The effect of patent scope on declaration of standard essential patents

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Abstract

Given the growing importance of technology standards and their overall effect on inventive activity (e.g., division of innovative activity, follow-on innovation, competition), scholars have examined various aspects of technology standard setting, including the efficiency of standard setting organizations, innovation outcome, and litigation involving standard essential patents (SEPs). However, investigation into how patent and invention attributes influence the declaration of SEPs is scarce. In this study, we examine the effect of patent scope on the declaration of SEPs and how this relationship is moderated by various invention attributes (i.e., inventor size, quality, and novelty). We find that narrowing of patent scope leads to a decline in declaration of SEPs. Furthermore, we find that the effect is stronger for inventions produced by small firms, high quality inventions, and novel inventions. These results are consistent with the notion that, when participating in technology standard setting, inventing firms behave strategically to protect value from their inventions.

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1 Introduction

Technology standard setting is a critical step in today's innovation process, especially in complex product industries such as information technology and communications where product development requires the use of interdependent technologies produced by multiple firms. For instance, producing a modern laptop computer requires implementation of hundreds of technical standards developed by various, independent entities (Biddle, White, & Woods, 2010). Given the need for such coordination, various organizations, which often operate on voluntary basis, work with the stakeholders to agree on technology standards as well as on licensing commitment. However, standard setting process has been characterized as highly politicized by self-interested firms seeking to maximize their own profits (Shapiro & Varian, 1998; T. Simcoe, 2012). Furthermore, even after standards have been established, lawsuits are quite prevalent between inventors and implementers over "fair" licensing royalty and the use of the technologies involved (Bekkers, Catalini, Martinelli, Righi, & Simcoe, 2023; Lerner & Tirole, 2015).

Given the growing importance of technology standards and the complexities involved, scholars have examined various aspects of standard setting, including efficiency of standard setting organizations (SSOs) (Bar & Leiponen, 2014; Delcamp & Leiponen, 2014; Leiponen, 2008; T. S. Simcoe, Graham, & Feldman, 2009), innovation outcome (Manders, de Vries, & Blind, 2016; Wen, Forman, & Jarvenpaa, 2022), and litigation involving inventors and implementers of standard essential technologies (Lemley & Shapiro, 2013; Lerner & Tirole, 2015). Despite these efforts, an area that has not received as much attention from prior studies is the scope of the standard essential patents (SEPs), which can in part determine "fair" licensing royalty as well as decisions in legal disputes.[1] [2] In this study, we build on

[1] A notable exception is Kuhn and Thompson (2019), who explore the effect of patent scope on declaration of standard essential patents as a part of a demonstration for using the patent scope measure that they introduce. However, they examine only the direct effect and do not fully explore potential mechanisms driving the relationship. This study explores a mechanism driving the relationship as well as heterogeneous effects of patent scope.

[2] While this study uses the same scope measure (number of words in the first independent claim) as Kuhn and Thompson (2019), the instrument used is significantly different from "examiner toughness" used by

this literature by exploring the degree to which patent scope influences declaration of SEPs and how this relationship is moderated by inventor and invention characteristics.

To facilitate our study, we construct a sample of patents produced by ETSI (The European Telecommunications Standards Institute) member firms that have declared at least one patent as standard essential during the sample period.[3] We also limit the sample to the patents in the same CPC (Cooperative Patent Classification) subclass as those declared standard essential. The final sample consists of 778,321 SEPs and non-SEPs produced by 634 patent assignees between years 2001 and 2018. For the patent scope measure, we follow Kuhn and Thompson (2019) and compute the change in the number of words in the first claim between patent grants and pre-grant publications, where an increase in the number of words indicates narrowing of patent scope.[4] To mitigate endogeneity concerns, we instrument the change in the number of words with the publication of a similar, prior patent during the examination period of the focal patent.[5] Our findings indicate that narrowing of patent scope leads to a decline in the likelihood that a patent is declared standard essential. Additionally, the relationship is stronger for inventions produced by small firms, for higher-quality inventions, and for novel inventions.

We contribute primarily to the literature on standard essential patents, in particular, relating to patent scope, inventor size, and the nature of the inventions underlying SEPs. Scope is an attribute of a patent that contributes significantly to determining the amount of value that firms can capture from their patented inventions, especially in standard-driven industries. Accordingly, under the current approach to standard setting, it is a key factor driving outcomes of licensing agreements and ex-post legal disputes. This study provides

Kuhn and Thompson (2019). This is to mitigate the possibility raised by a recent study showing that patent applicants might be able to avoid "tough" examiners through strategic citing (Barber IV & Diestre, 2022).

[3]We thank Qualcomm for the provision of the dataset consisting of declared ETSI standard essential patents along with the declaring firms and other relevant information.

[4]Kuhn and Thompson (2019) provide a detailed discussion of how the number of words in the first claim reflects the scope of a patent.

[5]The publication of a similar, prior patent during the patent examination period of the focal patent should lead to an increase in the number of words in the focal patent's claims as the focal patent's scope would be limited by the similar, prior patent.

evidence that patent scope indeed is an important factor driving the declaration of standard essential patents and that this effect varies depending on inventor size and the nature of the underlying invention (i.e., quality, novelty). The findings are consistent with the notion that firms behave in a way that protects returns from their inventions, especially given the uncertainties arising from ex-ante loose licensing commitments and potential, ex-post legal disputes.

Section 2 discusses the literature and hypotheses, Section 3 details sample construction and descriptive statistics, Sections 4 presents descriptive evidence, and Sections 5 and 6 present empirical specification and estimation results including an instrumental variables analysis. Section 7 summarizes the main findings and discusses potential improvements for future studies.

2 Background and Hypotheses

With the growing complexities involved in developing technology-driven products, standard setting and coordination among participating firms have become a central issue for innovation, especially in complex product industries such as electronics and communications (Biddle, Curci, Haslach, & Marchant, 2011; Blind, Kenney, Leiponen, & Simcoe, 2023). Not only does standard setting facilitates interoperability across technologies developed by multiple firms, but it also promotes division of innovative labor (Langlois & Robertson, 1992; T. Simcoe, 2012), follow-on innovation (Rysman & Simcoe, 2008), and entry into the standard-driven product markets (Kogut, Walker, & Kim, 1995; Koski & Kretschmer, 2005; Lampe & Moser, 2016; Swann, 2010). However, despite such need for coordination and significant implications that standard setting can have, standard setting process has been characterized as highly politicized by independent firms trying to maximize their private value (Shapiro & Varian, 1998; T. Simcoe, 2012).

