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

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Abstract

This paper tests for traces of discrimination against foreigners in the patent system. It focuses on patent applications filed in China, and for which the owner has made a public disclosure that they are or may become essential to the implementation of a technical standard. Such potentially standard-essential patents are of particularly high importance to their owner. We use the timing of disclosure to a leading standard-setting organization as a source of econometric identification and carry out extensive tests to ensure the exogeneity of timing. We find that foreign patent applications are significantly less likely to be granted by the Chinese patent office if their owners disclose them to be potentially essential to a standard *before* the substantive examination starts. Furthermore, the patent office spends, on average, one more year on the examination of such patents, and the scope of the patents are also more extensively reduced. Our findings contribute to the emerging discussion on technology protectionism.

JEL Codes: F53, F68, K39, L52, L63,

Keywords: discrimination, indigenous innovation, national treatment principle, standard-essential patent, technology protectionism

*R.B.: Performed studies and commissioned projects related to standardization in telecommunications (for the European Commission and the U.S. National Academies of Science), serves (unpaid) on an advisory board of a Standard Setting Organizations, and serves on IP-related court cases as expert witness. No COI to declare.

1. Introduction

The global rise of Chinese corporations is undeniable. Once seen as an opportunity for Western companies, China's economic growth is generating growing tensions with its major trade partners. A recent editorial in *The Economist* talks of "trade without trust," and the media have started to talk of a new Cold War.[1] In Europe, the European Commission has called China a "systemic rival" in pursuit of technological leadership.[2] Chinese firms initially prospered by relying on cheap labor and exploiting the economies of scale that the sheer size of their internal market offers. They are now becoming more sophisticated; buying firms in technologically-advanced countries and challenging incumbents.

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 critically 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). Accordingly, some Chinese companies such as Huawei and ZTE have become active contributors to global standards, including leading standards for 3G, 4G, and 5G mobile communications. These companies are now among the

[1] See The Economist (18 July, 2020): "China v America - Huawei and the tech cold war" [economist.com], Foreign Policy (12 August, 2020): "In the New Cold War, Deindustrialization Means Disarmament" [foreignpolicy.com], BBC News (24 July, 2020): "Why US-China relations are at their lowest point in decades" [bbc.com], New York Times (24 July, 2020): "How the Cold War Between China and U.S. Is Intensifying" [nytimes.com] All websites accessed Jan 15, 2021.

[2] Politico (12 March 2019): "EU slams China as 'systemic rival' as trade tension rises," politico.eu].

most prolific patent filers at the U.S. Patent and Trademark Office (USPTO) and the European Patent Office (EPO). They are also very well positioned in the race for recent technologies, as documented by a recent USPTO report on 5G technologies (Critharis et al., 2022). The domestic players Huawei and ZTE compete with large players like Nokia and Ericsson from Europe, Qualcomm and Motorola from the United States, Samsung and LG Electronics from South Korea, NTT DoCoMo from Japan, and Innovative Sonic from Taiwan. In terms of ownership of patents essential to mobile telecommunication standards, these ten firms own the overwhelming majority of patents.[3] In recent years, the share of SEPs owned by Chinese companies has been growing continuously, mainly at the expense of European and U.S. firms (Bekkers et al., 2020a).

The rise of Chinese telecommunication champions and their role in standardization processes 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 to comply with China's laws. It also had to pay a fine equivalent to $1 billion (Lexology, 2015).

Tensions surrounding SEPs provide the starting point for our analysis. There is nascent

[3] Appendix B presents information on the share of patents these companies have in our study sample.

evidence that the patent prosecution process is biased against foreigners, in China and elsewhere (Webster et al., 2014; de Rassenfosse and Raiteri, 2022; de Rassenfosse and Hosseini, 2020). 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 (2022) arrive at a similar conclusion using data from the China National Intellectual Property Administration (CNIPA, formerly called 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.

As far as we can ascertain, existing studies have all relied on the same identification strategy to document discrimination. They establish the counterfactual outcome using twin patents, which are applications covering the same invention but filed in different patent offices. Evidence that the grant outcome for the same invention differs across offices between locals and foreigners (e.g., Webster et al., 2014) is cause for concern. Yet, this approach is not immune to criticism, not least because applicants may be keener to push for a grant at their local patent offices than at foreign offices. Given the importance of the question, there is a need to alternative and stronger tests of discrimination.

The present paper moves forward the nascent literature on anti-foreign bias in two ways. First, we propose a novel identification strategy to test discrimination. We track whether the patent application was disclosed as potentially 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. Thus, evidence that SEP disclosure adversely affects the examination outcome would reinforce the foreign bias hypothesis. To establish the validity of this statistical test, we carefully assess the exogeneity of the timing of disclosure with respect to the timing of the patent examination in China. Second, we consider more outcome variables than previous studies, thereby providing a more comprehensive view of the effects of anti-foreign bias. In addition to the examination outcome, the analysis also considers two novel outcomes: the duration of the examination process and a reduction of the scope of protection (as determined by the patent claims) between the patent application and the patent that was eventually granted.

The paper also contributes to the rich body of work on standard-essential patents, which forms a subset of the literature on cumulative (and complementary) innovations (e.g., Scotchmer, 1991; Méniere, 2008; Gilbert and Katz, 2011; Aoki and Spiegel, 2009; Denicolò and Halmenschlager, 2012). Broadly speaking, research on SEPs has predominantly focused on the economic distortions they induce, in the context of royalties and licensing contracts (Dewatripont and Legros, 2013; Lemley and Shapiro, 2013; Lerner and Tirole, 2015; Ishihara and Yanagawa, 2018), innovation incentives (Ganglmair et al., 2012; Delcamp and Leiponen, 2014; Baron et al., 2016), or product price (Gallini, 2014). 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.

