Discrimination against foreigners in the patent system : evidence from standard-essential patents

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

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Abstract

This paper tests for traces of discrimination against foreign firms in the patent prosecution process. It focuses on the case of China and looks specifically at patent applications declared as essential to a technological standard. The choice of standard-essential patents (SEPs) is particularly suited because of the 'strategic' importance of such patents for China's indigenous innovation program. We exploit information on the timing of disclosure as SEP (before or after the patent application enters examination) to infer the likely presence of discrimination. We find that patent applications by foreign firms are treated unfavorably when examiners know that they are declared as standard essential. We interpret this result as a case of technology protectionism.

JEL Codes: F53, F68, K39, L52, L63, O25, O34

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

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1. Introduction

The global rise of Chinese corporations is undeniable. They initially prospered by relying on cheap labour 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 (Ernst, 2011). This industry heavily relies on technical standards to ensure devices and networks can interoperate. For companies active in this industry, 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, provide a strong bargaining position for cross-licensing deals, and represent a strategic asset to counter patent infringement accusations by competitors (Kang and Bekkers, 2015). Ownership of SEPs that have legal validity in China is particularly important 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. A well-known example is the 'iPhone' city of Zhengzhou, in east-central China, where the manufacturing firm Foxconn has 350,000 workers producing up to 500,000 iPhone devices per day (Barboza, 2016). Failure for Chinese companies to own essential patents for such standards would force them to remain low-margin players.

Initially, the Chinese government was keen to promote home-made standards and opposed to opening itself to global standards. Examples of such unique Chinese standards are the 3G mobile communications standard TD-SCDMA and the wireless encryption standard WAPI (Lee and Oh, 2008). In the end, this strategy was not very successful. These unique Chinese standards have generally been a failure: none of these standards have gained significant market support outside of China, and their adoption within China itself remained limited, despite strong government backing. Moreover, while the goal was that such 'indigenous' standards

would mainly incorporate IP of Chinese owners, in reality they also incorporated significant amounts of foreign IP (Breznitz and Murphree, 2013). Yet, despite the above policy, some strong Chinese companies such as Huawei and ZTE developed into very capable and successful adopters of, and contributors to, global standards such as leading standards for 3G and 4G mobile communications developed by 3GPP (known as WCDMA and LTE, respectively). These companies are now among the most innovative in the world, according to the number of patents they file at the U.S. Patent and Trademark Office (USPTO) and the European Patent Office (EPO).

The fact that China now finally embraces global standards, has not come without tension at the international level. Western observers 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 fact, in April 2014, the Guangdong High Court of China published its judgements 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 and to pay a fine equivalent to $1 billion (Lexology, 2015).

Another concern is that foreign companies may simply be denied patent protection for inventions that are standard essential. de Rassenfosse and Raiteri (2016) provide tentative evidence that foreign firms have a particularly low probability to receive a patent grant in China for inventions in selected strategic fields.

In this study we aim to shed more light on the cause(s) for potential anti-foreign bias in the prosecution of SEP applications at the SIPO. We focus on patent applications declared as standard 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. We investigate two possible explanations: the availability of earlier search reports at other patent offices, and whether the patent application is known to be essential to a standard at the time of examination. We consider three dimensions of the prosecution process, namely the examination outcome, the duration of the examination process and the possible reduction of scope between

the patent application and the patent that was eventually granted.

2. Hypothesis development

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, although their precise definitions differ between jurisdictions (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 an anti-foreign bias, since these criteria apply to all applicants regardless of their country of origin. We are concerned with systematic differences in the outcome of the Chinese prosecution process between foreigners and locals. This section discusses two possible explanations that may account for such differences. Both explanations are related to the information that is available to SIPO examiners.

The first potential explanation concerns the availability of prior art searches by other patent offices at the time a SIPO 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, the applicant has 12 months to seek protection in additional jurisdictions by filing 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. This might result in a less favourable examination outcome. Hence, we hypothesize:

H1: Applications for which an earlier search report is available will have a less favourable application outcome, ceteris paribus.

Note that validation of Hypothesis H1 would *not* be evidence of discrimination against foreign firms. The less favourable 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 is a direct test of discrimination. They key element here is whether

the examiner (or, in fact, any other party), can obtain information on whether a particular patent is essential to a technical standard or not. Such information 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.

In theory, such information on essentiality should not affect the prosecution process because it does not alter the nature of the invention. But if foreign discrimination occurs, then the fact that the examiner is aware of the application's SEP status before the application enters the substantive examination phase could affect the outcome of the examination.[2] On the contrary, if the declaration to the SSO was made $after$ the patent application entered the substantive examination phase, the examiner cannot identify that application as SEP when he (she) begins the examination process, and no such bias should occur. On the basis of the above, we hypothesize the following:

H2: Foreign patent applications that are known to be standard essential at the time they enter the substantive examination phase at SIPO have a less favourable examination outcome, ceteris paribus.