Technology standards can be established in both formal and informal organizations (Blind

et al., 2023; Delcamp & Leiponen, 2014; Leiponen, 2008) and through different processes (David & Greenstein, 1990; Farrell & Simcoe, 2012). However, in most cases, standard setting organizations operate under consensus rules and non-binding agreements (Lerner & Tirole, 2015; Jones, Leiponen, & Vasudeva, 2021). Given such lack of legally binding contracts and enforcement power of standard setting organizations, there is substantial flexibility for participating firms to act strategically in an effort to maximize their private value (Bar & Leiponen, 2014; Dokko & Rosenkopf, 2010; Fiedler, Larrain, & Prüfer, 2023; Jones et al., 2021; Lemley, 2007; Leiponen, 2008; T. Simcoe, 2012, 2012; Thomas, Leiponen, & Koutroumpis, 2023; Wiegmann, de Vries, & Blind, 2017). In turn, these behaviors can slow down the standard setting process (T. S. Simcoe et al., 2009; T. Simcoe, 2012) and even lead to ex post legal disputes over fair licensing royalties and boundaries of the licensed inventions (Lemley & Shapiro, 2013; Lerner & Tirole, 2015; Jones et al., 2021; T. S. Simcoe et al., 2009). Therefore, the question of value capture is one of the central issues for firms participating in standard setting. In this study, we explore the extent to which patent scope, a dimension of patent that is tightly linked to value appropriation (Cohen, Nelson, & Walsh, 2000; Teece, 1986), affects the likelihood that a patent is declared standard essential and how this relationship is moderated by firm and invention characteristics.

Because standard essential patents are those that implementers of the corresponding standard by definition infringe on, firms with SEPs can have a substantial advantage in licensing negotiations (Blind et al., 2023; Gilbert, 2010; Lerner & Tirole, 2015). Given this, SSOs often require member firms to commit to making standard technologies available for use – commonly under FRAND (fair, reasonable, and non-discrimitory) terms, and sometimes even under royalty-free terms. However, defining what constitutes FRAND for licensing can be controversial. At the same time, there is a level of agreement that FRAND licensing terms should reflect pre-standard bargaining outcome (Contreras & Layne-Farrar, 2017; Lerner & Tirole, 2015; Lemley & Shapiro, 2013; Swanson & Baumol, 2005), which in part is determined by the scope of the patent being licensed. Thus, an inventing firm should be

able to appropriate more returns from an SEP with a broad scope than from an SEP with a narrow scope.

The loose, FRAND licensing commitments made by inventing firms during standard setting process also are subject to ex post legal disputes (Lemley & Shapiro, 2013; Lerner & Tirole, 2015; T. S. Simcoe et al., 2009; Swanson & Baumol, 2005; Schmalensee, 2009). For instance, multinational corporations such as Apple, Google, and Samsung have been engaged in legal disputes over licensing commitments that they have pledged during communications standard setting (Lerner & Tirole, 2015). Accordingly, Bekkers et al. (2023) show evidence that declared SEPs are more likely to be litigated than non-SEPs randomly selected from the same application year and technology class.

Therefore, given that patent scope influences the degree to which inventing firms participating in standard setting can appropriate returns from their inventions, we hypothesize that firms are more likely to declare a patent standard essential when the patent has a broad scope than they are when a patent has a narrow scope.

Hypothesis 1. *SSO member firms are more likely to declare a patent standard essential when the patent has a broad scope than they are when it has a narrow scope.*

2.1 Firm size

While patent scope in general should help inventing firms to appropriate returns from their inventions, studies have shown that the effect is likely to vary across firm size (Arora & Ceccagnoli, 2006; Gans, Hsu, & Stern, 2000; Teece, 1986). Such heterogeneity exists because large firms have more resources and thus are usually superior than small firms in extracting value from their inventions (Arora, Cohen, Lee, & Sebastian, 2023; Cohen & Klepper, 1996; Teece, 1986; Bekkers et al., 2023; T. S. Simcoe et al., 2009). Accordingly, T. S. Simcoe et al. (2009) show that, within the standard setting context, small firms are more likely to file a lawsuit than large firms because they are not able to seek returns in the downstream markets that require complementary assets. Bekkers et al. (2023) also find that inventing firms with

downstream complementary assets are more likely to commit to royalty-free licensing. Given this difference, we hypothesize that small inventing firms are more likely to declare a patent standard essential when the patent is broad than when it is narrow.

Hypothesis 2. *Small SSO member firms are more likely than large SSO member firms to declare a patent standard essential when the patent has a broad scope than they are when the patent has a narrow scope.*

2.2 Invention quality

Inventions also differ in their quality. Prior studies show that the quality distribution for patented inventions has a wide range and that high quality inventions tend to imply higher commercial value (Astebro, 2003; Gambardella, Harhoff, & Verspagen, 2008; Gambardella, 2013; Hall, Jaffe, & Trajtenberg, 2005; Harhoff, Narin, Scherer, & Vopel, 1999; Kogan, Papanikolaou, Seru, & Stoffman, 2017; Lanjouw & Schankerman, 2004; Trajtenberg, 1990). Accordingly, even in the standard setting context, firms are more likely to make specific declarations (as opposed to generic blanket disclosures) when inventions are high quality because specific declarations allow firms to command higher royalty and render favorable decisions in legal disputes (Lerner, Tabakovic, & Tirole, 2016). Given that returns from high quality inventions are likely to be higher both in general and in the standard setting context, patent protection will be more important for high quality inventions than for low quality inventions when firms declare SEPs. Thus, we hypothesize that the patent scope-SEP relationship would be stronger for high quality inventions than for low quality inventions.