We find that patent applications by foreign firms systematically receive a less favorable treatment at the CNIPA if they are disclosed as SEP *before* entering substantive examination at the CNIPA (versus if they are disclosed after examination). The sample focuses on patent applications disclosed as potentially 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. SEPs by foreigners that are disclosed before examination at CNIPA are about nine percentage points less likely to be granted, face a prosecution delay of about one year, and have about 14 additional words per independent claim added during examination, suggesting a narrowing of the scope of the granted patented. These results holds controlling for a range of confounding factors, including most importantly a measure of the likelihood of the invention being granted (the 'twin patent' control) as well as the availability of search reports at foreign offices. We interpret the results as evidence of discrimination against foreigners.

With China being a production powerhouse for many standard-based products sold all over the world, the consequences of this finding extend considerably beyond the Chinese product market. Furthermore, although some technology companies may file a great number of patents, which mitigates the effect of discrimination on their bargaining position, policymakers ought to provide a fair patent system. Failure to do so would hurt international trade—indeed, patent rights facilitate international trade (Maskus and Penubarti, 1995; Ivus, 2015; Palangkaraya et al., 2017; de Rassenfosse et al., 2022a). Besides, discrimination against foreign MNEs would lower the returns to inventive activities, putting at risk the ability of the global patent system to stimulate R&D investment.

The rest of the paper is organized as follows. Section 2 explains the empirical setup, Section 3 presents the econometric implementation. The data are presented in Section 4. Sections 5 and 6 offer baseline results and robustness analyses, respectively. Section 7 concludes.

2. Empirical setup

This paper tests for the presence of a systematic difference in treatment between foreign and domestic firms in the patent prosecution process of SEPs. An invention deserves patent protection in a jurisdiction if it meets the patentability criteria in that jurisdiction. Generally, these criteria include novelty, inventive step/obviousness, and industrial applicability/usefulness, although there is variation in the actual implementation of these criteria across patent offices (de Rassenfosse et al., 2021). 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., 2020b). However, differences in patentability criteria across jurisdictions do not represent 'discrimination,' as these criteria apply to all applicants, regardless of their country of origin.

Our strategy for identifying discrimination works as follows. A priori, the treatment of SEPs does not depend on whether the examiner (or, in fact, any other party) knows that the invention is potentially 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 domestic). Thus, differences between foreigners and domestic firms in how knowledge about the SEP-status of an application affects the prosecution process would provide evidence of discrimination—positive or negative.

As alluded to, the study focuses on patent applications disclosed as potentially 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.[4] We consider the date of disclosures at the ETSI. It is the European standard-setting organization (SSO) that is the partnering organization within 3GPP where the lion's share of patent disclosures for these standards are made.[5] Note that the patent disclosures we use are made during the development of the standard; whether these patents will become factually essential can only be known once the standard is finalized and once the patents are granted—and thus the scope of their claims

[4]These disclosures are also known as 'declarations' because they usually include licensing commitments for the disclosed patents, such as a commitment to license patents on Fair, Reasonable and Non-discriminatory (FRAND) terms.

[5]The 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 SSOs 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.

is known (Bekkers et al., 2020a). Having noted this, whether these patents turn out to be factually essential or not is irrelevant to our study.

We ask the following research question: Are foreign patent applications that are known to be standard essential at the time they enter the substantive examination phase at CNIPA treated less favourably than similar domestic applications? We focus on three outcomes: the likelihood of a grant, the duration of examination, and the reduction in scope of the application. Two aspects of the identification strategy require special attention: the exogeneity of the timing of disclosure, and the availability of search reports in other jurisdictions. We discuss these two aspects in turn.

2.1. Exogeneity of the timing of disclosure

Since we will exploit the timing of disclosure as a source of identification, we need to ensure that this timing is exogenous to the filing decision at CNIPA. We start by discussing factors that drive the timing of SEP disclosure. We then offer an empirical test that provides evidence that the timing of disclosure is not associated with the decision to file in China.

Timing of SEP disclosure: policies and practices

The primary consideration regarding the timing of disclosure is the requirement set by SSOs to disclose SEPs in a 'timely' manner. The timing of disclosure is critical to efficient standards development and timely disclosure allows SSO working group members to make appropriate choices concerning the inclusion of alternative technologies (Maskus and Merrill, 2013). In fact, many SSOs have mechanisms that prevent the inclusion of patented technologies if there is no certainty that licenses will be available at FRAND conditions, and such mechanisms only work when patents (and associated licensing commitments) are timely disclosed.[6] Furthermore,

[6]See ETSI Rules of Procedure, 3 April 2019, Annex 6: ETSI Intellectual Property Rights Policy: Section 8, titled 'Non-availability of licences'.

early disclosure provides participants with the greatest opportunity to evaluate the relevance of standard-related patented technology, and gives patent holders and prospective licensees enough time to negotiate the terms and conditions of licenses outside the standards development process itself (Tsilas, 2003). SSO patent policies differ on the precise timing of when the actual disclosure statement must be submitted to the SSO (Bekkers and Updegrove, 2012). The SSO that is relevant to our study, ETSI, requires that disclosures are made in 'a timely fashion,' yet the organization has not agreed on a precise definition of 'timely' in this context.[7] In short, SSOs' rules push for early disclosure but firms might have different interpretations of what 'timely' actually means.

Even though the SSO's requirements in terms of disclosure timing are defined imprecisely, late disclosure can have important legal implication for patent holders. In court, patent owners that fail to disclose in a timely manner risk to lose the right to enforce their patents, as demonstrated in *Conversant vs. Apple*. In this case, a U.S. federal court concluded that "ETSI members were required to disclose their patents and patent applications on a particular technology at the time they make a proposal, regardless of whether that proposal is ultimately adopted." The judge established that Nokia, the original owner of one of the patents disputed in this case, had disclosed it four years later than it should have done. This delay was "untimely," and gave Nokia, and Conversant (who purchased the patent from Nokia), an "unfair competitive advantage." As a result, the patent was unenforceable.[8] In a similar vein, patent owners that deliberately conceal patents that might be essential to a standard may risk to lose the ability

[7]See ETSI Rules of Procedure, 3 April 2019, Annex 6: ETSI Intellectual Property Rights Policy, Section 4.1: "[...] each member shall use its reasonable endeavours, in particular during the development of a standard or technical specification where it participates, to inform ETSI of essential IPRs in a timely fashion. [...]", and ETSI Guide on IPRs, 19 September 2013, Article 2: "Definitions for 'Timeliness' or 'Timely' cannot be agreed because such definitions would constitute a change to the Policy."

