Discrimination in the patent system: Evidence from standard-essential patents

This version: August 5th, 2017

Gaétan de Rassenfosse[a], Emilio Raiteri[a,b], Rudi Bekkers[b]

[a] *Chair of Innovation and IP Policy, College of Management of Technology, École polytechnique fédérale de Lausanne. Lausanne, Switzerland.*
[b] *School of Innovation Sciences, Eindhoven University of Technology. Eindhoven, The Netherlands.*

Abstract

We test for traces of discrimination against foreigners in the patent system. We focus on the case of China and look specifically at patent applications declared as essential to a technological standard. The identification strategy exploits the timing of disclosure to the standard-setting organization. We find that patent applications are treated unfavorably if they are declared essential to a standard before substantive examination, but only if they are from foreign firms. Such patent applications are less likely to be granted, take longer to examine, and are more extensively amended. This result suggests violation of the national treatment principle.

JEL Codes: F53, F68, K39, L52, L63, O25, O34
Keywords: discrimination, indigenous innovation, national treatment principle, standard essential patent, technology protectionism

---

1. Introduction

The global rise of Chinese corporations is undeniable. They initially prospered by relying on cheap labor and exploiting economies of scale that the sheer size of the internal market offers. They are now becoming more sophisticated; buying firms in technologically-advanced countries and challenging established innovation champions. This situation is the result of a long transformation process that accelerated in the 2000s, when the country embraced at set of policies aimed at promoting 'indigenous innovation.' The overarching objective was to become a scientifically and technologically advanced country by year 2020 with unique intellectual property (IP) assets.

No industry illustrates better the rise of Chinese champions than the telecommunications industry. It is one of the selected 'strategic' industry that the government has actively sought to nurture (SCPRC, 2006; OECD, 2008; Breznitz and Murphree, 2011). This industry heavily relies on technical standards to ensure that devices and networks can interoperate. Owning patents on technologies used in those standards, known as standard-essential patents (SEPs), is a business imperative. By being indispensable to any party wanting to implement a technical standard, SEPs offer opportunities for collecting licensing fees, strengthen bargaining position in cross-licensing negotiations, and represent a strategic asset to counter patent infringement accusations by competitors (Kang and Bekkers, 2015). This is particularly true for SEPs that have legal validity in China as the country is not only one of the largest consumer markets for high-tech products, but also a manufacturing hotspot for many products relying on these standards.

After a failed attempt to develop local standards in the name of technological independence (Lee and Oh, 2008), the Chinese government and companies have embraced global standards.

Some Chinese companies such as Huawei and ZTE have become very successful contributors to global standards such as leading standards for 3G and 4G mobile communications. These companies are now among the most active patent filers at the U.S. Patent and Trademark Office (USPTO) and the European Patent Office (EPO).

The rise of Chinese telecommunication champions and their role in SEPs have generated tensions at the international level. Western observers have expressed concern that "Chinese competition authorities may target for investigation foreign firms that hold [patents] that may be essential to the implementation of certain standard technologies" (USITC, 2014, 35). In April 2014, the Guangdong High Court of China published its judgment in a case between Chinese firm Huawei Technologies and U.S. firm InterDigital. The latter was found guilty of abusing its dominant market position regarding essential patents (Orrick, 2014). In 2015, China's National Development and Reform Commission (NDRC) found that the patent licensing schemes used by U.S. firm Qualcomm violated China's Anti-Monopoly Law. The firm was ordered by the NDRC to rectify its patent licensing schemes in a way that is compliant with China's laws. It also had to pay a fine equivalent to $1 billion (Lexology, 2015).

Such tensions surrounding SEPs provide the starting point for our analysis. There is empirical evidence that the patent prosecution process is biased against foreigners, although the origin of such bias is difficult to establish. Using a sample of 'twin' patent applications granted by the USPTO and filed at the EPO and the Japan Patent Office (JPO), Webster et al. (2014) show that European firms are more likely to have their patents granted at the EPO than at the JPO, and inversely for Japanese firms. de Rassenfosse and Raiteri (2016) arrive at a similar conclusion using data from China's State Intellectual Property Office (SIPO). They find that patent applications by foreign firms in 'strategic' technology areas are less likely to be granted protection in China than otherwise similar applications by Chinese firms.

The present paper zooms into a particular class of strategic patents, namely SEPs, and considers more dimensions of the prosecution process than previous studies, namely the examination outcome, the duration of the examination process and a possible reduction of scope between the patent application and the patent that was eventually granted. We focus on patent applications declared as essential to two of the world's economically most important standards: the 3G (WCDMA) and 4G (LTE) standards for mobile communications, as created by 3GPP. Furthermore, the use of SEPs allows exploiting an original, and very robust, identification strategy: we track whether the patent application was disclosed as standard essential before or after it enters substantive examination at the Chinese patent office—mere disclosure as SEP should not affect the examination outcome, and a fortiori certainly not the subgroup of foreign patent applications only.

We find that patent applications by foreign firms receive a systematically less favorable treatment if they are disclosed as SEP before entering substantive examination at the SIPO (versus if they are disclosed after examination). SEPs by foreigners that are disclosed before examination at SIPO are about 9 percentage points less likely to be granted, face a delay of about one year, and have about 14 additional words per independent claim added during examination, suggesting that there has been additional reduction in scope of the patent. We find no such effect for applications by Chinese firms. This results holds controlling for a range of confounding factors—including most importantly invention quality—and an alternative hypothesis related to the availability of search reports at foreign offices. We interpret this result as evidence of discrimination against foreigners.

2. Hypotheses

There is a vast literature on standard-essential patents. Broadly speaking, research has focused on the distortions they induce, in the context of royalties and licensing contracts (Dewatripont and Legros, 2013; Lemley and Shapiro, 2013; Lerner and Tirole, 2015) or in the context of innovation incentives (Ganglmair et al., 2012; Delcamp and Leiponen, 2014; Baron et al., 2016). As far as we are aware of, the literature has so far never questioned the (in)ability of firms to obtain SEPs due to distortions in the patent system.

An invention deserves patent protection in a jurisdiction if it meets the patentability criteria in that jurisdiction. Generally, these criteria include novelty, inventive step/non-obviousness, and industrial applicability/usefulness, although there is considerable variation in the actual implementation of these criteria across offices (de Rassenfosse et al., 2016). In terms of patents related to technical standards, for instance, the EPO has adopted a broader definition of what comprises the prior art for novelty searches compared to other patent offices (Bekkers et al., 2016). However, differences in patentability criteria across jurisdictions do not represent 'discrimination,' as these criteria apply to all applicants regardless of their country of origin.

This paper investigates two possible explanations that may account for systematic differences between foreigners and locals in the patent prosecution process. Both explanations are related to the information that is available to examiners. The first potential explanation concerns the availability of prior art search reports by other patent offices at the time an examiner scrutinizes the application. Inventions can be patented in multiple countries and, hence, be examined multiple times. Once the first application describing an invention is filed (known as a 'priority filing'), the applicant has a limited period of time to seek protection in additional jurisdictions by submitting so-called 'second filings.' Thus, an examiner at an office of second filing may be able to consult search reports already written by colleagues at other offices. If patent examiners have access to earlier prior art searches, they may have additional information on the basis of which a patent could be rejected—information they might not have found themselves—resulting in a less favorable examination outcome. Hence, we hypothesize:

Hypothesis 1. *Applications for which an earlier search report is available at the time they enter the substantive examination phase at SIPO have a less favorable application outcome, ceteris paribus.*

Note that validation of Hypothesis 1 would *not* be evidence of discrimination against foreign firms. The less favorable outcome of foreigners would simply be a consequence of the fact that foreign applicants are more likely to have filed their invention at other offices before filing at the SIPO compared to Chinese firms.