Hypothesis 3. *SSO member firms rely more on patent scope in declaring a patent standard essential when the underlying invention is high quality than when it is low quality.*

2.3 Invention novelty

Some inventions are more novel than others in the sense that novel inventions are less familiar combinations of technological components than incremental inventions (Fleming, 2001). Given the lack (or a low level) of prior knowledge about the technological components and their combinations, delineating the boundaries and ascertaining the value of a novel invention is likely to be more challenging than it would be for an incremental invention (Kline & Rosenberg, 1986; Nelson, 1959; Rosenberg, 1998). Thus, during both licensing negotiation and legal disputes, a disagreement over the boundaries and the value of a novel invention is more likely to occur than it would for an incremental invention. In turn, patent protection would be more critical for novel inventions than for incremental inventions to protect the value of the inventions. Accordingly, we hypothesize that the patent scope-SEP relationship would be stronger for novel inventions than for incremental inventions.

Hypothesis 4. *SSO member firms rely more on patent scope in declaring a patent standard essential when the underlying invention is more novel than when it is incremental.*

3 Data and Measures

We construct a sample of 778,321 patents issued to 634 patent assigneees between years 2001 and 2018. The sample includes all the patents (both SEP and non-SEP) that are produced by ETSI member firms that have declared at least one standard essential patent during the sample period and in the same CPC subclasses as the SEPs.

We first obtain the list of patents declared standard essential by ETSI member firms as well as the names of those member firms. To identify ETSI member firms from the patent database, we match the patents from the ETSI SEP dataset with the patents from PatentsView maintained by the USPTO. We use the patent assignees associated with the matched patents to identify all the patents that were produced by the assignees that have declared at least one standard essential patent during the sample period. Furthermore, we

use the CPC data from PatentsView to identify the CPC subclasss of the SEPs and limit the sample to those CPC subclasses.

The dependent variable for this study is a dummy variable taking a value of 1 if a patent was declared standard essential, and 0 other wise.

3.1 Patent scope

We follow Kuhn and Thompson (2019) and use the change in the number of words in the first claim of a patent between granted patents and their pre-grant publications to approximate the change in patent scope, with a higher value indicating a narrower scope. To obtain the number of words in the first claim of the sample patents, we first extract the claims of the patents from the claims dataset in PatentsView. We keep only the first independent claim of each patent and clean the text by dropping stopwords and numerical values that are enumeration markers. We then count the number of remaining words. We repeat the process for pre-grant publications of the corresponding patents, which became available from year 2001. We obtain the measure of scope change by subtracting the number of words in the first claim of a pre-grant publication from the number in the first claim of the corresponding, granted patent. We normalize the change in the number of words within each CPC subclass. A higher z-score indicates more narrowing of the scope.

3.2 Firm size

Given the lack of a direct firm size measure, we proxy firm size using patent stock, which is highly correlated with firm sales. For each firm, we compute the cumulative number of patents produced by the firm within each CPC subclass, while depreciating the cumulative number by fifteen percent per year.[6] [7] For the regression analysis, we construct a dummy

[6] $Patent\ stock_{i,j,t} = 0.85 \times Cumulative\ number\ of\ patents\ produced_{i,j,t-1} + Patents\ produced_{i,j,t}$, where i denotes firm i, j denotes CPC subclass j, and t denotes year t.

[7] The empirical results are consistent even when using firm-level patent stock instead of patent stock within firm-patent class pairs.

variable taking a value of 1 for patents produced by firms with a patent stock in the top quartile of the patent stock distribution, and 0 otherwise.

For a subset of the assignees that are public firms represented in Compustat, we add sales information from Computstat and use sales as an alternative measure of firm size.

3.3 Invention quality

Following prior studies (Trajtenberg, 1990; Gambardella et al., 2008; Hall et al., 2005; Lanjouw & Schankerman, 2004), we measure the quality of an invention based on the number of citations that the invention receives from subsequent inventions, with a higher value indicating higher quality. To the extent that an invention induces follow-on invention as reflected in the citations that the patent receives, our measure captures the technical quality of the invention (Arora et al., 2023). To account for the systematic differences in the citation patterns across technology classes and to account for the truncation for the patents published during the latter years of our sample period, we normalize the citation count by CPC subclass-year average. For the regression analysis, we construct a dummy variable taking a value of 1 for patents in the top quartile of the quality distribution, and 0 otherwise.

As an alternative measure, we use the number of jurisdictions that an invention is patented in to proxy the quality of the inventions. We limit the jurisdictions to USPTO, EPO, and JPO.[8]

3.4 Invention novelty

In order to capture the novelty of an invention, for each patent, we follow Fleming (2001) and construct a measure of novelty based on the number of times a combination of technology classes (Cooperative Patent Classification groups) has been used prior to the focal patent – i.e., combination familiarity. More specifically, we implement the following: $C_i = \sum_A D$,

[8]The results are consistent when we do not limit jurisdictions and use all jurisdictions in which an invention is patented.

where C_i is the technology class combination used in invention i and D is a dummy indicating whether a prior invention used the same technology class combination as invention i. A indicates all inventions that came before invention i. A lower value indicates that an invention is more novel, whereas a higher value indicates that an invention is more incremental. For the regression analysis, we construct a dummy variable taking a value of 1 for patents with a combination familiarity is in the bottom half of the average similarity score distribution, and 0 otherwise.

As an alternative measure of novelty, we employ the *originality* measure indicating the range of technical knowledge an invention draws on (Hall, Jaffe, & Trajtenberg, 2001; Trajtenberg, Henderson, & Jaffe, 1997).

4 Descriptive Statistics

Table 1 presents the summary statistics for the main variables used in the analysis. About 4% of the patents included in the sample are declared standard essential with ETSI, with a standard deviation of 0.19. The change in the number of words in the first claim between granted patent and pre-grant publication is approximately 27.2, with a standard deviation of 36.4. The increase indicates that on average patent scope is narrowed during the examination period. The table also reports distributions for moderating variables.

[Insert Table 1 here]

Figure 1 presents the mean comparison of the share of SEPs between patents with a broad scope and patents with a narrow scope. A patent with a broad scope is a patent in the bottom half of the first claim's word count distribution, and a patent with a narrow scope is a patent in the top half of the distribution. The figure shows that the share of patents declared standard essential is 0.043 for patents with a broad scope and 0.029 for patent with a narrow scope. The difference is statistically significant at the 1% level, providing support for Hypothesis 1.

We further probe this relationship and the heterogeneous effects of patent scope through a regression analysis.