[8]*Conversant vs. Apple*, Case No.15-cv-05008-NC, especially at page 2, 4, 8. The Court stated that Nokia should have disclosed the disputed patent, originally applied for in November 1997, by June 1998 at the latest.

to enforce their patents, as demonstrated by various court cases (for instance *Qualcomm, v. Broadcomm*; *in re Dell Corporation*, and *Rambus v. Infineon*).[9] These legal risks create a strong incentive for companies to disclose potential SEPs as early as reasonably possible.

Another important consideration regarding the timing of disclosure relates to licensing practices in the field of mobile telecommunications. Firms in this field usually license entire portfolios, covering granted patents as well as patent applications (that may turn into granted patents later on). A patent owner has an incentive to show the maximum possible extent of its portfolio of patents that are essential, or may become essential, to maximize potential licensing fees. This practice acts as another incentive to disclose potential SEPs early so that the firm can include these disclosed patents in its licensing negotiations.

In conclusion, this discussion suggests that incentives work towards early disclosure. The literature on SEPs offers no reason to suspect that the timing of filing at CNIPA would be correlated with the timing of disclosure.

A test of exogeneity

Despite the arguments laid out above, foreign applicants who seek patent protection in China may deliberately postpone SEP disclosure, precisely because of concerns about discrimination at the CNIPA. Should they behave in this way, however, our sample would miss the most obvious cases of discrimination. It would include only non-obvious discrimination cases, such that our empirical setup would lead to conservative estimates. Below, we report a test of the exogeneity of CNIPA filing with respect to the disclosure date.

To perform the test, we start by identifying the sample of DOCDB patent families belonging to non-Chinese companies, disclosed as potentially essential to ETSI for the 3G and 4G standard

[9] *Qualcomm, Inc. v. Broadcomm, Inc.*, No. 2007-1545 (Fed. Cir. Dec. 1, 2008); *Dell VESA* case, *in re Dell Corporation*, 121 F.T.C. 616 (1996), and *Rambus v. Infineon* 145 F. Supp. 2d 721 (E.D. Va. 2001). See Dolmans (2002, p.185) and Maskus and Merrill (2013, p.75).

between 2001 and 2010, and that have at least one patent application at three of the IP5 offices: USPTO, EPO, JPO, KIPO, and CNIPA.[10] This selection leads to 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 *disclosure_lag*. It is computed as the lag in months between the date of the first application of the family in one of the five patent offices reported above and the disclosure date at ETSI. We then regress the *disclosure_lag* on the variable *Chinese_child*, which takes the value 1 if at least one of the patent applications belonging to a specific patent family was filed at CNIPA, and 0 otherwise. About 10 percent of the families in our sample do not have a Chinese member.

The test works as follows. If we find a significant effect for the variable *Chinese_child*, we would not be able to rule out the possibility that non-Chinese companies adapt their disclosure strategy at ETSI when they seek patent protection in China. On the other hand, if we find that the variable *Chinese_child* has no impact on the disclosure lag, we could conclude that foreign companies do not adapt the timing of disclosure to their Chinese filings. The regression model controls for a set of variables that can possibly affect disclosure timing, notably the size of the patent family, the number of citations received by a family, the number of applicants and inventors listed on the patent document, and the number of claims. We also include year and firm fixed effects.

Table 1 reports the results of two specifications of the test described above: without firm fixed effects in columns (1) and with firm fixed effects in column (2). As the table shows, both specifications point in the same direction. Patent families with a Chinese member do not exhibit a statistically different disclosure lag than families that do not have a Chinese member.

[10]The DOCDB 'simple' patent family captures patent documents that have exactly the same priority date or combination of priority dates.

This result provides evidence that foreign companies do not adopt different disclosure strategies for SEPs that cover China. We can thus conclude that the timing of disclosure is exogenous to the decision to file at CNIPA.

[Table 1 about here.]

Despite the theoretical and empirical arguments presented above, the econometric analysis will also control for the lag between the earliest priority filing date of a patent application and the date on which it was first disclosed to ETSI. Furthermore, should the timing of disclosure affect the patent prosecution process in any systematic manner, it should do so at every patent authorities and not exclusively at CNIPA. As briefly mentioned above and discussed in more detail in Section 4, the empirical analysis will exploit information on the grant outcome of twin patent applications filed in foreign jurisdictions.

2.2. Availability of prior art search

Another important aspect of the identification strategy relates to the availability of prior art search reports by other patent offices at the time a CNIPA patent 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 the 'priority filing'), the applicant has a limited period of time to seek protection in additional jurisdictions by submitting so-called 'second filings.' Consequently, 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. In short, applications for which an earlier search report is available at the time they enter the substantive examination phase at CNIPA may have a less favorable application outcome. If the availability of a search report correlates with the timing of disclosure, ignoring this information in the regression model would lead to an omitted variable bias. Consequently, the regression analysis will control for the availability of foreign search reports.

3. Econometric implementation

3.1. Regression models

As mentioned, the 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.[11] We estimate the following regression model:

$$\Pr(grant_i = 1|\text{covariates}) = \Phi(\beta_1 foreign_i + \beta_2 known\_SEP_i + \beta_3 (foreign \times known\_SEP)_i + \beta_4 sra_i + \beta_5 PFE_i + \mathbf{X_i}\gamma) \tag{1}$$

where $\Phi(\cdot)$ is the Probit link function. The variables $foreign_i$, $known\_SEP_i$ and the interaction term $(foreign \times known\_SEP)_i$ are the variables of interest. The dummy variable $foreign_i$ takes the value 1 if application for invention i is filed by a foreign applicant and 0 otherwise.

