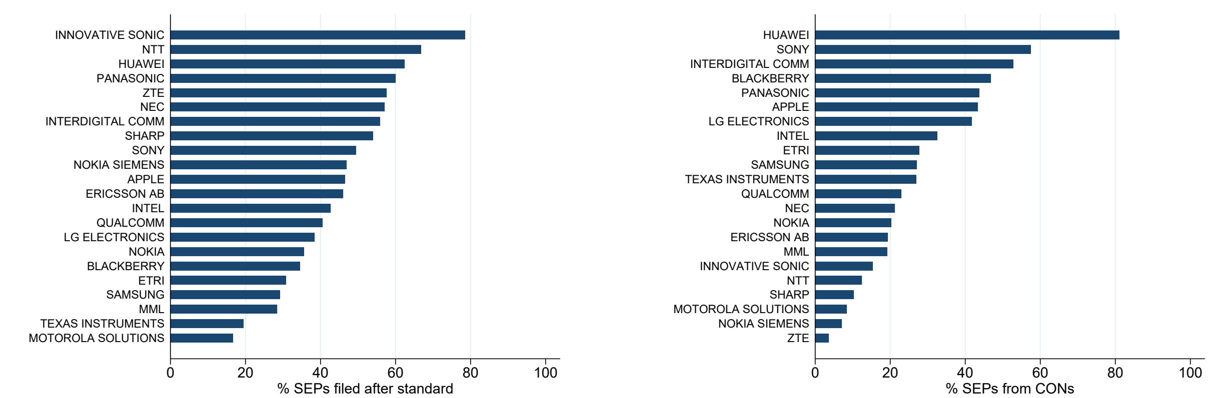
(a) SEPs filed after standard (b) SEPs filed as CONs



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.

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	0	0	0	1
CONs	959,733	0.013	0.166	0	0	0	0	98
PostStandard × SEP	959,733	0.086	0.281	0	0	0	0	1
SEP	959,733	0.137	0.343	0	0	0	0	1
Age	959,733	10.425	8.580	0	4	9	15	64

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the quarter of family disposal or the end of year 2016 if its family 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 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).

Table A2: Difference in differences models of continuation filing, declared SEPs and controls

Outcome	CON × 100					
Specification	OLS					
Sample	SEPs and controls			SEPs and controls matched on pre-standard CONs		
Model	pooled cross-section	tech & cohort	FE	pooled cross-section	tech & cohort	FE
	(1)	(2)	(3)	(4)	(5)	(6)
PostStandard × SEP	1.73***	1.66***	2.09***	1.75***	1.77***	2.28***
	(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	168,883	168,883	168,883
R-squared	0.01	0.02	0.08	0.02	0.05	0.08
Applications	46,919	46,919	46,919	9,446	9,446	9,446
Mean of outcome	0.90	0.90	0.90	1.33	1.33	1.33

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 A3: Difference in differences models of continuation filing, anticipation

Outcome	CON × 100					
Specification	OLS					
Sample	Info on the entire family			Info on first application in the family		
Model	pooled cross-section	tech & cohort	FE	pooled cross-section	tech & cohort	FE
	(1)	(2)	(3)	(4)	(5)	(6)
PostStandard × SEP	1.17***	1.05***	1.99***	1.74***	1.64***	2.08***
	(0.10)	(0.09)	(0.12)	(0.08)	(0.08)	(0.15)
Standard $(t-1)$	0.57***	0.59***	1.28***	0.67***	0.60***	0.60***
	(0.19)	(0.19)	(0.21)	(0.15)	(0.15)	(0.18)
Standard $(t-2)$	0.23	0.25	0.92***	-0.07	-0.13	-0.10
	(0.18)	(0.18)	(0.20)	(0.08)	(0.09)	(0.12)
Standard $(t-3)$	0.23	0.26	0.88***	-0.06	-0.12	-0.10
	(0.19)	(0.19)	(0.20)	(0.08)	(0.09)	(0.11)
Standard $(t-4)$	0.28	0.30	0.85***	-0.16**	-0.22***	-0.22**
	(0.19)	(0.19)	(0.21)	(0.06)	(0.07)	(0.09)
SEP	0.66***	0.75***		-0.07***	0.08**	
	(0.06)	(0.06)		(0.03)	(0.04)	
Quarter FE	✓	✓	✓	✓	✓	✓
Age FE	✓			✓		
AU-E-FQ FE		✓			✓	
Age^2, age^3 & age^4		✓	✓		✓	✓
Application FE			✓			✓
Observations	927,567	927,567	927,567	742,204	742,204	742,204
R-squared	0.02	0.03	0.07	0.01	0.02	0.08
Applications	53,112	53,112	53,112	46,919	46,919	46,919
Mean of outcome	1.12	1.12	1.12	0.85	0.85	0.85