[Insert Figure 1 here]

5 Empirical Specification

To examine the relationship between patent scope and declaration of ESTI SEPs, we estimate the following econometric specification:

$$SEP_p = \beta_0 + \beta_1 Word\ count\ change_p + \mathbf{Z}'_p\gamma + \tau_t + \upsilon_c + \phi_f + \varepsilon_p \quad (1)$$

SEP_p is a dummy variable indicating whether patent p was declared ESTI standard essential. $Word\ count\ change_p$ is the Z-score for the change in the number of words in the first independent claim between granted patent p and its pre-grant publication. $\mathbf{Z}'_p$ is a vector of controls, including patent stock and citation count normalized by CPC subclass-year average to account for varying citation patterns across technology areas and truncation toward the end of the sample period. τ_t, υ_c, and ϕ_f are complete sets of grant year, CPC subclass, and patent assignee dummies, respectively. ε_p is an i.i.d. error term. The coefficient of interest is β_1. If narrower patent scope leads to a lower probability that a patent is declared standard essential (Hypothesis 1), we expect $\beta_1 < 0$.

Additionally, using the same empirical specification and split samples, we explore how the patent scope-SEP relationship varies across large and small firms; high and low quality inventions; and novel and incremental inventions. We again expect $\beta_1 < 0$ if narrower scope leads to a lower probability of a patent being declared standard essential.

5.1 Instrumental variable

To mitigate endogeneity concerns, we employ instrumental variables analysis. The change in the number of words in the first independent claim is instrumented with a dummy variable indicating whether a similar prior patent was published during the focal patent's examination period (i.e., prior to issuance of the focal patent). Given the priority that the prior patent has over the focal patent, once the similar prior patent is published, the scope of the focal patent should narrow (Lee, 2023), and such narrowing should be reflected in the increased number of words in the first claim (Kuhn & Thompson, 2019).

To determine similarity of patents, we use the data published by Arts, Hou, and Gomez (2021), which compare the title, abstract, and claims of patents to derive textual similarity of patent pairs. We designate two patents to be similar when their similarity is in the top quartile of the cosine similarity score distribution.[9]

Figure 2 illustrates how the publication of a similar prior patent can narrow the scope of a focal patent with such narrowing reflected in the number of words added to the first independent claim of the focal patent. Going from left to right, the vertical lines at the top represent patent application filing date and patent issuance date of the focal patent.[10] The vertical lines at the bottom represent the patent application date and earliest publication date of a similar, prior patent. Given the varying lengths in patent examination period, a situation can arise in which a similar prior patent is disclosed while the focal patent is being examined. Given the similarity and the priority of the prior patent, the scope of the focal patent is adjusted to be narrower than it initially was. Such narrowing is reflected in the increased number of words in the first independent claim of the focal patent.[11] Before it is

[9]Some of the studies that have used textual similarity to compare document contents are Arts, Cassiman, and Gomez (2018); Feng (2020); Kelly, Papanikolaou, Seru, and Taddy (2021); Lee (2023); Whalen, Lungeanu, DeChurch, and Contractor (2020).

[10]Technically, application filing date is the priority date of the patent. A patent's application date and priority date can be the same, but the priority date can be earlier than the application date, if there is an earlier patent application filed for the same underlying invention. For illustration, we present the case where the priority date and the priority date are the same. However, it extends to the case where the priority date is earlier than the application date.

[11]Kuhn and Thompson (2019) provide explanation and validation of the patent scope measure as reflected

published, the scope of the prior patent as reflected in the first claim is not known. Thus, the narrowing of the focal patent's scope is an unexpected event from the perspective of the focal inventor.[12]

[Insert Figure 2 here]

6 Estimation Results

Table 2 presents the estimation results investigating the relationship between patent scope and declaration of standard essential patents. Columns 1 through 3 report OLS results, and Columns 4 and 5 report results from the first and the second stage of two stage least squares analysis (2SLS). Column 1 shows a negative relationship between *first claim word count change* and declaration of SEPs and indicates that one standard deviation increase in *first claim word count change* (i.e., narrowing of patent scope) is associated with 0.006 percentage point decline (or 16.7% decline at the sample mean) in the likelihood that a patent is declared standard essential.

Column 2 controls for the firm's patent stock within each CPC subclass to proxy firm size. Prior studies have shown that large and small firms have different motivations in declaring SEPs (Bar & Leiponen, 2014; T. S. Simcoe et al., 2009) and also that they dedicate different levels of resources while engaging in standard setting processes (Leiponen, 2008). Thus, firm size could influence SEP declaration intensity. Column 3 further controls for invention quality by adding patent citation count normalized by CPC subclass-year average. High-quality inventions are more likely to be covered under specific SEP declarations (Lerner et al., 2016) and are more likely to be licensed out (Gambardella, Giuri, & Luzzi, 2007; Harhoff et al., 1999; Lee, 2023). The results continue to show that narrowing of patent scope leads to a decline in the likelihood that a patent is declared standard essential. Additionally, the coefficients on firm size and invention quality variables are positive and statistically

in the word count of the first independent claim of a patent.

[12]Lee (2023) provides validation tests relating to the focal inventor's knowledge of a similar prior invention.

significant at the 1% level, indicating that patents produced by large firms and patents protecting high quality inventions are more likely to be declared standard essential.

Columns 4 and 5 report results from two-stage least squares (2SLS) analysis. The first-stage results in column 4 indicate that, as expected, when a similar prior patent is published during the examination of a focal patent, the number of words in the first claim of the focal patent increases by 0.37 in z-score (i.e., patent scope narrows). F-statistics is 59.1 indicating a strong first stage relationship. Furthermore, the second-stage results reported in column 5 show that one standard deviation increase in the number of words in the first claim (i.e., scope narrowing) leads to 0.086 percentage point decline in the likelihood that a patent is declared standard essential.

These results provide support for Hypothesis 1 and show that patent scope is a significant determinant for declaration of SEPs.

[Insert Table 2 here]

6.1 Heterogeneous effects of patent scope on declaration of SEPs

To examine the heterogeneous effects of patent scope on declaration of SEPs, we present in Table 3 the extent to which the effects of patent scope vary across firm size, invention quality, and invention novelty. The table reports second stage results from two-stage least squares analysis. (First stage results are reported in Appendix Table A1.)