[11]Patent withdrawals occur for two broad reasons. Firstly, an applicant can choose to withdraw because it lost commercial interest in the invention, for instance, because market opportunities have diminished. Secondly, an applicant can withdraw if it becomes clear during the prosecution process that the patent application is likely to be rejected. A study by Lazaridis and van Pottelsberghe de la Potterie (2007) suggests that up to 54 percent of all patent withdrawals at the EPO could be considered as 'induced' by the work of EPO examiners (i.e., equivalent to rejections). With SEPs, however, we expect this percentage to be much higher, as SEPs are valuable assets and lack of commercial interest is, therefore, unlikely. For that reason, we consider withdrawals to be equivalent to rejections.

The dummy variable $known\_SEP_i$ takes the value 1 if the SEP disclosure at ETSI pre-dates the request for examination, and thus the substantive examination phase at CNIPA, and 0 otherwise. The interaction term $(foreign \times known\_SEP)_i$ is the key variable. It takes the value 1 when the applicant is foreign and the patent application is publicly known to be a SEP.

The variable sra_i stands for 'Search Report Available.' It takes the value 1 if at least one search report was available for an equivalent application at the USPTO, the EPO or, in the case of the Patent Cooperation Treaty (PCT) route, the World Intellectual Property Organization (WIPO), at the time the substantive examination at CNIPA took place. It takes the value of 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.

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 exploit the grant status of twin patents (Webster et al., 2014; Sampat and Shadlen, 2015). 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 (2022). We interpret the variable PFE_i as an invention 'pseudo fixed effect' that captures other patent offices' assessment of the patentability of invention i. It forms our best guess for what the grant outcome should be. Thus, the regression models test whether CNIPA's decision deviates from that of other offices as a function of the timing of disclosure. Finally, the vector variable $\mathbf{X_i}$ includes a range of control variables and fixed effects (firm, time, patent 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:

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

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 two variables are used exclusively for the grant lag analysis.

Third dependent variable: change in scope

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

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

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 claimed invention during examination. The reason is that each word added in a claim introduces a further legal limitation upon its scope. To illustrate, consider the first independent claim of an application that 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 brakes 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 prosecution process at the CNIPA. 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 Treaty (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 patent 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 CNIPA and the date of the request for examination.

- Priority-to-disclosure lag (*prior_disc_lag*) reports the time-lag in months between the priority date of the invention (i.e., the date of its first filing) and its disclosure date at ETSI. This variable controls for the age of the invention at the time it is disclosed as potentially 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: an invention pseudo fixed effect (for regression models 1 and 2, discussed above); a firm fixed effect; an application year fixed effect; and a patent 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 foreign and domestic firms (de Rassenfosse et al., 2022b). The regressions include a binary variable for each of the 39 patent attorney agencies in the sample.

4. Data

4.1. Data sources and sample construction

The dataset used for the analysis covers 48 firms holding 1,653 SEPs. We construct it by combining data from five sources. The EPO Worldwide Patent Statistical Database (PATSTAT) is the main data source. 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 CNIPA and on the grant date. We also crawled the Google Patent website and the CNIPA website to recover the number of independent and dependent claims at the CNIPA, the number of words per claim, and information on the patent attorney agency.[12]

In order to put domestic and foreign firms on the same level, we impose that all applications in the sample have a 'direct equivalent' (i.e., twin) at selected patent authorities (see below). The selection ensures that we compare foreign applications with Chinese applications of international stature —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. 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, Japan, Korea, Russia, Taiwan, the United States, and the member states of the European Patent Convention (corresponding to the following patent offices: CIPO, JPO, KIPO, RFSIP, TIPO, USPTO, and EPO, respectively).

[12]We used https://patents.google.com and https://english.cnipa.gov.cn.

To sum up, the sample is composed of applications for SEPs filed at the CNIPA 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 obtain an external measure of the 'patentability' of the invention.

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

- *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 disclosed as SEP before entering the examination phase at CNIPA.

- *Sample 2*: As regression model (2) uses grant lag as dependent variable, one must estimate it on a sample that only contains granted patents. There are 1,477 granted patents but Sample 2 contains 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 $slow$).[13]

- *Sample 3*: As regression model (3) has scope change as dependent variable, we must estimate it on a sample that only contains granted patents. Sample 3 contains 1,436 patents due to missing data on the full text 41 patent application at CNIPA, which we need to compute the change in scope.

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

4.2. Descriptive statistics

Table 2 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 CNIPA 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 they enter into the examination phase at CNIPA (26% vs. 28%). About 60 percent of foreign applications reached CNIPA through the PCT route. The corresponding figure for applications by Chinese applicants is much lower (8.8%) due to the fact that local applicants first file at home (and will use the PCT route for second filings). 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 2 about here.]

5. Results

Table 3 displays the results of a probit regression model. The effect of search report availability is tested in columns (1)–(2), and the discrimination is tested in columns (3)–(4). Column (5) provides the full regression results. The results are consistent across specifications and we focus our discussion on column (5).

As suspected, the availability of a search report negatively correlates with the probability of grant. On average, an application with a foreign search report available at the time it enters substantive examination at the CNIPA 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 variable PFE.[14]

Regarding the test for discrimination, we find strong evidence of negative discrimination against foreigners. The results show that being a foreign patent owner reduces the likelihood of the patent applications granted at the CNIPA by about 9 percentage points when the patent is disclosed as being potentially essential to a standard prior to examination.

[Table 3 about here.]

Table 4 displays the results of a Poisson regression for model (2), related to the grant lag. Again, the results are consistent across specifications and we focus the discussion on column (5). 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 evidence of discrimination, as suggested by the negative and statistically significant effect 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 (12.6 months). Note that this result controls for the speed of the prosecution process of the twins at the other offices (variables $fast$ and $slow$).

[Table 4 about here.]