The second explanation relates to discrimination. Previous studies have documented differences in the prosecution of SEPs versus non-SEPs (Berger et al., 2012). SEPs relate to very specific technologies, which translates into specific filing strategies. There is thus nothing necessarily discriminating regarding differences examination outcome between SEPs and non-SEPs. However, a priori, we would not expect the treatment of SEPs to depend on whether the examiner (or, in fact, any other party) knows that the invention is essential to a standard or not. Indeed, information on essentiality does not alter the nature of the technology. And, a fortiori, this difference should not depend on the country of origin of the applicant (foreign versus local). Thus, differences between foreigners and locals in how knowledge about the SEP-status of an application affects the prosecution process would provide evidence of discrimination—positive or negative. To assess the presence of discrimination we therefore test the following:

Hypothesis 2. *Foreign patent applications that are known to be standard essential at the time they enter the substantive examination phase at SIPO have a different examination outcome, ceteris paribus.*

Discrimination is negative if foreigners face an unfavorable treatment and positive if they face a favorable treatment. Information on essentiality is publicly available via disclosure processes at Standard Setting Organizations (SSOs). Virtually all large SSOs have policies in place that require members to timely disclose patents or patent applications that are essential to a standard or, if a standard is still under development, essential to technical proposals for that standard (see Lemley, 2002; Bekkers and Updegrove, 2012).[1] Such disclosures are then made publicly available via the websites of these SSOs.

Although previous studies on SEPs suggest that disclosure timing may be correlated with patent characteristics that affect both the grant outcome and the duration of the examination process (Bekkers et al., 2012), there is no reason to believe that the incentives to disclose an application at a given point in time should be systematically different for Chinese and foreign applicants. We might also be concerned that foreign applicants that decide to seek patent protection in China, might deliberately postpone to declare a patent application as standard-essential, precisely because of concerns of discrimination at the SIPO. To rule out this possibility we ran a test in which we compare the lag between the first patent application of a given patent family and the declaration date at the ETSI, between patent families that have a Chinese member (i.e., an application at SIPO) and families that do not. Appendix C presents this test in details and shows that non-Chinese companies do not adopt different disclosure strategies for standard-essential inventions for which they seek patent protection in China, confirming the goodness of our identification.

that is presented in 8

[1]Because such policies also require potentially essential patents to be disclosed, not all declared patents will eventually be factually essential to the final standard. But this fact does not have any implications for the way this disclosure information is used in our paper.

3. Econometric approach

3.1. Regression models

Our analysis covers three facets of the prosecution process: the likelihood of a grant, the duration of examination, and the reduction in scope of the application.

First dependent variable: grant outcome

The first outcome variable, $grant_i$, captures the grant status of patent application for invention i. It takes the value 1 if the patent application was granted and 0 if it was rejected or withdrawn after the filing of a request for substantive examination. We estimate the following model:

$$\begin{aligned} grant_i = &\beta_1 sra_i + \beta_2 foreign_i + \beta_3 known\_SEP_i + \beta_4 (foreign \times known\_SEP)_i \\ &+ \beta_5 PFE_i + \mathbf{X_i}\gamma + \varepsilon_i \end{aligned} \tag{1}$$

The variables sra_i stands for 'Search Report Available' and is used to test Hypothesis 1. It takes that value 1 if at least one search report was available for an equivalent application at the USPTO, the EPO or the World Intellectual Property Organization (WIPO) at the time the substantive examination at SIPO took place, and 0 otherwise. We focus on these three offices as they produce the bulk of search reports in our sample. Appendix A provides some technical information regarding the construction of the variable.

The variables $foreign_i$, $known\_SEP_i$ and the interaction term $(foreign \times known\_SEP)_i$ are used to test Hypothesis 2 in the spirit of a difference-in-differences framework. The dummy variable $foreign_i$ takes the value 1 if application for invention i is filed by a foreign applicant and 0 otherwise. The dummy variable $known\_SEP_i$ takes the value 1 if the public disclosure that application i is a SEP pre-dates the request for examination, and thus the substantive examination phase, and 0 otherwise. As the study focuses on the 3GPP WCDMA and LTE standards, we consider the date of disclosures at European Telecommunications Standards

Institute (ETSI). It is the European SSO that is the partnering organization within 3GPP where the lion's share of patent disclosures for these standards are made.[2] The interaction term $(foreign \times known\_SEP)_i$ is the variable of interest for Hypothesis 2. It takes the value 1 when the applicant is foreign and the patent is publicly known to be a SEP.

Failure to control for invention quality would lead to biased estimates. In particular, we may observe less favorable outcomes for foreign firms if their applications were systematically of lower quality than applications by Chinese firms, and the other way round. To account for this possibility, we build on the recent 'twin patent' approach (Webster et al., 2014; Sampat and Shadlen, 2015; de Rassenfosse et al., 2016; de Rassenfosse and Raiteri, 2016). We track 'twin' applications of invention i in other jurisdictions and we measure the variable PFE_i as the average grant rate of these twin applications, following de Rassenfosse and Raiteri (2016). We interpret the variable PFE_i as an invention pseudo fixed effect that captures other patent offices' assessment of the patentability of invention i. Finally, the vector variable $\mathbf{X_i}$ includes a range of control variables and fixed effects (firm, time, attorney agency) that may affect the outcome of the examination process. We present the elements of $\mathbf{X_i}$ at the end of this section.

Second dependent variable: grant lag

The second outcome variable, $grant\_lag_i$, reports the duration (in months) between the request for examination and the grant decision (for the subset of patents that eventually get granted). We estimate the following regression model:

[2] 3GPP is a partnership of regional SSOs and does not have its own IP policy or disclosure rules. Instead, companies participating in 3GPP must also be member of one or more of the partnering SSOs, and must use these SSO to disclose their IP. In practice, the bulk of disclosures for 3GPP standards takes place at ETSI. Disclosures at other partnering organizations are few, and usually overlap with those already present at ETSI. Baron et al. (2015) provides a detailed discussion of the 3GPP standards.

$$
\begin{aligned}
grant\_lag_i = &\beta_1 sra_i + \beta_2 foreign_i + \beta_3 known\_SEP_i + \beta_4 (foreign \times known\_SEP)_i \\
&+ \beta_5 fast_i + \beta_6 slow_i + \mathbf{X_i}\gamma + \varepsilon_i
\end{aligned} \tag{2}
$$

Most variables are similar to the earlier model. But instead of the invention pseudo fixed effect variable, the regression model now includes the dummy variables $fast_i$ and $slow_i$. We consider a patent application as fast (slow) if the average deviation from the mean of the prosecution time of twins at the other patent offices is in the top (bottom) decile in these offices. Thus the $fast_i$ and $slow_i$ dummies report whether the twin applications at other patent authorities were granted particularly fast or slow compared to the average prosecution time for SEPs at each authority. These variables are used exclusively for the grant lag analysis.