Columns 1 and 2 report results relating to firm size. Consistent with Hypothesis 2, the results show that the effect of patent scope on declaration of SEPs is positive for patents produced by both large (column 1) and and small (column 2) firms, but it is statistically significant (at 1% level) only for small firms. Specifically, for small firms, one standard deviation increase in the number of words in the first claim (narrowing of patent scope) leads to a 0.086 percentage point decline in the likelihood that a patent is declared standard essential. These results are consistent with the prior findings that small firms are more likely

to file patent infringement lawsuit and with the interpretation that they rely more on patents to protect their returns.

Columns 3 and 4 report results relating to invention quality. The negative coefficient on *First claim word count change* shows that narrowing of patent scope leads to a decline in the declaration of SEPs. Consistent with Hypothesis 3, while the coefficient is statistically significant (at 1% level) for high quality inventions (column 3), it is not statistically significant for low quality inventions (column 4). The results show that, for high quality inventions, a one standard deviation increase in the number of words in the first claim leads to 0.124 percentage point decline in the likelihood that a patent is declared standard essential.

Columns 5 and 6 report results relating to invention novelty. Consistent with Hypothesis 4, the results show that the effect of patent scope is positive and statistically significant (at 1% level) for novel inventions (column 5), while it is not statistically significant for incremental inventions (column 6). Specifically, for novel inventions, one standard deviation increase in the number of words in the first claim leads to 0.129 percentage point decline in declaration of standard essential patents.

Taken together, these findings are consistent with the notion that, when providing access to their inventions in standard setting contexts, firms do rely on patent scope to protect their returns, especially given the uncertainties arising from loose licensing commitments made and potential legal disputes. The observed heterogeneous effects provide evidence that firms act strategically depending on the nature of the inventions they are providing access to and the reosurces that they possess.

[Insert Table 3 here]

6.2 Robustness tests

We further test the robustness of the main findings using alternative measures of firm size, quality, and novelty. We also check whether the main findings are robust to an alternative threshold for invention similarity score.

6.2.1 Firm size

We use firms' annual sales as an alternative measure of firm size (Arora et al., 2023). To do so, we first match the patent assignees in our sample to Compustat by first matching to Kogan et al. (2017) to obtain Compustat firm identifier (i.e., *permno*). We designate a firm in the top decile of the sales distribution as large, and small otherwise. Given the availability of sales data, the resulting sample is limited to public firms represented in Compustat.

Columns 1 and 2 of Table 4 report results relating to large firm (column 1) and small firm (column 2). (First-stage results are presented in Appendix Table A1.) Column 1 shows that the coefficient on *First claim word count change* is negative but statistically insignificant, while column 2 shows that the coefficient is negative and statistically significant (at 5% level). The results support the main finding that the effect of patent scope on declaration of SEPs is stronger for small firms.

6.2.2 Invention quality

As an alternative measure of quality, we employ the number of jurisdictions among USPTO, EPO, and JPO in which an invention is patented (Putnam, 1996; Lanjouw & Schankerman, 2004). We merge the patents in our sample to PatStat's application data to obtain DOCDB patent family, whose member patents protect the same underlying invention. We then count the number of distinct jurisdictions among USPTO, EPS, and JPO in which the member patents have been issued. We designate inventions patented in at least two of the three jurisdictions as high quality, and those patented in only one jurisdiction as low quality.[13]

Columns 3 and 4 of Table 4 report a robustness test using this measure. (First-stage results are presented in Appendix Table A1.) The coefficient is negative and statiscally significant only for high quality patents (column 3). These results support the main findings, indicating that the effect of patent scope on declaration of SEPs is stronger for high quality

[13]The results hold even if we use the total number of jurisdictions (beyond the main three used here) to define high quality inventions.

inventions.

6.2.3 Invention novelty

As an alternative measure of novelty, we use the originality measure from Trajtenberg et al. (1997) and Hall et al. (2001). The measure is based on the diversity of technical knowledge to produce an invention, with a higher value indicating more original and a lower value indicating less original. We designate an invention to be of high originality if it is in the top half of the originality score distribution, and low originality otherwise.

Columns 5 and 6 of Table 4 report the results using this measure. (First-stage results are presented in Appendix Table A1.) Consistent with the main findings, the results indicate that the effect of patent scope on declaration of SEPs is negative and statistically significant (at 5% level) only for original inventions (column 5).

[Insert Table 4 here]

6.2.4 Alternative score threshold for invention similarity – 90th percentile

To ensure that the main results are robust to changes in the similarity score threshold when defining similar inventions, we replicate our analysis using an alternative threshold. We designate two inventions to be similar if textual similarity score between the two inventions is in the 90th percentile of the score distribution.

Table 5 present the results using the 90th percentile threshold. (The first-stage results are reported in Appendix Table A3.) The results continue to be consistent with our main findings. Narrowing of patent scope leads to a decline in declaration of SEPs (column 1). This relationship is stronger for inventions produced by small firms relative to inventions produced by large firms (columns 2 and 3); high-quality inventions relative to low-quality inventions (columns 4 and 5); and novel inventions relative to incremental inventions (columns 6 and 7).

[Insert Table 5 here]

7 Concluding Remarks

Standard setting has become a central part of inventive activity, especially in complex product industries such as information and communication technologies. However, due to the voluntary membership and loose commitments by member firms to make relevant patents available, standard setting has been characterized as highly political with firms attempting to maximize their private returns. This study looks at the degree to which the declaration of a standard essential patent is influenced by the patent scope, which facilitates firms in appropriating returns from their inventions. We find that firms are more likely to declare a patent standard essential when the patent has a broad scope than when it has a narrow scope. Additionally, we find that this effect is stronger when the patent is produced by a small firm, high quality, and novel. These results are consistent with the notion that, when participating in standard setting, inventing firms leverage patent scope to protect and maximize their returns from providing access to their technologies.

There are limitations to this study and avenues for further investigation. First, the sample used in this study is confined to a specific standard setting organization, ETSI. As Bekkers et al. (2023) point out, the different ways in which standard setting organizations operate can influence intellectual property (IP) strategy of the member firms. Thus, a future study examining SEPs declared at multiple SSO's would provide deeper insights into the role of IP in the standard setting process.