Next, Table 5 displays the OLS regression coefficients for model (3), concerning the reduction

[14] Additional results (not reported) reveal that the effect is mainly driven by USPTO search report. The lack of statistical significance for EPO search reports is surprising, as it is commonly believed that the EPO is more rigorous than the USPTO in its searches, leading to lower allowance rates (Bekkers et al., 2020b). 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 possible interpretation is that CNIPA examiners look predominantly at USPTO search reports.

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., there are more words per independent claim). We observe that the availability of search reports at the time of examination at the CNIPA does not have an impact on the scope of the granted patent, relative to the scope of the patent application.

Again, we find evidence of bias against foreigners: 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 5 about here.]

To sum up, we find evidence of discrimination across all outcomes. Applications by foreigners that are disclosed as SEP before examination are scrutinized more 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 these effects for such applications (i.e., disclosed as SEP before examination) by Chinese firms.

6. Robustness analysis

Several robustness checks confirm the validity of the main findings.

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 disclosure 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 6 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 applications disclosed before examination becomes larger in magnitude, reaching 13 percentage points. The effect on the grant lag also increases in size and is now about 15 months longer for foreign applications disclosed as SEP before the examination process. The results on the reduction in scope are similar in magnitude.

[Table 6 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 any of 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 excludes families with merged and split members. The sample now contains 2,764 patent applications filed at CNIPA, of which 2,207 are filed by foreigners and 557 by Chinese firms. A total of 872 applications belong to families disclosed as SEP before the start of the examination process at CNIPA. Table 7 reports the results of the analysis conducted on this enlarged sample. As the table shows, this robustness check confirms the magnitude of the effects reported in Tables 3–5.

[Table 7 about here.]

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. After all, patent law does not allow an applicant to widen the scope of the patent application during the prosecution process. Having read several patent applications that 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 to illustrate, 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." Clearly, the latter claim is narrower than the former, despite the fact that it contains fewer words. Therefore, we also propose an alternative variable to measure change in scope, namely the absolute change in the number of words per independent claim. The rationale here 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 8 reports the results of the regression analysis with this alternative dependent variable.

[Table 8 about here.]

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

7. Conclusion and discussion

This paper examines anti-foreign bias in the prosecution of patent applications. It focuses on patent applications filed at the Chinese patent office and disclosed by their owner to be potentially essential to two of the world's most valuable standards: the 3G WCDMA and 4G LTE standards for mobile communications. The choice of this specific category of patents is particularly appropriate to test for discrimination 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.

The empirical analysis show that patent applications disclosed as SEP before entering into the substantive examination phase at the CNIPA are about nine 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. Furthermore, if such foreign-owned inventions do receive a patent, the grant decision arrives substantially later, about a year on average, and the scope of the application is significantly reduced. In other words, it seems that CNIPA examiners scrutinize more carefully these applications, resulting overall in a less favorable prosecution process.[15]

We come to these findings after controlling for an extensive number of alternative explanations, including the availability of search reports, 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 potential essentiality disclosure. 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. We also carried out tests that confirm that the timing of disclosure is indeed exogenous with respect to the timing of the patent examination in China.

Our study has explicitly ruled out a large number of potential explanations for the effect we observe. Our design does not allow us to track down additional underlying mechanisms by which discrimination may happen, and doing so would require an entirely different study. Do examiners themselves look at these SEP disclosure sources? Or do they receive information in the form of third-party observations from Chinese competitors? And if they do, why do

[15] Alternatively, examiners may scrutinize Chinese applications less carefully, resulting in positive discrimination for domestic applicants. In relative terms, however, foreign applicants face a more exacting prosecution process.

these foreign SEPs receive a particularly unfavorable treatment? Chinese rivals Huawei and ZTE fought a bitter court cases over SEPs in Germany, so why would such firms bring third-party observations relating to foreign applications to the attention of the patent office, but not relating to applications of their domestic rivals? Policy-wise, given the highly strategic nature of SEPs, it makes sense to examine applications for SEPs more carefully, as hinted, e.g., by scholars who have mused on a two-tier patent system (Lichtman and Lemley, 2007; Atal and Bar, 2014). However, if such suggestions are followed, scrutiny should apply to all applications for potentially standard essential patents—not only those filed by foreigners.

Other mechanisms than 'protectionism' may be at play (e.g., rivalry towards specific actors), but the nature of our sample precludes us from investigating them in depth. One could also study to what degree the present results would hold for SEPs 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 hand, such standards are usually developed by SSOs that allow 'blanket disclosures,' which impedes the identification of the patents in question. This feature complicates the execution of a study such as ours, 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 might want to think strategically about the timing of their SEP disclosures. The 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), and later disclosure might go against the public interest.

Policy makers may want to consider how our findings affect markets that are based on technical standards. These markets are gaining in importance with developments such as the Internet of Things, smart grids, smart cities, e-health, etc. With China being a production powerhouse for many standards-based products sold all over the globe, the consequences go considerably beyond the Chinese product market.

Finally, although the findings suggest that China does not uphold the national treatment principle, at least as far as SEPs are concerned, we have not investigated whether similar forms of discrimination exist at other patent offices. Other scholars have researched this question. Using data on twin patents, de Rassenfosse and Hosseini (2020) find no evidence of disparate treatment of foreigners at the USPTO. However, they suggest that foreigners might be subject to unintentional discrimination, in the sense that policies, practices, and rules may have disparate impacts on foreigners compared to locals. We believe that the issue of discrimination has significant importance and that it would be appropriate to address it in the dialogue between the world major patent offices. One venue for doing so is the IP5, the forum of patent offices of Europe, Japan, Korea, China, and the United States. Another venue is the World Trade Organization, whose members are responsible for upholding the TRIPS Agreement.

References

Aoki, R. and Spiegel, Y. (2009). Pre-grant patent publication and cumulative innovation. *International Journal of Industrial Organization*, 27(3):333–345.