Third dependent variable: change in scope

The third outcome variable relates to changes in the scope of the invention described in the patent document. We estimate the following model:

$$
\begin{aligned}
\Delta scope_i = &\beta_1 sra_i + \beta_2 foreign_i + \beta_3 known\_SEP_i + \beta_4 (foreign \times known\_SEP)_i \\
&+ \mathbf{X_i}\gamma + \varepsilon_i
\end{aligned} \tag{3}
$$

The outcome variable $\Delta scope$ is computed as the difference in the number of words per independent claim included in the granted patent and in the patent application.

As suggested by Malackowski and Barney (2008) and Okada et al. (2016), an increase in the number of words per independent claim between the patent application and the granted document is a proxy for the reduction in the scope of the patent during examination. The reason is that each word added in a claim introduces a further legal limitation upon its scope. We provide a simplified example: suppose that the first independent claim of an application reads “A bike brake using a round disk”, whereas the first claim of the granted patent reads “A bike brake using a round disc made of metal.” Apparently, during the patent prosecution process, the examiner believed that the first claim was too broad. The resulting granted patent is reduced in scope, as it no longer covers breaks using non-metal discs, for instance carbon ceramic discs.

3.2. Control variables

In all the above equations, the vector $\mathbf{X_i}$ controls for variables that may affect the probability of grant at the SIPO. We consider the following covariates:

- PCT (*pct*) is a binary variable that takes the value 1 if an application is filed through the Patent Cooperation Treat (PCT) route and 0 otherwise. The PCT is an international patent law treaty that provides a unified procedure for filing patent applications in multiple jurisdictions.

- Patent family size (*family_size*) is the number of countries covered by the INPADOC family. The INPADOC family contains all the patents documents directly or indirectly linked to one specific priority document.

- Number of IPC classes (*tot_IPC*) is the number of IPC classes listed in the patent application.

- Number of inventors (*nb_inv*) reports the total number of inventors listed in the patent application.

- Examination-request lag (*exam_request_lag*) reports the time-lag in months between the application date at the SIPO and the date of the request for examination.

- Priority-to-declaration lag (*prior_decl_lag*) reports the time-lag in months between the priority date of the invention (i.e., the date of its first filing) and its declaration date at ETSI. This variable controls for the age of the invention at the time it is declared as essential to the standard implementation.

- Number of independent claims (*nb_indep_claims*) reports the number of independent claims listed in the patent application.

- Number of words per claim (*words_claim*) reports the average number of words per claim included in the patent application.

- Difference in independent claims (*diff_ic*) collects the difference in the number of independent claims between the patent application and the granted patent. This variable is used exclusively for the scope reduction analysis.

We also control for four fixed effects: a invention pseudo fixed effect (discussed above); a firm fixed effect; an application year fixed effect; and an attorney agency fixed effect. Regarding the latter, China patent law stipulates that a foreign applicant that has no residence in China must appoint a licensed patent attorney agency to handle the patent application. Chinese applicants may instead appoint any patent attorney agency. The quality of the agency may affect the grant outcome and the grant lag, especially if there are differences in the quality of attorneys between foreigners and locals. The regressions include a binary variable for each of the 39 patent agencies in the sample.

4. Data

4.1. Data sources and sample construction

We combine data from five sources. The EPO Worldwide Patent Statistical Database (PATSTAT, April 2015 edition) is the main source of information. We identify applications for SEPs by collecting disclosure data from ETSI and focus on disclosures related to the 3G WCDMA and 4G LTE standards developed by 3GPP; Appendix B expands on this data collection. The INPADOC legal status table (a PATSTAT add-on) provides information on the grant outcome at the SIPO and on the grant date. We also crawled the Google Patent website and the SIPO website to recover the number of independent and dependent claims at the SIPO, the number of words per claim, and information on the attorney agency.[3]

In order to put locals and foreigners on the same level, we impose that all applications in the sample have a 'direct equivalent' at selected patent authorities. The selection ensures that we compare foreign applications with Chinese applications of international stature (i.e., akin to a 'common support' requirement) and allows us to compute the invention pseudo fixed effect and the $fast$ and *slow* dummies. A direct equivalent is a patent protecting exactly the same invention in a different jurisdiction (Martínez, 2010). We identify direct equivalents by identifying, for each INPADOC family, Chinese applications that claim only one priority filing and that are claimed by only one priority filing in a jurisdiction (that is, we exclude split equivalents and merged equivalents). We consider seven jurisdictions, namely Canada, member states of the European Patent Convention, Japan, Korea, Russia, Taiwan and the United States (corresponding to the following patent offices: CIPO, EPO, JPO, KIPO, RFSIP, TIPO, and USPTO, respectively).

To sum up, the sample is composed of applications for SEPs filed at the SIPO by foreign and domestic firms (between years 2001 and 2009). All these applications are disclosed at ETSI and relate to the 3G WCDMA and 4G LTE standards. These SEPs have at least one unique direct equivalent in selected foreign patent offices, which allows us to control for invention quality.

[3]See `https://patents.google.com/` and `http://english.sipo.gov.cn/`.

The three regressions models call for three samples: one composed of patent applications, and the other two composed of granted patents.

- *Sample 1*: The sample contains 1,653 SEP applications used for estimating regression model (1). A total of 421 applications are filed by Chinese firms and 1,232 applications are filed by foreign firms. A total of 457 applications (349 foreign and 108 Chinese) were declared as SEP before entering the examination phase at SIPO.

- *Sample 2*: The analysis for model (2) is based on granted patents. There are 1,477 granted patents but the sample reduces to 1,311 patents due to missing data on the grant date of some twin applications at foreign offices (required to compute the variables $fast$ and $slow$).[4]

- *Sample 3*: The analysis for model (3) is also based on granted patents. The sample reduces to 1,436 patents due to missing data on the full text of the original patent application at SIPO, which we need to compute the change in scope.

4.2. Descriptive statistics

Table 1 displays descriptive statistics of all variables for the groups of Chinese and foreign firms (for Sample 1). The last column of the table reports the result of a t-test for the difference in means between groups. As the table shows, applications by Chinese firms have a higher issuance rate at SIPO than foreign applications (variable $grant$), despite the fact that their grant rate at other patent offices is significantly lower on average (variable PFE). Chinese applications are also granted significantly faster than foreign applications ($grant\_lag$). There is no statistical difference between the two groups in the share of patents that are publicly disclosed as SEP when

[4] We obtain similar results if we run the analysis on the full sample of 1,477 granted patents without controling for the variables $fast$ and $slow$.

they enter into the examination phase at SIPO. In 60 per cent of the cases foreign applications reached SIPO through the PCT route. Given that for applications by Chinese applicants the SIPO application is very often the priority application, only a minor share reached SIPO through the PCT route. For the same reason, a small fraction of applications by Chinese firms have a search report available at the start of the examination process.

[Table 1 about here.]

5. Results

Table 2 displays the regression coefficients for model (1), related to the grant outcome. Columns (1)–(5) present results of a linear probability model and columns (6)–(10) present results of a probit regression model. Hypothesis 1 is tested separately in columns (1)–(2) and (6)–(7) whereas Hypothesis 2 is tested separately in columns (3)–(4) and (8)–(9). Hypotheses are tested jointly in columns (5) and (10). The results are consistent across specifications and we focus our discussion on columns (5) and (10).