Another avenue for future research is to investigate whether the strategic behaviors of the firms in declaring SEPs lead to substantially different outcomes in licensing negotiations and legal disputes. In other words, it would be insightful to understand whether firms relying on patent scope when declaring SEPs can command higher royalty and see more favorable court decisions.

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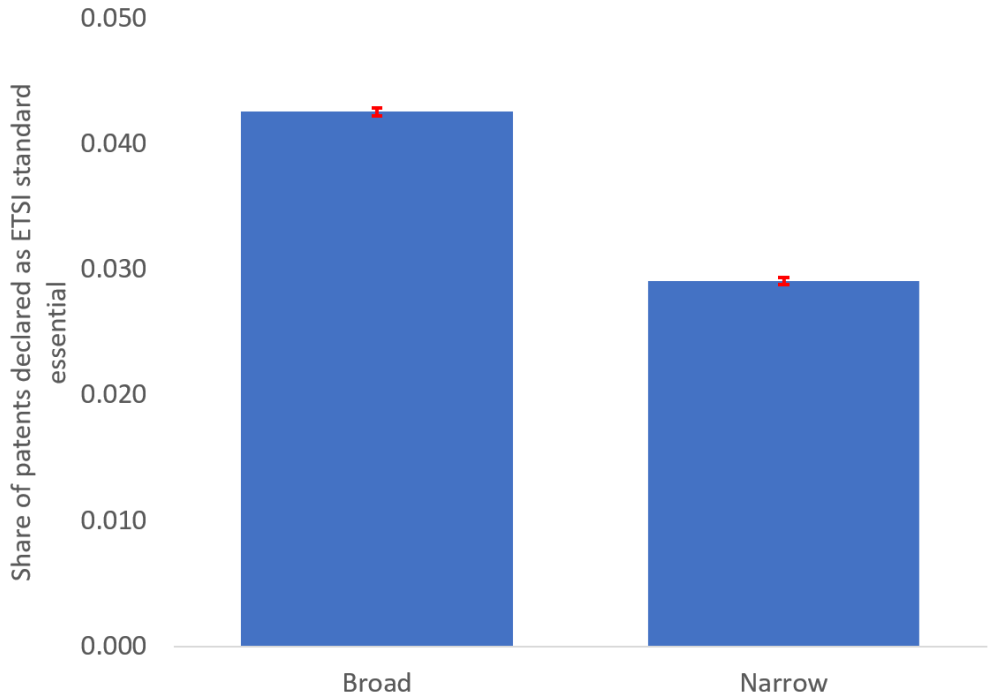
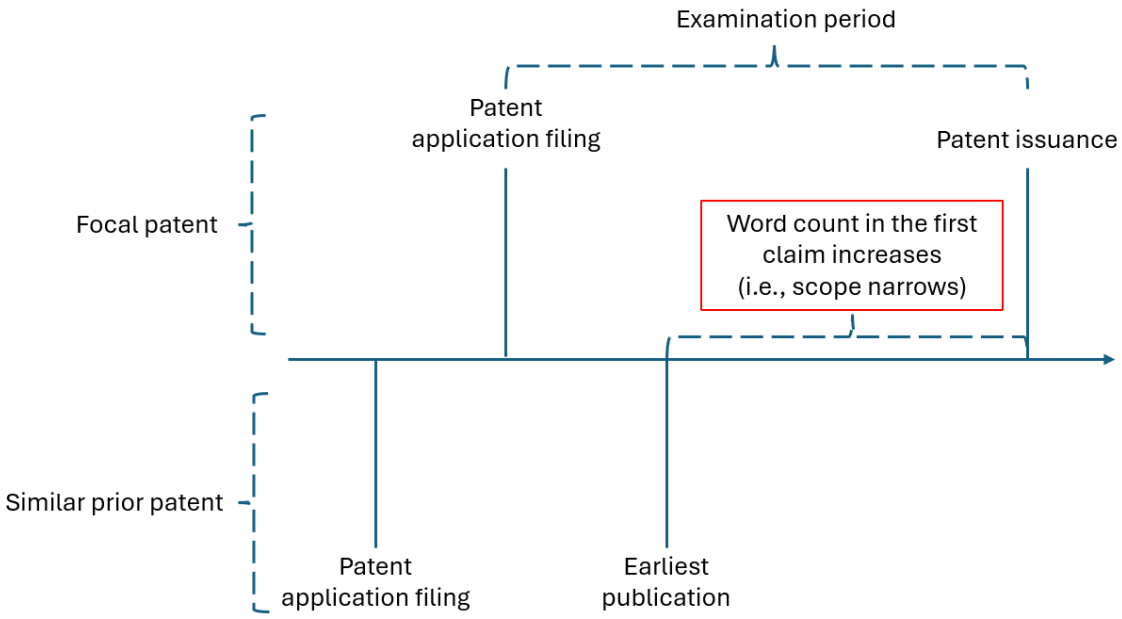
Figure 1: Mean comparison of broad and narrow patents



Notes: The figure presents the difference in the share of patents that are declared ETSI standard essential between patents with a broad scope and patent with a narrow scope. Broad scope is defined as being in the bottom half of the first claim word count distribution within each CPC subclass.

Figure 2: Illustration of Patent Scope Narrowing



Notes: The figure illustrates the timing of the publication of a similar, prior patent that narrows the scope of the focal patent.

Table 1: Summary Statistics for the Main Variables

				Distribution		
VARIABLES	No. Obs.	Mean	Std. Dev.	10th	50th	90th
SEP	778,321	0.04	0.186	0	0	0
Change in first claim word count	778,321	27.2	36.43	0	17	72
Norm. forward cites	778,321	0.80	2.497	0	0.32	1.882
Component combination familiarity	778,321	3995	6,501	1	771	13,652
Number of jurisdictions patented	778,321	1.74	0.759	1	2	3
Originality	695,900	0.35	0.284	0	0.41	0.72
Patent stock	63,234	73.9	314	5.16	14.6	136
Sales	3,338	40,179	42,480	795	24,251	99,751

Notes: The table presents summary statistics for the main variables used in this study. *SEP* is a dummy variable taking a value of 1 if a patent was declared standard essential, and 0 otherwise. *First claim word count change* is the change in the number of words in the first claim between granted patent and pre-grant publication, a proxy for patent scope change (Kuhn & Thompson, 2019). *Norm. forward cites* is the number of citations that a patent receives normalized by CPC subclass-year average. *Number of jurisdictions patented* is the number of jurisdictions among USPTO, EPO, and JPO in which an invention is patented. *Originality* is based on (Trajtenberg et al., 1997) and is the variety of CPC subclasses that an invention draws knowledge from. *Patent stock* is the cumulative number of patents a firm generated within each CPC subclass over the sample period and is depreciated 15% annually. *Sales* is annual sales obtained only for public firms represented in Compustat.