Clearly, validation of Hypothesis H2 would be evidence of discrimination against foreign firms.

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.

The first outcome variable, $grant_i$, captures the grant outcome of patent application for invention i. It takes the value 1 if the patent application was granted and 0 if it was rejected

[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.

[2] Chinese patent law requires the applicant to file a request for examination within three years after the application date.

or withdrawn after the filing of a request for substantive examination.

In order to test the two hypotheses, we estimate the following model:

$$\begin{aligned} grant_i = & \beta_1 EPO\_sra_i + \beta_2 USPTO\_sra_i + \beta_3 PCT\_sra_i \\ & + \beta_4 foreign_i + \beta_5 known\_SEP_i + \beta_6 (foreign \times known\_SEP)_i \\ & + \beta_7 PFE_i + \mathbf{X_i}\gamma + \varepsilon_i \end{aligned} \tag{1}$$

The variables EPO_sra_i, $USPTO\_sra_i$ and PCT_sra_i (where 'sra' standards for 'Search Report Available') are used to test Hypothesis H1. We focus on these three search reports as they account for the bulk of search reports in our sample. The variable EPO_sra_i indicates whether an EPO search report was available at the time the substantive examination at SIPO took place. It takes the value 1 if a patent application at SIPO has a direct equivalent at the EPO for which the initial search report performed by an EPO examiner is already publicly available before the applicant files the request for examination at SIPO. The variables $USPTO\_sra_i$ and PCT_sra_i are similarly defined. (See section 4 for more details.)

The variables $foreign_i$, $known\_SEP_i$ and interaction term $(foreign \times known\_SEP)_i$ are used to test Hypothesis H2. 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 date of the public disclosure of a patent application being a SEP for invention i pre-dates the request for examination, and thus the substantive examination phase, and 0 otherwise. Since our study focuses on the 3GPP WCDMA and LTE standards, we consider the date of disclosures at European Telecommunications Standards Institute (ETSI), the European SSO that is the partnering organization within 3GPP where the lion's share of patent disclosures for these standards are made.[3] The interaction term $(foreign \times known\_SEP)_i$ is our variable of interest for Hypothesis H2. It takes 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

[3]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

may observe a discriminatory treatment against foreigners if patent applications by foreign firms are of systematically lower quality than applications by Chinese firms. 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). 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 (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 that may affect the outcome of the examination process. The control variables are presented at the end of this section.

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

$$\begin{aligned} grant\_lag_i = & \beta_1 EPO\_sra_i + \beta_2 USPTO\_sra_i + \beta_3 PCT\_sra_i \\ & + \beta_4 foreign_i + \beta_5 known\_SEP\_i + \beta_6 (foreign \times known\_SEP)_i \\ & + \beta_7 fast_i + \beta_8 slow_i + \mathbf{X_i}\gamma + \varepsilon_i \end{aligned} \tag{2}$$

Most variables are similar to the earlier model. But instead of the pseudo fixed effect variable, we now include the variables $fast_i$ and $slow_i$, which are similar in spirit to the pseudo fixed effect. We define a patent applicant as fast (slow) if the average deviation from the mean of the grant lag at the equivalents' patent office is in the top (bottom) decile. Thus this dummy reports whether the twin applications at other patent authorities were granted particularly fast (slow) compared to the average grant-lag for SEP patents at each authority. (Note that this control variable is used exclusively for the grant-lag analysis.[4]

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

[4]We lose some observations because it was not possible to retrieve the information on the grant-lag for some twin applications.

$$\begin{aligned}\Delta scope_i =& \beta_1 EPO\_sra_i + \beta_2 USPTO\_sra_i + \beta_3 PCT\_sra_i \\ &+ \beta_4 foreign_i + \beta_5 known\_SEP\_i + \beta_6 (foreign \times known\_SEP)_i \\ &+ \mathbf{X_i}\gamma + \varepsilon_i\end{aligned} \tag{3}$$

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 Yoshimi 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 due to examination. The rationale behind this interpretation 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", while 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 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. Covariates

In all the above equations, the vector $\mathbf{X_i}$ includes control variables that may affect the probability of grant at the SIPO. We consider the following patent-level control variables:

- Patent family size (*family_size*) is the number of distinct countries covered by the INPADOC family.
- Number of IPC classes (*tot_IPC*)is the number of IPC classes mentioned in the SIPO application.
- Number of inventors (*nb_inv*) reports the total number of inventors listed in the patent document.
- Examination-request lag (*exam_request_lag*) reports the time-lag in months between the date of application at the SIPO and the date of the request for examination.

- Priority-declaration lag (*dec_prior_lag*) reports the time-lag in months between the priority date of the invention and its declaration date at ETSI. This variable allows to control for the age of the invention when 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 a patent application.