As suspected, the availability of a search report is negatively associated with the probability of grant. On average, an application with a foreign search report available at the time it enters substantive examination at the SIPO is 2.8–8.0 percentage points less likely to be granted. This result comes in addition to the baseline probability of grant for that invention, which is captured by the invention pseudo fixed effect PFE.[5]

Regarding Hypothesis 2, we find strong evidence of (negative) discrimination. The results suggest that foreigners reduce the likelihood of having their patent applications granted at the

[5]Additional results not reported suggest that the effect is mainly driven by USPTO search report. The lack of statistical significance for EPO search reports is surprising, as it is a common believe that the EPO is more rigorous than the USPTO in its searches, leading to lower allowance rates (Bekkers et al., 2016). Furthermore, the EPO has a broader definition of prior art than other patent offices regarding SEPs, which also includes technical proposals that are shared in the context of standards setting (Ibid.). A simple interpretation is that SIPO examiners only look at USPTO search reports.

SIPO by about 8.9–9.4 percentage points when they disclose essentiality prior to examination.

[Table 2 about here.]

Table 3 displays the regression coefficients for model (2), related to the grant lag. We use both an OLS regression model (columns 1–5) and a Poisson regression model (columns 6–10). Again, the results are consistent across specifications and we focus the discussion on columns (5) and (10).

We find no support for Hypothesis 1: the coefficient associated with the variable sra is not significantly different from zero. Thus, conditional on being granted, the availability of search reports does not affect the grant lag.

We do find strong support in favor of Hypothesis 2, as suggested by the negative and statistically significant coefficient associated with the interaction term $foreign \times known\_SEP$. Foreign firms that have disclosed the essentiality of their applications before substantive examination starts face a delay of about one year (8.5–12.6 months). Note that this result controls for the speed of the prosecution process of the twin patents at the other offices (variables $fast$ and $slow$).

[Table 3 about here.]

Next, Table 4 displays the OLS regression coefficients for model (3), related to the reduction in scope. The results are consistent across specifications and we focus the discussion on column (5). Note that a positive coefficient indicates that the scope of a granted patent is reduced (i.e., more words per independent claim).

We find no support for Hypothesis 1. We observe that the availability of search reports at the time of examination at the SIPO does not have an impact on the scope of the granted patent, relative to the scope of the patent application.

We find support for Hypothesis 2: foreign applications disclosed as SEP (the interaction term) experience a larger reduction in scope, with an average of 13.6 additional words per independent claim included during the examination process.

[Table 4 about here.]

To sum up, we find mixed support for Hypothesis 1, related to the availability of search reports. The existence of foreign search reports significantly reduces the likelihood that the patent application will be granted. However, conditional on being granted, foreign search reports do not seem to have an effect on the prosecution process. We do find strong support for Hypothesis 2: applications by foreigners that are disclosed as SEP before examination are scrutinized very carefully by Chinese examiners. They have a significantly lower probability of grant, take significantly longer to be examined and experience a significant reduction in scope. And, indeed, we do not observe such effects for applications by Chinese firms.

6. Robustness analysis

We performed several robustness checks to confirm the validity of our results.

6.1. Time window

We ran the above regression models on a reduced sample that excludes applications for which the absolute time-lag between the declaration date and the request for examination date is shorter than three months. This test accounts for the possibility that an examiner may be able to identify a SEP application as such if it is disclosed soon after the start of the substantive examination. Table 5 reports the results of the analysis conducted on this reduced sample. As the table shows, the negative effect on the grant outcome for foreign SEP application disclosed before examination becomes larger in magnitude, reaching between 11 and 13 percentage points. The effect on the grant lag also increases in size and is now 10–15 months longer for foreign applications disclosed as SEP before the examination process. The results on the reduction in scope are similar in magnitude but loses statistical significance.

[Table 5 about here.]

6.2. Larger sample

We also ran the analysis on a larger sample that is no longer restricted to applications that have a direct equivalent at the seven selected patent authorities—thus we are not able to compute the variables PFE, $fast$ and $slow$. The sample is still composed of applications that belong to an international family and that have a unique application in China, and still does not consider continuations and divisionals.[6] The sample now contains 2,764 patent applications filed at SIPO, of which 2,207 are filed by foreigners and 557 by Chinese firms. A total of 872 applications belong to families declared as SEP before the start of the examination process at SIPO. Table 6 reports the results of the analysis conducted on this enlarged sample.

[Table 6 about here.]

As the table shows, this robustness check confirms the magnitude of the effects reported in Tables 2–4.

6.3. Measuring change in scope

Although it is clear that an increase in the number of words per claim implies a reduction in scope, it would be erroneous to interpret a decrease in the number of words per claim as an increase in scope. Indeed, an increase in the scope of a claimed invention is theoretically not possible in patent law. Looking manually through several cases of patent applications having

[6] A continuation application is a patent application filed by an applicant who wants to pursue additional claims to an invention disclosed in an earlier application. A divisional patent application is an application that contains matter from a previously filed application. Divisionals are generally used when the parent application lacks unity of invention.

experienced a decrease in the number of words per claim, we almost invariably came to the conclusion that the changes were also associated with a reduction in scope. Using a simplified example, consider an application with the claim "A bike seat covered with leather, microfibre, or hemp canvass" and the granted patent with the claim "A bike seat covered with microfibre, or hemp canvass." Therefore, we also propose an alternative variable, namely the absolute number in the change of the number of words (*Absolute* $\Delta Scope$). The rationale for this variable is that any significant change, be it adding or removing parts of the claimed invention, leads to a reduction in scope. We call this variable *Absolute* $\Delta Scope$. Table 7 reports the results of the regression analysis with the dependent variable *Absolute* $\Delta Scope$.

[Table 7 about here.]

As the table shows, as in the case of the $\Delta Scope$ used in the main analysis, prior availability of search reports does not affect the change in scope of the granted patent. A foreign application disclosed as SEP (the interaction term) experiences a larger reduction in scope, with a change of up to 21 words per independent claim between the application and the granted document.

7. Discussion

This paper examines anti-foreign bias in the prosecution of patent applications. It focuses on patent applications filed at the SIPO and declared as essential to two of the world's most valuable standards: the 3G WCDMA and 4G LTE standards for mobile communications. The choice of standard-essential patents is particularly suited because it allows us to exploit information on the timing of disclosure as SEP to infer the presence of discrimination. Besides, SEPs are of high strategic importance for China's indigenous innovation program and, indeed, for any telecommunication firms operating in China.

Our findings can be summarized as follows. First, the availability of search reports before substantive examination at the SIPO has a mixed effect on the outcome of the prosecution process. The existence of foreign search reports significantly reduces the likelihood that the patent application will be granted. We also find that, conditional on a patent being granted, foreign search reports do not seem to have an influence on the prosecution process. Second, patent applications disclosed as SEP before entering into the substantive examination phase at the SIPO are about 9 percentage points less likely to be granted when the patent owner is foreign. Domestic patent owners do not experience such a drop in the likelihood of obtaining a patent. Besides, if such foreign-owned patents do receive a grant, the grant decision arrives substantially later, about a year on average, and the scope of the application is significantly reduced. In other words, in seems that examiners scrutinize more carefully these applications, resulting overall in a less favorable prosecution process.