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., Henkel, J., M. Tur, E., Vorst, T. v. d., Driesse, M., Kang, B., Martinelli, A., Maas, W., Nijhof, B., Raiteri, E., and Teubner, L. (2020a). Pilot study for essentiality assessment of Standard Essential Patents. Nikolaus Thumm (ed.). Study commissioned by the EC. Technical report, Publications Office of the European Union.

Bekkers, R., Martinelli, A., and Tamagni, F. (2020b). The impact of including standards-related documentation in patent prior art: Evidence from an EPO policy change. *Research Policy*, 49(7):Published on–line 23 July 2020.

Bekkers, R., Raiteri, E., Martinelli, A., and M. Tur, E. (2020c). Landscape study of potentially essential patents disclosed to ETSI. Nikolaus Thumm (ed.). Study commissioned by the EC. Technical report, Publications Office of the European Union.

Bekkers, R. and Updegrove, A. (2012). *A study of IPR policies and practices of a represen-*

tative group of Standards Setting Organizations worldwide. National Academies of Science, Washington, DC.

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

Critharis, M., Toole, A., Wu, E., Hannon, C., Miller, R., and Diehl, M. (2022). Patenting activity among leading 5g innovators. Technical report, USPTO Office of Policy and International Affairs.

de Rassenfosse, G., Grazzi, M., Moschella, D., and Pellegrino, G. (2022a). International patent protection and trade: Transaction-level evidence. *European Economic Review*, 147:104160.

de Rassenfosse, G., Griffiths, W. E., Jaffe, A. B., and Webster, E. (2021). Low-quality patents in the eye of the beholder: Evidence from multiple examiners. *Journal of Law, Economics, & Organization*, 37(3):607–636.

de Rassenfosse, G. and Hosseini, R. (2020). Discrimination against foreigners in the U.S. patent system. *Journal of International Business Policy*, (3):349–366.

de Rassenfosse, G., Jensen, P. H., Julius, T., Palangkaraya, A., and Webster, E. (2022b). Is the patent system a level playing field: The effect of patent attorney firms. *Journal of Industrial Economics*, forthcoming.

de Rassenfosse, G. and Raiteri, E. (2022). Technology protectionism and the patent system: Evidence from China. *Journal of Industrial Economics*, 70(1):1–43.

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

Denicolò, V. and Halmenschlager, C. (2012). Optimal patentability requirements with complementary innovations. *European Economic Review*, 56(2):190–204.

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

Dolmans, M. (2002). Standards for standards. *Fordham Int'l LJ*, 26:163.

Gallini, N. (2014). Cooperating with competitors: Patent pooling and choice of a new standard. *International Journal of Industrial Organization*, 36:4–21.

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.

Gilbert, R. J. and Katz, M. L. (2011). Efficient division of profits from complementary innovations. *International Journal of Industrial Organization*, 29(4):443–454.

Ishihara, A. and Yanagawa, N. (2018). Dark sides of patent pools with independent licensing. *International Journal of Industrial Organization*.

Ivus, O. (2015). Does stronger patent protection increase export variety? evidence from us product-level data. *Journal of International Business Studies*, 46(6):724–731.

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

Lazaridis, G. and van Pottelsberghe de la Potterie, B. (2007). The rigour of EPO's patentability criteria: An insight into the "induced withdrawal". *World Patent Information*, 29(4).

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.

Maskus, K. and Merrill, S. A. (2013). *Patent Challenges for Standard-Setting in the Global Economy: Lessons from Information and Communications Technology*. The National Academies Press, Washington, DC.

Maskus, K. E. and Penubarti, M. (1995). How trade-related are intellectual property rights? *Journal of International economics*, 39(3-4):227–248.

Méniere, Y. (2008). Patent law and complementary innovations. *European Economic Review*, 52(7):1125–1139.

OECD (2008). *OECD Reviews of Innovation Policy - China*. Organisation for Economic Co-operation 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].

Palangkaraya, A., Jensen, P. H., and Webster, E. (2017). The effect of patents on trade. *Journal of International Economics*, 105:1–9.

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.

Scotchmer, S. (1991). Standing on the shoulders of giants: cumulative research and the patent law. *Journal of Economic Perspectives*, 5(1):29–41.

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.

Tsilas, N. L. (2003). Toward greater clarity and consistency in patent disclosure policies in a post-Rambus world. *Harvard Journal of Law & Technology*, 17:475.

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. Our variable sra_i takes value 1 if the A1 or A3 publications pre-date the request for examination at CNIPA. We used the PATSTAT database to determine the publication dates of documents with specific kind codes. The variable also takes the value 1 if a patent application at CNIPA has a direct equivalent at the USPTO for which the initial search performed by USPTO examiners is already available before the applicant files the request for examination at CNIPA. To construct this variable we exploit the data from the USPTO PUBLIC 'Patent Application Information Retrieval' (Public PAIR) database.[16] We determined the date of the PTO-892 form ('Notice of References Cited') for the focal patent. This form 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 takes the value 1. Finally, the variable also takes value 1 if the application reached CNIPA through the PCT route. In such case we do not have to consider specific dates: by definition, the PCT search report will be available already before the substantive examination at CNIPA takes place.

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

Appendix B: Identification of SEPs

We used the ETSI disclosure database to identify patents (and patent applications) that are potentially essential to the WCDMA and LTE standards.[17] In 2012, this database underwent a significant upgrade, known as project 'DARE.' In collaboration with the EPO, patent disclosure were linked with data from internal EPO patent databases. On 22 June 2016, the ETSI database contained 371,119 patent records 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.[18] 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 percent could be identified in PATSTAT by the data in the 'Patent Number' field provided by ETSI. Another 1.1 percent could be identified using the 'Application Number' field (which follows the so-called EPODOC formatting). Another 3.3 percent was identified using the 'Patent Family' field. So, in total, we matched 88.2 percent 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 cases correspond to disclosures with incomplete or erroneous patent references, using a wide range of non-standard formatting. A manual inspection of several dozens of these unmatched numbers (still 36,823 in total) led to no further identification of patents or patent families.