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the quarter of family disposal or the end of year 2016 if its family is still pending in columns (1)-(3), and to the quarter of disposal or the end of year 2016 if still pending in columns (4)-(6). 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 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 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 control applications in art-unit-examiner-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 A4: Hazard models of continuation filing

Outcome	CON × 100			
Specification	OLS			
Models	Myopic		Quasi-myopic	
Model	pooled cross-section	tech & cohort	pooled cross-section	tech & cohort
	(1)	(2)	(3)	(4)
PostStandard × SEP	1.02***	1.09***	1.11***	1.20***
	(0.08)	(0.08)	(0.08)	(0.08)
Standard ($t-1$)			0.66***	0.74***
			(0.17)	(0.17)
Standard ($t-2$)			0.47***	0.54***
			(0.17)	(0.17)
Standard ($t-3$)			0.35**	0.42**
			(0.17)	(0.17)
Standard ($t-4$)			0.15	0.19
			(0.16)	(0.16)
SEP	0.49***	0.53***	0.36***	0.38***
	(0.04)	(0.04)	(0.04)	(0.04)
Quarter FE	✓	✓	✓	✓
Age FE	✓		✓	
AU-E-FQ FE		✓		✓
Age^2, age^3 & age^4		✓		✓
Observations	1,071,574	1,071,574	1,052,185	1,052,186
R-squared	0.01	0.02	0.01	0.02
Applications	65,486	65,486	65,486	65,486
Mean of outcome	0.81	0.81	0.78	0.78

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 family disposal or the end of year 2016 if censored. 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. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A5: Hazard models of continuation filing, declared SEPs and controls

Outcome	CON × 100			
Specification	OLS			
Models	Myopic		Quasi-myopic	
Model	pooled cross-section (1)	tech & cohort (2)	pooled cross-section (3)	tech & cohort (4)
PostStandard × SEP	1.17***	1.24***	1.23***	1.33***
	(0.08)	(0.08)	(0.08)	(0.08)
Standard $(t-1)$			0.77***	0.86***
			(0.18)	(0.18)
Standard $(t-2)$			0.34**	0.42***
			(0.16)	(0.16)
Standard $(t-3)$			0.32*	0.39**
			(0.16)	(0.17)
Standard $(t-4)$			0.11	0.15
			(0.15)	(0.15)
SEP	0.44***	0.50***	0.32***	0.35***
	(0.04)	(0.04)	(0.04)	(0.04)
Quarter FE	✓	✓	✓	✓
Age FE	✓		✓	
AU-E-FQ FE		✓		✓
Age^2, age^3 & age^4		✓		✓
Observations	1,004,990	1,004,995	988,569	988,570
R-squared	0.01	0.02	0.01	0.02
Applications	63,158	63,158	63,158	63,158
Mean of outcome	0.83	0.83	0.79	0.79

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 censored. 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. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A6: Difference in differences and hazard models of continuation filing, only SEPs