We come to these findings after extensively controlling for a number of alternative explanations, including invention pseudo fixed effects, cohort effects, firm effects, and patent attorney agency effects, as well as for a large number of control variables such as, e.g., the examination request lag and the time lag for essentiality declaration. The identification strategy of exploiting the timing of disclosure as SEP further rules out alternative explanations such as potential differences in the use of regional patent offices between Chinese and foreign firms.

Having explicitly or implicitly ruled out alternative explanations, the fate of some of the foreign SEPs that we observe is puzzling, as no obvious explanation can be put forward to account for it. Do examiners themselves look at these disclosure sources? Or do they receive information in the form of third-party observations from Chinese competitors? And if they do, why do these foreign SEPs receive a particularly unfavorable treatment? Given the highly strategic nature of SEPs, it makes sense to examine applications for SEPs more carefully, as hinted by scholars who have mused on a two-tier patent system (Lichtman and Lemley, 2007; Atal and Bar, 2014). However, greater scrutiny should also apply to applications by Chinese firms.

Future studies could help us understand to what degree the present results would also hold for essential patents related to standards other than ETSI/3GPP. On the one hand, standards for wireless LAN networks and for video coding/storage have also been recognized to be of strategic importance to China, and we might expect similar effects. On the other, such standards are usually developed by SSOs that allow 'blanket disclosures' that impede the identification of patents believed to be essential, which may complicate the execution of a study like this, and might result in weaker effects than we find, or no effects at all. Future research on standards should investigate the role of disclosure policy of SSOs taking into account the novel perspective that the present paper brings.

Our study has both managerial and policy implications. Firms need to think strategically about the timing of their SEP disclosures. Our finding suggests one argument in favor of disclosing patents to SSOs after the Chinese patent prosecution phase is finished. At the same time, there are several other considerations in order to determine the optimal timing of disclosure, including SSO disclosure policies themselves, which often require members to disclose in a "timely fashion" (Bekkers and Updegrove, 2012).

Finally, although our findings suggest that China breaches the national treatment principle, one of the pillars of the international patent system, we have not investigated whether similar forms of discrimination exist at other patent offices. In any case, we believe that this topic has significant importance and that it would be appropriate to address it in the dialogue between the world major patent offices. On place for doing so is the IP5, the forum of patent offices of Europe, Japan, Korea, China, and the United States.

8. Acknowledgement

The Chair of Innovation and IP Policy at EPFL gratefully acknowledges support from the CPIP at Antonin Scalia Law School, George Mason University.

References

Atal, V. and Bar, T. (2014). Patent quality and a two-tiered patent system. *The Journal of Industrial Economics*, 62(3):503–540.

Baron, J., Gupta, K., and Roberts, B. (2015). Unpacking 3GPP standards. *Searle Center on Law, Regulation and Economic Growth Working Paper*.

Baron, J., Pohlmann, T., and Blind, K. (2016). Essential patents and standard dynamics. *Research Policy*, 45(9):1762–1773.

Bekkers, R., Catalini, C., Martinelli, A., and Simcoe, T. (2012). Intellectual property disclosure in standards development. In *Conference Proceedings of the NBER conference on Standards, Patents and Innovation*.

Bekkers, R., Martinelli, A., and Tamagni, F. (2016). The causal effect of including standards-related documentation into prior art: evidence from a recent EPO policy change. In *European Economic Association 31th annual congress of the European Economic Association and the 69th European meeting of the Econometric Society, Geneva, 22 August 2016*.

Bekkers, R. and Updegrove, A. (2012). *A study of IPR policies and practices of a representative group of Standards Setting Organizations worldwide*. National Academies of Science, Washington, DC.

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

Breznitz, D. and Murphree, M. (2011). *Run of the red queen: Government, innovation, globalization, and economic growth in China*. Yale University Press.

de Rassenfosse, G., Jaffe, A. B., and Webster, E. (2016). Low-quality patents in the eye of the beholder: Evidence from multiple examiners. National Bureau of Economic Research WP No. 22244.

de Rassenfosse, G. and Raiteri, E. (2016). Technology protectionism and the patent system: Strategic technologies in China. Available at SSRN, WP No. 2803379.

Delcamp, H. and Leiponen, A. (2014). Innovating standards through informal consortia: The case of wireless telecommunications. *International Journal of Industrial Organization*, 36:36–47.

Dewatripont, M. and Legros, P. (2013). 'Essential' patents, frand royalties and technological standards. *The Journal of Industrial Economics*, 61(4):913–937.

Ganglmair, B., Froeb, L. M., and Werden, G. J. (2012). Patent hold-up and antitrust: How a well-intentioned rule could retard innovation. *The Journal of Industrial Economics*, 60(2):249–273.

Kang, B. and Bekkers, R. (2015). Just-in-time patents and the development of standards. *Research Policy*, 44:194–1961.

Lee, H. and Oh, S. (2008). The political economy of standards setting by newcomers: China's WAPI and South Korea's WIPI. *Telecommunications Policy*, 32:662–671.

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

Lemley, M. A. and Shapiro, C. (2013). A simple approach to setting reasonable royalties for standard-essential patents. *Berkeley Technology Law Journal*, 28:1135–1166.

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

Lexology (2015). Qualcomm to pay the highest fine ever imposed in china for violation of chinese antitrust laws in patent licensing practices. Available at http://www.lexology.com [Accessed 4 Jan 2017].

Lichtman, D. and Lemley, M. A. (2007). Rethinking patent law's presumption of validity. *Stanford Law Review*, pages 45–72.

Malackowski, J. E. and Barney, J. A. (2008). What is patent quality–a merchant banc's perspective. *Nouvelles-Journal of the Licensing Executives Society*, 43(2):123.

Martínez, C. (2010). Patent families: when do different definitions really matter? *Scientometrics*, 86(1):39–63.

OECD (2008). *OECD Reviews of Innovation Policy - China*. Organisation for Economic Cooperation and Development, Paris.

Okada, Y., Naito, Y., and Nagaoka, S. (2016). Claim length as a value predictor of a patent. Technical report, Institute of Innovation Research Working Paper No 16-04, Hitotsubashi University.

Orrick (2014). Chinese court publishes decisions finding that interdigital violated AML through discriminatory pricing, sets FRAND rate for licensing interdigital SEPs under chinese standards. Available at http://blogs.orrick.com [Accessed 4 Jan 2017].

Sampat, B. and Shadlen, K. (2015). TRIPS implementation and secondary pharmaceutical patenting in Brazil and India. *Studies in Comparative International Development*, 50(2):228–257.

SCPRC (2006). *Outline of the Long–Term National Plan for the Development of Science and Technology (2006–2020)*. State Council of the People's Republic of China (SCPRC), Beijing.

USITC (2014). *2014 Special report 301*. Office of the United States Trade Representative.

Webster, E., Jensen, P. H., and Palangkaraya, A. (2014). Patent examination outcomes and the national treatment principle. *The RAND Journal of Economics*, 45(2):449–469.

Appendix A: Availability of search reports

This Appendix provides additional explanation regarding the construction of the variable capturing the availability of search reports.