In terms of patent families, the matched list of 286,258 patents includes considerable overlap. Firstly, many patents are disclosed as potentially essential for more than one project. Secondly,

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

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

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.

In our dataset, the ten largest firms in terms of patent families come from Europe (Nokia and Ericsson, holding together 28% of the patents), China (Huawei and ZTE, 22%), the United States (Qualcomm and Motorola, 12%), South Korea (Samsung and LG Electronics, 12%), Japan (NTT DoCoMo, 5%), and Taiwan (Innovative Sonic, 2%). This distribution results in a good geographical spread of our patents. While the above firms together own 81 percent of all patent families in our dataset, there is a long tail of 38 companies that own the remaining 19 percent of the patent families. It is important to note that patent family ownership shares in our dataset do not necessarily reflect the global patent family ownership shares, such as those reported in a recent study for the European Commission (Bekkers et al., 2020c). The reason for this apparent discrepancy is that we only consider patent families for which the owner applied for protection in China (and also in at least one of the selected foreign patent offices, see Section 4.1). Not all firms filed for protection in China to the same extent, especially when it comes to older patents.

List of Tables

Table 1: Exogeneity of the disclosure date

	Poisson	
	(1)	(2)
Family_size	-0.439***	-0.405***
	(0.161)	(0.128)
Citations	-0.019	-0.002
	(0.023)	(0.018)
Chinese_child	-1.341	-1.341
	(1.909)	(1.588)
Inventors	0.365	0.469
	(0.612)	(0.456)
Applicants	0.349	0.034
	(0.232)	(0.208)
nb_claims	-0.042	-0.024
	(0.068)	(0.047)
App_Year Effects	Yes	Yes
Firm Effects		Yes
N	5489	5489
R^2	0.293	0.372

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

The dependent variable, *disclosure_lag* is computed as the lag in months between the priority date and the disclosure date at ETSI. Standard errors clustered at the firm level in parentheses.

Table 2: Descriptive statistics by applicant country of residence

	Chinese applicants				Foreign applicants				t-test
	Min	Mean	Max	S.D.	Min	Mean	Max	S.D.	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_disc_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 3: Results for Grant Outcome

	Probit				
	(1)	(2)	(3)	(4)	(5)
sra	-0.037*	-0.028*			-0.028*
	(0.020)	(0.015)			(0.016)
foreign			0.042	0.055	-0.003
			(0.073)	(0.060)	(0.048)
known_SEP			0.113***	0.092***	0.054**
			(0.033)	(0.035)	(0.022)
foreign X known_SEP			-0.123***	-0.133***	-0.089***
			(0.038)	(0.031)	(0.029)
pct	0.233***	0.224***			0.216***
	(0.018)	(0.025)			(0.029)
exam_request_lag		-0.003**		0.001	-0.003***
		(0.001)		(0.001)	(0.001)
log_family_size		-0.000		-0.013	0.005
		(0.015)		(0.021)	(0.013)
log_tot_IPC		-0.023		-0.015	-0.022
		(0.020)		(0.025)	(0.019)
nb_inv		0.016***		0.023***	0.016***
		(0.006)		(0.007)	(0.005)
prior_disc_lag		-0.000*		-0.001**	-0.000**
		(0.000)		(0.000)	(0.000)
log_nb_indep_claims		0.014		0.019	0.016*
		(0.010)		(0.017)	(0.009)
log_words_claim		0.041***		0.033**	0.040***
		(0.015)		(0.016)	(0.013)
Fixed effects:					
PFE	0.133***	0.115***	0.223***	0.219***	0.111***
	(0.027)	(0.022)	(0.042)	(0.039)	(0.018)
Firm Effects	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes
Observations	1425	1425	1425	1425	1425
Pseudo R^2	0.339	0.376	0.177	0.203	0.386

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

Regressions performed on Sample 1. The sample reduces to 1,425 observations because some of the agency and firm fixed effects perfectly predict the outcome. The dependent variable, *grant*, captures the status of a patent application. It takes the value 1 if the application was granted and 0 if it was rejected or withdrawn. Columns (1)–(5) report marginal effects.

Standard errors clustered at the firm level in parentheses.

Table 4: Results for Grant Lag

	Probit				
	(1)	(2)	(3)	(4)	(5)
sra	-0.856	0.445			-0.107
	(1.909)	(1.761)			(1.411)
foreign			8.348***	8.165*	5.040
			(2.636)	(4.195)	(4.516)
known_SEP			-10.348***	-8.529***	-10.330***
			(2.694)	(3.224)	(2.525)
foreign X known_SEP			11.151***	11.574***	12.646***
			(2.825)	(3.800)	(3.266)
pct	11.675***	14.097***			14.008***
	(2.837)	(2.320)			(2.330)
exam_request_lag		-0.395***		-0.013	-0.348***
		(0.099)		(0.055)	(0.070)
log_family_size		-2.100**		-2.519***	-2.361**
		(0.913)		(0.905)	(0.932)
log_tot_IPC		1.173		1.601*	1.307
		(0.854)		(0.913)	(0.825)
nb_inv		0.332*		0.469**	0.372*
		(0.183)		(0.197)	(0.193)
prior_disc_lag		0.022		0.031	0.028
		(0.025)		(0.025)	(0.025)
log_nb_indep_claims		1.360		1.491*	1.117
		(0.980)		(0.793)	(0.857)
log_words_claim		-2.358*		-3.380**	-2.401*
		(1.372)		(1.632)	(1.326)
Fixed effects:					
fast	-3.356***	-3.461***	-4.850***	-4.544***	-3.831***
	(1.121)	(1.096)	(1.415)	(1.520)	(1.226)
slow	1.077	0.532	2.222*	1.689*	0.538
	(0.766)	(0.851)	(1.188)	(0.925)	(0.826)
Firm Effects	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes
Observations	1311	1311	1311	1311	1311
Pseudo R^2	0.257	0.273	0.241	0.249	0.283

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

Regressions performed on Sample 2. The sample reduces to 1,311 observations because it was not possible to retrieve the information on the grant lag of twin application for 166 patents. The dependent variable, *grant_lag*, reports the duration (in months) between the request for examination and the grant decision.