- Difference in independent claims (*diff_ic*) is a variable that collects the difference in the number of independent claims between the patent application and the granted patent (Note that this control 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 act as its agent 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. We then include a binary variable for each of the patent agency in our sample.

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; Berger 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.

4. Data

4.1. Data sources and sample construction

We combine data from different sources. The EPO Worldwide Patent Statistical Database (PATSTAT, April 2015 edition) is the main source of patent information. We identify SEP applications by collecting disclosure data from ETSI and focus on disclosures related to the 3G WCDMA and 4G LTE standards developed by 3GPP; Appendix A expands on this data

collection. The INPADOC legal status table (a PATSTAT add-on) provides the information on the grant outcome at the SIPO and on the date of the grant. 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 that was used for the patent in question.[5]

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. A direct equivalent is a patent protecting exactly the same invention in a different jurisdiction (Martinez, 2010). We identify direct equivalents by identifying for each INPADOC family Chinese applications that claim only one priority filing and/or that are claimed by only one priority filing in a jurisdiction (that is, we exclude split equivalents and merged equivalents). One can think of this requirement as similar in spirit to the common support requirement in econometric matching models. The sample is then composed of SEP applications filed at the SIPO by foreign and domestic firms between 2001 and 2009, that have at least one unique direct equivalent in one of the following patent offices: CIPO, EPO, JPO, KIPO, RFSIP, TIPO, and USPTO. All these applications are disclosed at ETSI and related to the 3G WCDMA and 4G LTE standards.

Due to data availability, we have produced four samples:

- Sample 1: 1653 SEP applications used for estimating regression model 1. Of these, 421 are filed by Chinese applicants and 1,232 filed by foreign applicants. A total of 457 applications (349 foreign and 108 Chinese) was declared as SEP before entering the examination phase at SIPO.

- Sample 2: the analysis for model 2 and model 3 is based on patents that are actually granted, which reduces our sample to 1,477 applications. The sample further reduces to 1,426 because for some patents the grant date of the twin application at other patent office is not available or the full text of the patent application is not available on the Google Patents website.

The construction of the variables capturing the availability of search reports deserves further

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

explanation. We construct the variable EPO_sra_i by exploiting the different publication kind codes at the EPO. A1 and A3 publication kinds refer to publications that include a search report. The variable takes value 1 if A1 or A3 publications pre-date the request for examination at SIPO. For the same reason, the variable takes value 1 of the EP patent was granted before the request for examination (publication code B1 or B2). In a similar way, $USPTO\_sra_i$ indicates whether an USPTO search report was available at the time the substantive examination at SIPO took place. It 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—or if the USPTO patent was granted. To construct this variable we exploit the data from the USPTO - PUBLIC Patent Application Information Retrieval (Public PAIR) Database.[6] 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, PCT_sra_i is a binary variable that takes value 1 if the application reached SIPO through the PCT route and 0 otherwise. Since for patents that follow the PCT route, the PCT search report will always be available before the substantive examination at SIPO takes place, we do not have to consider a specific date.

4.2. Descriptive statistics

Table 1 displays descriptive statistics by country of residence for Sample 1. The last column of the table reports the difference in the averages of the two groups and its statistical significance. As the table shows Chinese applications on average have a higher issuance rate at SIPO than foreign applications (variable *grant*), although their grant rate at other patent offices is on average significantly lower (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 SIPO. In 60 per cent of the cases foreign applications reached the Chinese patent office through the PCT route. In half of the cases the search report by the EPO is already available for foreign applications, whereas the one by the USPTO is available only

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

in 17 per cent of the cases. Given that for Chinese applications the application at SIPO is very often the priority application, only a minor share reached SIPO through the PCT route and have USPTO or EPO search report available when the examination process began.

Table 1: Descriptive statistics by country of residence

	Chinese applicants				Foreign applicants				t-test
	min	mean	max	sd	min	mean	max	sd	Diff.
granted	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	-16.29*
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	0.437	0.0	0.283	1	0.451	-0.026
EPO_sra	0.0	0.095	1		0.0	0.511	1		-0.416*
USPTO_sra	0.0	0.021	1		0.0	0.170	1		-0.148*
PCT_sra	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
dec_prior_lag	4.0	38.373	140	21.531	3.0	65.705	191	37.679	-27.33*
log_fam_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				

The column t-test reports the difference between the averages of the two groups and the statistical significance of that difference.
* $p < 0.01$.

5. Results

Table 2 displays the regression coefficients for the first model (Grant Outcome), estimated using as a linear probability model and a probit regression.[7]

Concerning Hypothesis 1, we observe that the availability of USPTO and EPO search reports has a negative impact, although only the USPTO search report has a statistically significant effect. 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

[7]Note that the sample reduces to 1,425 applications for the probit model, as some of the agency and firms fixed-effects perfectly predicts the outcome.