Table 2: Relationship between Patent Scope and Declaration of Standard Essential Patents

Dependent variable:	A dummy for SEP			First claim word count change	A dummy for SEP
	(1)	(2)	(3)	(4)	(5)
	OLS			2SLS	
				1st stage	2nd stage
First claim word count change	-0.006**	-0.006**	-0.006**		-0.086*
	(0.002)	(0.002)	(0.002)		(0.039)
log(1+Patent stock)		0.008**	0.008**	-0.005	0.008**
		(0.002)	(0.002)	(0.005)	(0.002)
log(1+Number of patent citations)			0.012**	0.074**	0.018**
			(0.003)	(0.009)	(0.005)
A dummy for prior patent disclosure				0.037**	
				(0.005)	
1st stage F statistics				59.1	
Assignee dummies	Yes	Yes	Yes	Yes	Yes
CPC subclass dummies	Yes	Yes	Yes	Yes	Yes
Grant year dummies	Yes	Yes	Yes	Yes	Yes
SE cluster	Assignee	Assignee	Assignee	Assignee	Assignee
Sample mean of DV	0.036	0.036	0.036	0.034	0.034
Number of firms	634	634	634	620	620
Observations	778,321	778,321	778,321	743,071	743,071
R-squared	0.24	0.24	0.24		-0.24

Notes: The table presents regression results for the relationship between patent scope and declaration of ETSI standard essential patent. *First claim word count change* is the change in the number of words in the first claim between a granted patent and its pre-grant publication. *Patent stock* is the cumulative number of patents produced by a firm within each CPC subclass, depreciated 15% annually. *Number of patent citations* is the number of forward citations that a patent receives, normalized by the CPC subclass-grant year average. A dummy for prior patent disclosure takes a value of 1 if a similar prior patent is disclosed before a focal patent is granted (i.e., during the patent examination period of the focal patent). Robust standard errors are in parentheses and clustered at the patent assignee level. ** $p < 0.01$, * $p < 0.05$

Table 3: Heterogeneous Effects of Patent Scope on Declaration of SEPs

Dependent variable:	A dummy for SEP					
	(1)	(2)	(3)	(4)	(5)	(6)
	Firm size		Invention quality		Invention novelty	
	Large	Small	High	Low	High	Low
First claim word count change	-0.058	-0.086**	-0.124*	-0.074	-0.129*	-0.036
	(0.077)	(0.027)	(0.049)	(0.039)	(0.054)	(0.028)
log(1+Patent stock)	-0.015	0.007**	0.008**	0.007**	0.009**	0.005**
	(0.010)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
log(1+Number of patent citations)	0.014	0.019**	0.005*	0.029**	0.025**	0.009*
	(0.007)	(0.004)	(0.003)	(0.009)	(0.006)	(0.004)
1st stage F statistics	22.24	54.30	26.81	50.09	32.68	47.79
Assignee dummies	Yes	Yes	Yes	Yes	Yes	Yes
CPC subclass dummies	Yes	Yes	Yes	Yes	Yes	Yes
Grant year dummies	Yes	Yes	Yes	Yes	Yes	Yes
SE cluster	Assignee	Assignee	Assignee	Assignee	Assignee	Assignee
Sample mean of DV	0.03	0.04	0.04	0.03	0.05	0.02
Observations	182,780	560,291	187,632	555,340	367,042	375,871
R-squared	-0.11	-0.23	-0.52	-0.17	-0.38	-0.07

Notes: The table presents regression results for the heterogenous effects of patent scope on declaration of ETSI standard essential patent. *Firm size* is measured as the cumulative number of patents produced by a firm in a given CPC subclass. *Invention quality* is measured as the number of citations that a patent receives, normalized by CPC subclass-year average. *Invention novelty* is based on component combination familiarity. Robust standard errors are in parentheses and clustered at the patent assignee level. ** $p < 0.01$, * $p < 0.05$

Table 4: Robustness Tests

Dependent variable:	A dummy for SEP					
	(1)	(2)	(3)	(4)	(5)	(6)
	Firm size		Quality		Novelty	
	Large	Small	High	Low	High	Low
First claim word count change	-0.129	-0.058*	-0.188*	-0.017	-0.114*	-0.050
	(0.081)	(0.028)	(0.075)	(0.016)	(0.044)	(0.040)
log(1+Patent stock)	0.006*	0.008**	0.009**	0.005**	0.007**	0.007**
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
log(1+Number of patent citations)	0.015	0.019**	0.027**	0.007**	0.016**	0.013**
	(0.008)	(0.004)	(0.007)	(0.003)	(0.005)	(0.004)
1st stage F statistics	30.33	38.83	28.00	73.63	25.41	55.88
Assignee dummies	Yes	Yes	Yes	Yes	Yes	Yes
CPC subclass dummies	Yes	Yes	Yes	Yes	Yes	Yes
Grant year dummies	Yes	Yes	Yes	Yes	Yes	Yes
SE cluster	Assignee	Assignee	Assignee	Assignee	Assignee	Assignee
Sample mean of DV	0.03	0.04	0.05	0.02	0.03	0.03
Observations	259,476	483,577	405,210	337,759	333,042	334,465
R-squared	-0.82	-0.08	-0.94	-0.01	-0.55	-0.08

Notes: The table presents robustness tests for the heterogenous effects of patent scope on declaration of ETSI standard essential patent. *Firm size* is measured as annual sales of firms. *Invention quality* is measured as the number of jurisdictions (among USPTO, EPO, and JPO) that an inventions is patented in. *Invention novelty* is based on originality scores from Trajtenberg et al. (1997). Robust standard errors are in parentheses and clustered at the patent assignee level. ** $p < 0.01$, * $p < 0.05$