We exploit two different publication kind codes at the EPO. Kind codes A1 and A3 refer to publications that include a search report. The variable takes value 1 if the A1 or A3 publications pre-date the request for examination at SIPO. The variables also takes the value 1 if a patent application at SIPO has a direct equivalent at the USPTO for which the initial search realized by USPTO examiners is already available before the applicant files the request for examination at SIPO. To construct this variable we exploit the data from the USPTO PUBLIC 'Patent Application Information Retrieval' (Public PAIR) Database.[7] We determined the date of the PTO-892 form ('Notice of References Cited') for the patent in question, which lists the first set of citations the examiner made to prior art. If the release of that document pre-dates the request for examination the variable $USPTO\_sra_i$ takes the value 1. Finally, the variable also takes value 1 if the application reached SIPO through the PCT route and 0 otherwise. In such case, the PCT search report will always be available before the substantive examination at SIPO takes place.

Appendix B: Identification of SEPs

We used the ETSI disclosure database to identify patents that are essential to the WCDMA and LTE standards.[8] In 2012, this database underwent a significant upgrade, known as project 'DARE.' In collaboration with the EPO, patent declarations were linked with data from internal EPO patent databases. On 22 June 2016, the ETSI database contained 371,119 patent records

[7] Available at `http://portal.uspto.gov/pair/PublicPair`.

[8] This database is publicly available at `https://ipr.etsi.org/`.

for 291 different 'projects.' We identified 181 of these projects to be related to the WCDMA and/or LTE standards, and these projects in total included 324,374 records.[9] Each of these records has three different fields that may allow for identification of this patent and matching with the PATSTAT patent database. Of these records, 83.9 per cent could be identified in PATSTAT by the data in the 'Patent Number' field provided by ETSI. Another 1.1 per cent could be identified using the 'Application Number' field (which follows the so-called EPODOC formatting). Another 3.3 per cent was identified using the 'Patent Family' field. So, in total, we matched 88.2 per cent of all ETSI records with PATSTAT. We did not find any inconsistencies for patents that we could identify by two or even three fields. Virtually all the remaining, unmatched patents are patents that ETSI and the EPO, in their collaborative effort, had not been able to identify either (which can be recognized by having an empty 'Patent Families' field). Generally, these are declarations with incomplete or erroneous patent references, using a wide range of non-standard formatting. Testing several dozen of these unmatched numbers (still 36,823 in total) by hand, we found those numbers which we could eventually manually recognize, all were already part of recognized patent or patent family.

In terms of patent families, the matched list of 286,258 patents includes considerable overlap. Firstly, many patents are disclosed as essential for more than one project. Secondly, the ETSI database automatically included all known patent family members of the disclosed patents, so for many patents dozens of family members are included. Using PATSTAT, we found the patents in the list to belong to 12,692 unique DOCDB patent families.

[9] Note that in ETSI, the term UMTS is often used in relation to the 3G WCDMA standard.

Appendix C: Exogeneity of the declaration date to ETSI

One potential concern that we may have is that the declaration date of a SEP patent application at ETSI is not exogenous. In particular, we would like to rule out that non-Chinese applicants change their disclosure strategy when they know they are going to seek patent protection in China. To test this hypothesis we run a test on the sample of DOCDB patent families belonging to non-Chinese companies, declared as essential to ETSI for the 3G and 4G standard between 2001 and 2010, that have at least one patent application at three of the main five IP office: USPTO, EPO, JPO, KIPO, and SIPO. In this way we identify 5,489 DOCDB patent families. To test whether the timing of disclosure is independent from the decision to file a patent application in China, we construct the variable *Declaration_lag*, that is computed as the lag in months between the first application of the family in one of the five patent offices reported above and the disclosure at ETSI. We then regress the *Declaration_lag* on the variable *Chinese_child*, that takes the value 1 if at least one of the patent applications belonging to a specific patent family was filed at SIPO, and 0 if the patent family has no members filed at the Chinese patent office. About 10 per cent of the families in our sample does not have a Chinese member. The main idea of this test is clearly that if we found a significant effect for the variable *Chinese_child* we would not be able to rule out the possibility that non-Chinese companies change their declaration strategy when they know they are going to seek patent protection in China. If instead the variable*Chinese_child* had no significant impact on the declaration lag, this would suggest that foreign companies do not behave differently in terms of disclosure timing, if they know they will file a patent application at the Chinese patent office for an invention declared as standard-essential at ETSI.

In the regression we control for a set of additional variables that can possibly affect disclosure timing and in particular for the size of the patent family, for the number of citations received by a family, for the number of applicants and inventors, and for the number of claims. We also include year and firm fixed effects.

Table 8 reports the result of different specification of the model described above. Column 1 and 2 reports the result from an OLS regression, columns 3 and 4 from a Poisson regression that take into account the count nature of the outcome variable. Columns 2 and 4 also include firms' fixed effects. As the table shows, all specifications point in the same direction, families with a Chinese member do not have statistically different declaration-lag compared to the families that do not have one. Thus, this result provides evidence that foreign companies do not implement different disclosure strategies for standard-essential inventions for which they seek patent protection in China, confirming the goodness of our identification strategy.

[Table 8 about here.]

List of Tables

Table 1: Descriptive statistics by applicant country of residence

	Chinese applicants				Foreign applicants				t-test
	min	mean	max	sd	min	mean	max	sd	Diff.
grant	0.0	0.931	1		0.0	0.881	1		0.050*
grant_lag	4.0	25.390	71	11.927	12.0	41.676	109	14.637	-16.290*
Δ Scope	-122.0	41.861	337	60.021	-216.0	35.653	1575	68.319	6.208
known_SEP	0.0	0.257	1		0.0	0.283	1		-0.026
sra	0.0	0.154	1		0.0	0.832	1		-0.678*
pct	0.0	0.088	1		0.0	0.607	1		-0.519*
exam_request_lag	7.0	22.513	44	7.173	3.0	26.081	63	7.329	-3.568*
nb_inv	1.0	2.423	8	1.576	0.0	2.567	13	1.546	-0.145
prior_decl_lag	4.0	38.373	140	21.531	3.0	65.705	191	37.679	-27.330*
log_family_size	0.7	1.301	2	0.430	0.7	1.807	3	0.464	-0.506*
log_tot_IPC	0.0	0.851	2	0.461	0.0	0.963	2	0.445	-0.111*
nb_indep_claims	1.0	3.105	12	2.132	1.0	4.523	55	3.160	-1.418*
log_words_claim	3.5	4.302	6	0.352	3.2	4.048	6	0.363	0.254*
PFE	0.0	0.555	1	0.411	0.0	0.697	1	0.323	-0.141*
fast	0.0	0.172	1		0.0	0.089	1		0.083*
slow	0.0	0.039	1		0.0	0.124	1		-0.084*
N	421				1232				

Figures based on the sample of patent applications (Sample 1).
The column t-test reports the difference in means between the two groups and the statistical significance of that difference.
* $p < 0.01$