Columns (1)–(5) report marginal effects.

Standard errors clustered at the firm level in parentheses.

Table 5: 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_disc_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

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
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.
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.
Standard errors clustered at the firm level in parentheses.

Table 6: Results with a time window

	Grant (1)	Grant_lag (2)	Δscope (3)
sra	-0.026	0.862	-0.842
	(0.017)	(1.377)	(3.136)
foreign	0.006	4.677	10.831*
	(0.043)	(3.630)	(6.131)
known_SEP	0.097***	-12.591***	-12.515***
	(0.024)	(2.081)	(4.005)
foreign X known_SEP	-0.133***	15.135***	11.774***
	(0.029)	(2.698)	(3.366)
pct	0.206***	14.434***	10.630**
	(0.026)	(2.365)	(4.213)
exam_request_lag	-0.003***	-0.380***	0.067
	(0.001)	(0.080)	(0.272)
log_family_size	0.004	-1.904*	-8.289***
	(0.014)	(0.998)	(2.829)
log_tot_IPC	-0.024	1.493	2.859
	(0.019)	(0.928)	(2.784)
nb_inv	0.016***	0.404*	3.566**
	(0.005)	(0.210)	(1.666)
prior_disc_lag	-0.000**	0.027	0.056
	(0.000)	(0.025)	(0.071)
log_nb_indep_claims	0.015*	1.163	-6.543*
	(0.008)	(0.797)	(3.501)
log_words_claim	0.041***	-1.789	
	(0.014)	(1.190)	
diff_ic			1.954***
			(0.692)
Fixed effects:			
PFE	0.109***		
	(0.016)		
fast		-4.249***	
		(1.305)	
slow		1.106	
		(0.852)	
Firm Effects	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes
Constant			148.417***
			(21.937)
N	1313	1214	1336
R^2	0.396	0.281	0.160

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
The dependent variable *grant* (1) captures the status of a patent application. It takes the value 1 if the application was granted and 0 if it was rejected or withdrawn. The dependent variable *grant_lag* (2) reports the duration (in months) between the request for examination and the grant decision. The outcome variable Δ*scope* (3) is computed as the difference in the number of words per independent claim included in the granted patent and in the patent application.
Columns (1)-(2) report marginal effects.
For Columns (1)-(2) the R^2 row reports the pseudo R^2
Standard errors clustered at the firm level in parentheses.

Table 7: Results with larger sample

	Grant (1)	Grant_lag (2)	Δscope (3)
foreign	0.077	4.641	102.009***
	(0.098)	(4.312)	(9.126)
known_SEP	0.060*	-8.948***	-15.829***
	(0.031)	(1.218)	(2.271)
foreign X known_SEP	-0.071**	9.503***	16.405***
	(0.033)	(0.998)	(2.401)
log_family_size	0.025**	-1.647	-9.359***
	(0.011)	(1.008)	(2.496)
log_tot_IPC	0.034***	1.192*	-1.567
	(0.008)	(0.632)	(2.294)
prior_disc_lag	-0.000	0.015	0.053
	(0.000)	(0.016)	(0.056)
pct	0.223***	12.439***	9.518***
	(0.016)	(2.038)	(3.096)
log_nb_indep_claims	-0.005	1.588*	-6.806**
	(0.008)	(0.879)	(2.925)
log_words_claim	0.040***	-2.298**	
	(0.014)	(1.094)	
nb_inv	0.012***	0.624***	2.611***
	(0.003)	(0.171)	(0.674)
diff_ic			2.550***
Fixed effects:			
Firm Effects	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes
Constant			101.529***
			(5.154)
N	2617	2467	2465
R^2	0.289	0.248	0.130

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
The dependent variable *grant* (1) captures the status of a patent application. It takes the value 1 if the application was granted and 0 if it was rejected or withdrawn. The dependent variable *grant_lag* (2) reports the duration (in months) between the request for examination and the grant decision. The outcome variable $\Delta scope$ (3) is computed as the difference in the number of words per independent claim included in the granted patent and in the patent application.
Columns (1)-(2) report marginal effects.
For Columns (1)-(2) the R^2 row reports the pseudo R^2
Standard errors clustered at the firm level in parentheses.

Table 8: Results for absolute change in scope

	Absolute ΔScope				
	(1)	(2)	(3)	(4)	(5)
sra	-3.118	-3.207			-3.558
	(2.624)	(2.685)			(2.947)
foreign			0.754	5.124	4.673
			(8.448)	(6.504)	(6.439)
known_SEP			-18.496***	-16.649***	-16.854***
			(2.424)	(3.243)	(3.273)
foreign X known_SEP			16.767***	20.877***	20.747***
			(3.887)	(3.578)	(3.533)
pct	8.529**	7.313*			6.875*
	(3.387)	(3.901)			(3.772)
exam_request_lag		0.088		0.221	0.143
		(0.252)		(0.211)	(0.261)
log_family_size		-6.712**		-7.615**	-7.379**
		(2.922)		(3.031)	(3.020)
log_tot_IPC		-0.637		-0.475	-0.658
		(2.419)		(2.377)	(2.402)
nb_inv		3.054**		3.113**	3.100**
		(1.315)		(1.383)	(1.379)
prior_disc_lag		0.084		0.080	0.080
		(0.056)		(0.063)	(0.063)
log_nb_indep_claims		-6.093*		-7.021**	-7.112**
		(3.487)		(3.193)	(3.255)
log_words_claim					
diff_ic		1.737*		1.895**	1.883**
		(0.868)		(0.853)	(0.848)
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	71.306***	70.428***	127.683***	58.696***	67.520***
	(6.012)	(11.248)	(11.514)	(7.581)	(10.522)
N	1436	1436	1436	1436	1436
R^2	0.112	0.136	0.117	0.142	0.144

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

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.

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

Standard errors clustered at the firm level in parentheses.