Table 5: Alternative Score Threshold for Invention Similarity - 90th Percentile

Dependent variable:	A dummy for SEP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Full sample	Firm size		Invention quality		Invention novelty	
		Large	Small	High	Low	High	Low
First claim word count change	-0.148**	-0.064	-0.164**	-0.205*	-0.131**	-0.179**	-0.091**
	(0.040)	(0.083)	(0.042)	(0.080)	(0.036)	(0.059)	(0.034)
log(1+Patent stock)	0.007**	-0.015	0.007**	0.008**	0.007**	0.009**	0.005**
	(0.002)	(0.010)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
log(1+Number of patent citations)	0.023**	0.014	0.025**	0.006	0.038**	0.028**	0.014**
	(0.005)	(0.007)	(0.005)	(0.003)	(0.008)	(0.006)	(0.004)
1st stage F statistics	41.21	11.98	29.83	13.94	33.87	20.44	30.21
Assignee dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CPC subclass dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grant year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE cluster	Assignee	Assignee	Assignee	Assignee	Assignee	Assignee	Assignee
Sample mean of DV	0.03	0.03	0.04	0.04	0.03	0.05	0.02
Observations	743,071	182,780	560,291	187,632	555,340	367,013	375,900
R-squared	-0.76	-0.14	-0.91	-1.47	-0.60	-0.76	-0.54

Notes: The table presents regression results for the relationship between patent scope and declaration of ETSI standard essential patent based on a 90th percentile threshold for invention similarity sore. Robust standard errors are in parentheses and clustered at the patent assignee level. ** $p < 0.01$, * $p < 0.05$

Appendix A Additional Figures and Tables

Table A1: Heterogeneous Effects of Patent Scope on Declaration of SEP - First Stage

Dependent variable:	First claim word count change					
	(1)	(2)	(3)	(4)	(5)	(6)
	Firm size		Quality		Novelty	
	Large	Small	High	Low	High	Low
Dummy for a prior patent disclosure	0.044**	0.034**	0.034**	0.038**	0.035**	0.037**
	(0.009)	(0.005)	(0.007)	(0.005)	(0.006)	(0.005)
log(1+Patent stock)	0.012	-0.003	0.000	-0.006	-0.005	-0.004
	(0.031)	(0.003)	(0.006)	(0.005)	(0.005)	(0.005)
log(1+Number of patent citations)	0.064*	0.080**	0.013	0.167**	0.075**	0.075**
	(0.026)	(0.006)	(0.009)	(0.016)	(0.008)	(0.012)
1st stage F statistics	22.24	54.30	26.81	50.09	32.68	47.79
Assignee dummies	Yes	Yes	Yes	Yes	Yes	Yes
CPC subclass dummies	Yes	Yes	Yes	Yes	Yes	Yes
Grant year dummies	Yes	Yes	Yes	Yes	Yes	Yes
SE cluster	Assignee	Assignee	Assignee	Assignee	Assignee	Assignee
Sample mean of DV	0.03	0.04	0.04	0.03	0.05	0.02
Observations	182,780	560,291	187,632	555,340	367,042	375,871

Notes: The table presents first stage regression results from the 2SLS analysis. Robust standard errors are in parentheses and clustered at the patent assignee level. ** $p < 0.01$, * $p < 0.05$

Table A2: Robustness Tests - First Stage

Dependent variable:	First claim word count change					
	(1)	(2)	(3)	(4)	(5)	(6)
	Firm size		Quality		Novelty	
	Large	Small	High	Low	High	Low
Dummy for a prior patent disclosure	0.036**	0.037**	0.028**	0.047**	0.033**	0.037**
	(0.007)	(0.006)	(0.005)	(0.006)	(0.007)	(0.005)
log(1+Patent stock)	-0.007	-0.004	-0.006	-0.000	0.000	-0.005
	(0.006)	(0.006)	(0.005)	(0.006)	(0.004)	(0.006)
log(1+Number of patent citations)	0.083**	0.070**	0.062**	0.087**	0.091**	0.056**
	(0.015)	(0.010)	(0.010)	(0.010)	(0.009)	(0.010)
1st stage F statistics	30.33	38.83	28.00	73.63	25.41	55.88
Assignee dummies	Yes	Yes	Yes	Yes	Yes	Yes
CPC subclass dummies	Yes	Yes	Yes	Yes	Yes	Yes
Grant year dummies	Yes	Yes	Yes	Yes	Yes	Yes
SE cluster	Assignee	Assignee	Assignee	Assignee	Assignee	Assignee
Sample mean of DV	0.03	0.04	0.05	0.02	0.03	0.03
Observations	259,476	483,577	405,210	337,759	333,042	334,465

Notes: The table presents first stage regression results from the 2SLS analysis. Robust standard errors are in parentheses and clustered at the patent assignee level. ** $p < 0.01$, * $p < 0.05$

Table A3: Alternative Score Threshold for Invention Similarity - 90th Percentile - First Stage

Dependent variable:	A dummy for SEP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Full sample	Firm size		Invention quality		Invention novelty	
		Large	Small	High	Low	High	Low
Dummy for a prior patent disclosure	0.031**	0.032**	0.029**	0.028**	0.031**	0.034**	0.026**
	(0.005)	(0.009)	(0.005)	(0.007)	(0.005)	(0.007)	(0.005)
log(1+Patent stock)	-0.005	0.011	-0.003	0.000	-0.006	-0.005	-0.004
	(0.005)	(0.032)	(0.003)	(0.006)	(0.005)	(0.005)	(0.005)
log(1+Number of patent citations)	0.074**	0.064*	0.080**	0.013	0.167**	0.075**	0.075**
	(0.009)	(0.026)	(0.006)	(0.009)	(0.016)	(0.008)	(0.012)
1st stage F statistics	41.21	11.98	29.83	13.94	33.87	20.44	30.21
Assignee dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CPC subclass dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grant year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE cluster	Assignee	Assignee	Assignee	Assignee	Assignee	Assignee	Assignee
Sample mean of DV	0.03	0.03	0.04	0.04	0.03	0.05	0.02
Observations	743,071	182,780	560,291	187,632	555,340	367,013	375,900

Notes: The table presents first stage regression results from the 2SLS analysis using 90th percentile as the threshold for invention similarity. Robust standard errors are in parentheses and clustered at the patent assignee level. ** $p < 0.01$, * $p < 0.05$