Outcome	CON × 100									
Specification	OLS									
Models	DID, myopic			DID, quasi-myopic			Hazard, myopic		Hazard, quasi-myopic	
Model	cross-section	tech cohort	FE	cross-section	tech cohort	FE	cross-section	tech cohort	cross-section	tech cohort
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PostStandard	0.26***	0.20*	0.19	0.33***	0.47***	0.52***	0.15*	0.39***	0.21**	0.67***
	(0.10)	(0.12)	(0.12)	(0.10)	(0.15)	(0.16)	(0.09)	(0.13)	(0.09)	(0.17)
Standard $(t-1)$				0.39**	0.58***	0.61***			0.31*	0.54***
				(0.18)	(0.20)	(0.21)			(0.17)	(0.20)
Standard $(t-2)$				0.07	0.27	0.31			0.20	0.45**
				(0.17)	(0.19)	(0.19)			(0.17)	(0.20)
Standard $(t-3)$				0.17	0.38**	0.42**			0.20	0.43**
				(0.17)	(0.20)	(0.20)			(0.17)	(0.19)
Standard $(t-4)$				0.18	0.36*	0.41**			-0.03	0.14
				(0.18)	(0.19)	(0.19)			(0.16)	(0.17)
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓			✓			✓		✓	
AU-E-FQ FE		✓			✓			✓		✓
Age^2, age^3 & age^4		✓	✓		✓	✓		✓		✓
Application FE			✓			✓				
Observations	162,126	161,936	162,126	153,354	153,168	153,354	131,348	131,211	128,008	127,872
R-squared	0.02	0.06	0.07	0.02	0.06	0.07	0.02	0.08	0.02	0.08
Applications	7,019	7,012	7,019	7,019	7,012	7,019	7,019	7,003	7,019	7,003
Mean of outcome	2.67	2.67	2.67	2.44	2.44	2.44	1.80	1.80	1.73	1.72

Notes. The unit of observation is an application-quarter. An application is included in the sample from its filing quarter to the quarter of family disposal or the end of year 2016 if its family is still pending in columns (1)-(6), and to the earliest of the filing quarter of its first continuation, the quarter of family disposal or the end of year 2016 if censored in columns (7)-(10). 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. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A7: Difference in differences and hazard models of continuation filing, only declared SEPs

Outcome	CON × 100									
Specification	OLS									
Models	DID, myopic			DID, quasi-myopic			Hazard, myopic		Hazard, quasi-myopic	
Model	cross-section (1)	tech cohort (2)	FE (3)	cross-section (4)	tech cohort (5)	FE (6)	cross-section (7)	tech cohort (8)	cross-section (9)	tech cohort (10)
PostStandard	0.22**	0.41***	0.38***	0.27***	0.72***	0.77***	0.15*	0.49***	0.19**	0.80***
	(0.09)	(0.13)	(0.14)	(0.09)	(0.17)	(0.21)	(0.09)	(0.14)	(0.09)	(0.18)
Standard $(t-1)$				0.37**	0.71***	0.74***			0.35**	0.70***
				(0.18)	(0.21)	(0.23)			(0.18)	(0.21)
Standard $(t-2)$				0.07	0.39**	0.44**			0.02	0.39**
				(0.16)	(0.19)	(0.20)			(0.16)	(0.19)
Standard $(t-3)$				0.12	0.40**	0.45**			0.12	0.45**
				(0.17)	(0.19)	(0.20)			(0.17)	(0.19)
Standard $(t-4)$				-0.07	0.18	0.22			-0.09	0.16
				(0.16)	(0.18)	(0.18)			(0.16)	(0.17)
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓			✓			✓		✓	
AU-E-FQ FE		✓			✓			✓		✓
Age^2, age^3 & age^4		✓	✓		✓	✓		✓		✓
Application FE			✓			✓				
Observations	125,427	125,427	125,427	122,606	122,608	122,608	121,914	121,907	119,324	119,319
R-squared	0.02	0.07	0.08	0.02	0.08	0.09	0.02	0.08	0.02	0.08
Applications	6,834	6,834	6,834	6,834	6,834	6,834	6,834	6,827	6,834	6,827
Mean of outcome	1.93	1.93	1.93	1.84	1.84	1.84	1.86	1.85	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)-(6), 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 (7)-(10). 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. Standard errors clustered by application in parentheses. *** p<0.01, ** p<0.05, * p<0.1