Table 2: Results for Grant Outcome

	OLS					Probit				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
sra	-0.099***	-0.080***			-0.080***	-0.037**	-0.028**			-0.028**
	(0.030)	(0.030)			(0.030)	(0.017)	(0.014)			(0.014)
foreign			0.042	0.064	-0.001			0.042	0.055	-0.003
			(0.067)	(0.068)	(0.072)			(0.048)	(0.045)	(0.033)
known_SEP			0.085**	0.073**	0.047			0.113**	0.092**	0.054*
			(0.035)	(0.036)	(0.036)			(0.045)	(0.044)	(0.030)
foreign X known_SEP			-0.094**	-0.106**	-0.094**			-0.123***	-0.133***	-0.089***
			(0.041)	(0.041)	(0.040)			(0.048)	(0.046)	(0.031)
pct	0.369***	0.396***			0.397***	0.233***	0.224***			0.216***
	(0.031)	(0.032)			(0.032)	(0.023)	(0.024)			(0.025)
exam_request_lag		-0.006***		0.001	-0.006***		-0.003***		0.001	-0.003***
		(0.001)		(0.001)	(0.002)		(0.001)		(0.001)	(0.001)
log_family_size		-0.011		-0.021	-0.007		-0.000		-0.013	0.005
		(0.019)		(0.021)	(0.019)		(0.014)		(0.020)	(0.014)
log_tot_IPC		-0.018		-0.006	-0.018		-0.023*		-0.015	-0.022*
		(0.018)		(0.019)	(0.018)		(0.013)		(0.018)	(0.012)
nb_inv		0.016***		0.022***	0.016***		0.016***		0.023***	0.016***
		(0.005)		(0.006)	(0.005)		(0.005)		(0.006)	(0.004)
prior_decl_lag		-0.000*		-0.001*	-0.001**		-0.000**		-0.001**	-0.000**
		(0.000)		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
log_nb_indep_claims		0.011		0.018	0.013		0.014		0.019	0.016*
		(0.014)		(0.015)	(0.014)		(0.009)		(0.014)	(0.009)
log_words_claims		0.046**		0.027	0.046**		0.041**		0.033	0.040***
		(0.021)		(0.023)	(0.021)		(0.016)		(0.021)	(0.015)
Fixed effects:										
PFE	0.186***	0.179***	0.237***	0.242***	0.181***	0.133***	0.115***	0.223***	0.219***	0.111***
	(0.025)	(0.026)	(0.028)	(0.030)	(0.027)	(0.020)	(0.020)	(0.023)	(0.024)	(0.019)
Firm Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.847***	1.138***	0.738***	0.705***	1.142***					
	(0.046)	(0.115)	(0.082)	(0.134)	(0.133)					
N	1653	1653	1653	1653	1653	1425	1425	1425	1425	1425
R^2	0.268	0.287	0.145	0.158	0.290	.347	.383	.177	.203	0.394

Regressions performed on Sample 1. The sample reduces to 1,425 applications for the probit models because some of the agency and firm fixed effects perfectly predict the outcome.
Columns (6)–(10) report marginal effects.
For Columns (6)–(10) the R^2 row reports the pseudo R^2.
Robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Results for Grant Lag

	OLS						Poisson			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
sra	-1.134	0.103			-0.392	-0.856	0.445			-0.107
	(1.458)	(1.476)			(1.445)	(1.466)	(1.468)			(1.430)
foreign			9.935***	9.755***	6.864***			8.348***	8.165***	5.040*
			(2.553)	(2.524)	(2.647)			(2.636)	(2.567)	(2.600)
known_SEP			-5.892***	-3.999**	-5.809***			-10.348***	-8.529***	-10.330***
			(1.582)	(1.640)	(1.785)			(2.694)	(2.666)	(2.805)
foreign X known_SEP			6.712***	7.304***	8.503***			11.151***	11.574***	12.646***
			(1.892)	(1.873)	(1.974)			(2.825)	(2.774)	(2.892)
pct	13.247***	16.130***			16.076***	11.675***	14.097***			14.008***
	(1.748)	(1.753)			(1.741)	(1.513)	(1.476)			(1.466)
exam_request_lag		-0.427***		-0.007	-0.380***		-0.395***		-0.013	-0.348***
		(0.080)		(0.070)	(0.081)		(0.072)		(0.064)	(0.074)
log_family_size		-1.961**		-2.463**	-2.313**		-2.100**		-2.519***	-2.361***
		(0.956)		(1.013)	(0.956)		(0.849)		(0.923)	(0.849)
log_tot_IPC		1.139		1.659*	1.298		1.173		1.601*	1.307
		(0.884)		(0.926)	(0.872)		(0.814)		(0.877)	(0.802)
nb_inv		0.438		0.571*	0.481*		0.332		0.469*	0.372
		(0.287)		(0.296)	(0.284)		(0.237)		(0.250)	(0.237)
prior_decl_lag		0.026*		0.036*	0.033*		0.022*		0.031*	0.028*
		(0.014)		(0.019)	(0.019)		(0.012)		(0.017)	(0.016)
log_nb_indep_claims		1.435**		1.535**	1.193*		1.360**		1.491**	1.117*
		(0.723)		(0.761)	(0.707)		(0.668)		(0.708)	(0.652)
log_words_claims		-2.315**		-3.378***	-2.433**		-2.358**		-3.380***	-2.401**
		(1.053)		(1.093)	(1.048)		(1.003)		(1.048)	(0.998)
Fixed effects:										
fast	-2.429**	-2.532**	-4.022***	-3.751***	-2.854**	-3.356**	-3.461**	-4.850***	-4.544***	-3.831***
	(1.218)	(1.230)	(1.221)	(1.227)	(1.182)	(1.385)	(1.358)	(1.415)	(1.410)	(1.306)
slow	1.570	0.986	2.840*	2.319	1.041	1.077	0.532	2.222*	1.689	0.538
	(1.392)	(1.366)	(1.480)	(1.491)	(1.354)	(1.106)	(1.079)	(1.188)	(1.199)	(1.072)
Firm Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	33.439***	55.624***	30.239***	46.509***	42.205***					
	(9.107)	(10.059)	(9.122)	(10.678)	(10.791)					
N	1311	1311	1311	1311	1311	1311	1311	1311	1311	1311
R^2	0.431	0.460	0.392	0.408	0.475	0.2572	0.272	0.240	0.249	0.282

Sample 2 is used in this regression. The sample reduces to 1,311 applications because it was not possible to retrieve the information on the grant lag of twin applications for 166 patent.
Columns (6)–(10) report marginal effects.
For Columns (6)–(10) the R^2 row reports the pseudo R^2
Robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Results for Reduced Scope

	Δscope				
	(1)	(2)	(3)	(4)	(5)
sra	-0.436	0.057			-0.650
	(3.769)	(3.805)			(3.896)
foreign			6.583	11.760	9.456
			(7.285)	(7.322)	(7.372)
known_SEP			-14.609**	-13.102**	-13.624**
			(6.468)	(6.607)	(6.620)
foreign X known_SEP			9.895	13.511*	13.619*
			(7.267)	(7.345)	(7.359)
pct	10.442**	9.534**			9.154**
	(4.172)	(4.489)			(4.471)
exam_request_lag		-0.017		0.237	0.065
		(0.218)		(0.210)	(0.225)
log_family_size		-8.661***		-9.170***	-9.116***
		(2.916)		(2.920)	(2.942)
log_tot_IPC		1.978		2.119	1.906
		(3.098)		(3.092)	(3.091)
nb_inv		3.214***		3.310***	3.260***
		(1.203)		(1.219)	(1.212)
prior_decl_lag		0.081*		0.055	0.053
		(0.042)		(0.052)	(0.052)
log_nb_indep_claims		-5.176*		-5.997**	-6.083**
		(2.723)		(2.779)	(2.758)
diff_ic		1.997***		2.144***	2.126***
		(0.700)		(0.733)	(0.709)
Fixed effects:					
Firm Effects	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes
Constant	136.264***	166.379***	126.817***	143.175***	156.159***
	(13.188)	(19.524)	(15.468)	(19.931)	(21.085)
N	1436	1436	1436	1436	1436
R^2	0.124	0.147	0.126	0.149	0.151

Sample 3 is used in this regression. The sample reduces to 1,436 applications because it was not possible to retrieve the full-text of 41 applications.
Robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Results with a time window

	Grant		Grant_lag		Δ scope
	OLS	Probit	OLS	Poisson	OLS
sra	-0.086***	-0.026*	0.682	0.862	-0.842
	(0.031)	(0.014)	(1.511)	(1.472)	(4.052)
foreign	0.006	0.006	6.627***	4.677*	10.831
	(0.074)	(0.030)	(2.527)	(2.492)	(7.667)
known_SEP	0.069*	0.097***	-7.179***	-12.591***	-12.515*
	(0.038)	(0.033)	(1.998)	(3.049)	(6.784)
foreign X known_SEP	-0.118***	-0.133***	10.014***	15.135***	11.774
	(0.042)	(0.034)	(2.144)	(3.108)	(7.582)
pct	0.404***	0.206***	16.500***	14.434***	10.630**
	(0.034)	(0.024)	(1.816)	(1.518)	(4.663)
exam_request_lag	-0.006***	-0.003***	-0.410***	-0.380***	0.067
	(0.002)	(0.001)	(0.085)	(0.076)	(0.233)
log_family_size	-0.007	0.004	-1.778*	-1.904**	-8.289***
	(0.020)	(0.014)	(1.005)	(0.890)	(3.086)
log_tot_IPC	-0.024	-0.024*	1.555*	1.493*	2.859
	(0.019)	(0.012)	(0.919)	(0.849)	(3.208)
nb_inv	0.017***	0.016***	0.528*	0.404*	3.566***
	(0.006)	(0.004)	(0.294)	(0.242)	(1.267)
prior_decl_lag	-0.001**	-0.000**	0.031	0.027	0.056
	(0.000)	(0.000)	(0.020)	(0.017)	(0.056)
log_nb_indep_claims	0.011	0.015*	1.232*	1.163*	-6.543**
	(0.014)	(0.009)	(0.728)	(0.665)	(2.850)
log_words_claims	0.049**	0.041***	-1.899*	-1.789*	
	(0.022)	(0.016)	(1.073)	(1.010)	
diff_ic					1.954***
					(0.709)
Fixed effects:					
PFE	0.183***	0.109***			
	(0.028)	(0.019)			
fast			-3.273***	-4.249***	
			(1.241)	(1.362)	
slow			1.750	1.106	
			(1.404)	(1.100)	
Firm Effects	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes
Constant	0.846***		36.525***		148.417***
	(0.150)		(10.994)		(21.937)
N	1536	1313	1214	1214	1336
R^2	0.298	0.396	0.473	0.281	0.160

Columns (2) and (4) report marginal effects.
For Columns (2) and (4) the R^2 row reports the pseudo R^2
Robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Results with larger sample

	Grant Probit	Grant_lag Poisson	Δscope OLS
foreign	0.077	4.641	23.354
	(0.098)	(5.680)	(27.375)
known_SEP	0.060*	-8.948***	-15.829**
	(0.031)	(2.062)	(6.157)
foreign × known_SEP	-0.071**	9.503***	16.405**
	(0.033)	(2.123)	(6.561)
pct	0.223***	12.439***	9.518***
	(0.016)	(1.032)	(3.314)
log_family_size	0.025**	-1.647***	-9.359***
	(0.011)	(0.620)	(2.820)
log_tot_IPC	0.034***	1.192***	-1.567
	(0.008)	(0.427)	(1.858)
prior_decl_lag	-0.000	0.015	0.053
	(0.000)	(0.012)	(0.046)
log_nb_indep_claims	-0.005	1.588***	-6.806***
	(0.008)	(0.443)	(2.170)
log_words_claims	0.040***	-2.298***	
	(0.014)	(0.753)	
nb_inv	0.012***	0.624***	2.611***
	(0.003)	(0.158)	(0.761)
diff_ic			2.550***
			(0.568)
Fixed effects:			
Firm Effects	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes
Constant			95.285***
			(24.841)
N	2617	2467	2465
R^2	0.289	0.248	0.130

Columns (1) and (2) report marginal effects.
For Columns (1) and (2) the R^2 row reports the pseudo R^2
Robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Results for absolute change in scope

	Absolute ΔScope				
	(1)	(2)	(3)	(4)	(5)
sra	-3.118	-3.207			-3.558
	(3.380)	(3.401)			(3.478)
foreign			0.754	5.124	4.673
			(6.679)	(6.808)	(6.934)
known_sep			-18.496***	-16.649***	-16.854***
			(6.047)	(6.156)	(6.176)
int_known_sep			16.767**	20.877***	20.747***
			(6.718)	(6.737)	(6.761)
pct	8.529**	7.313*			6.875*
	(3.770)	(4.006)			(3.984)
exam_request_lag		0.088		0.221	0.143
		(0.203)		(0.198)	(0.211)
log_family_size		-6.712**		-7.615***	-7.379***
		(2.759)		(2.760)	(2.778)
log_tot_IPC		-0.637		-0.475	-0.658
		(2.869)		(2.847)	(2.849)
nb_inv		3.054***		3.113***	3.100***
		(1.150)		(1.164)	(1.159)
prior_decl_lag		0.084**		0.080*	0.080*
		(0.038)		(0.048)	(0.048)
log_nb_indep_claims		-6.093**		-7.021***	-7.112***
		(2.469)		(2.483)	(2.477)
diff_ic		1.737***		1.895***	1.883***
		(0.577)		(0.589)	(0.579)
Fixed effects:					
Firm Effects	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes
Constant	102.188***	131.009***	97.257***	116.912***	122.262***
	(12.205)	(18.198)	(14.191)	(18.617)	(19.782)
N	1436	1436	1436	1436	1436
R^2	0.112	0.136	0.117	0.142	0.144

Sample 3 is used in this regression. The sample reduces to 1,436 applications because it was not possible to retrieve the full-text of 41 applications.
Robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Exogeneity

	OLS		POISSON	
	(1)	(2)	(3)	(4)
Family_size	-0.380***	-0.485***	-0.439***	-0.405***
	(0.064)	(0.065)	(0.062)	(0.066)
Citations	-0.027*	-0.001	-0.019	-0.002
	(0.016)	(0.015)	(0.012)	(0.011)
Chinese_child	-1.960	-0.813	-1.341	-1.341
	(1.252)	(1.254)	(1.029)	(1.011)
Inventors	0.515	0.820**	0.365	0.469
	(0.419)	(0.411)	(0.307)	(0.290)
Applicant	0.418	-0.121	0.349	0.034
	(0.416)	(0.405)	(0.293)	(0.273)
nb_claims	-0.051**	-0.020	-0.042*	-0.024
	(0.025)	(0.026)	(0.022)	(0.021)
Year_fe	Yes	Yes	Yes	Yes
Firm_fe		Yes		Yes
_cons	80.099***	127.691***		
	(3.532)	(4.026)		
N	5489	5489	5489	5489
R^2	0.349	0.454	0.293	0.372

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$