Table 2: Results for Grant Outcome

	OLS					Probit				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
EPO_sra	-0.032*	-0.022			-0.022	-0.014	-0.010			-0.011
	(0.017)	(0.017)			(0.017)	(0.014)	(0.012)			(0.011)
USPTO_sra	-0.083***	-0.074**			-0.075**	-0.066***	-0.052***			-0.052***
	(0.032)	(0.031)			(0.031)	(0.020)	(0.018)			(0.017)
PCT_sra	0.332***	0.368***			0.370***	0.216***	0.207***			0.198***
	(0.027)	(0.029)			(0.030)	(0.021)	(0.023)			(0.023)
foreign			0.042	0.064	-0.012			0.042	0.055	0.000
			(0.067)	(0.068)	(0.071)			(0.048)	(0.045)	(0.031)
known_sep			0.085**	0.073**	0.044			0.113**	0.092**	0.051*
			(0.035)	(0.036)	(0.036)			(0.045)	(0.044)	(0.029)
foreign × known_sep			-0.094**	-0.106**	-0.093**			-0.123***	-0.133***	-0.088***
			(0.041)	(0.041)	(0.040)			(0.048)	(0.046)	(0.030)
exam_request_lag		-0.006***		0.001	-0.007***		-0.003***		0.001	-0.003***
		(0.001)		(0.001)	(0.002)		(0.001)		(0.001)	(0.001)
log_fam_size		-0.013		-0.021	-0.009		0.002		-0.013	0.007
		(0.019)		(0.021)	(0.019)		(0.014)		(0.020)	(0.013)
log_tot_IPC		-0.016		-0.006	-0.017		-0.021*		-0.015	-0.021*
		(0.018)		(0.019)	(0.018)		(0.012)		(0.018)	(0.011)
nb_inv		0.016***		0.022***	0.015***		0.015***		0.023***	0.015***
		(0.005)		(0.006)	(0.005)		(0.004)		(0.006)	(0.004)
dec_prior_lag		-0.000*		-0.001*	-0.001**		-0.000**		-0.001**	-0.001***
		(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)	(0.008)
log_words_claim		0.045**		0.027	0.045**		0.037**		0.033	0.036**
		(0.021)		(0.023)	(0.021)		(0.015)		(0.021)	(0.014)
Fixed effects:										
PFE	0.186***	0.179***	0.237***	0.242***	0.181***	0.129***	0.111***	0.223***	0.219***	0.106***
	(0.026)	(0.027)	(0.028)	(0.030)	(0.027)	(0.019)	(0.019)	(0.023)	(0.024)	(0.018)
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
_cons	0.838***	1.089***	0.738***	0.705***	1.104***					
	(0.045)	(0.113)	(0.082)	(0.134)	(0.133)					
N	1653	1653	1653	1653	1653	1425	1425	1425	1425	1425
R^2	0.267	0.287	0.145	0.158	0.290	.347	.383	.177	.203	0.394

Standard errors in parentheses

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

Right-hand side columns report the marginal effect for the probit model

allowance rates (Bekkers et al., 2016). Furthermore, the EPO has a more-encompassing definition of prior art which is especially relevant for the area this study focuses on: in contrast to other patent offices, also technical proposals that are shared in the context of standards setting are considered to be part of the state of the art (Ibid.). Even though a SIPO examiner should strictly adhere to the SIPO definitions of prior art, this still may lead to documents that the SIPO examiner could find a basis to reject a patent. Despite both factors, nevertheless, our data suggest no impact of the availability of EPO search reports. Concerning the effect of the availability of a PCT search report we see that, contrary to what we hypothesized, there is a *positive* impact: the availability of an PCT search report strongly increases the likelihood

that the SIPO examiner grants the patent. All the above findings are robust when we allow for alternative explanations via control variables. Altogether we conclude that the availability of a USPTO search report has a negative effect on the grant rate, one of EPO has no effect, and one of PCT has an unexpected positive effect, and thus reject the grant outcome part of Hypothesis 1.

Concerning Hypothesis 2, we find a strong negative and significant effect (between 8.8 and 9.3 percentage points) on the grant outcome for foreign application disclosed as SEP before entering the substantive examination at SIPO. This effect is stable after control variables are added.

For the estimation of the second model (Grant Lag) we both use OLS and Poisson regression models. Results are shown in Table 3. Because we can only consider patents that are actually granted, the overall sample is somewhat smaller than that for the first model. Concerning Hypothesis 1, we find that the availability of USPTO or EPO search reports does not affect the time lag. Yet, we observe that the availability of PCT search report before the SIPO examiner starts the substantive examination has a strong, positive effect on the time it takes to examine a SIPO patent. Note that the time lag we investigate is defined as the period between the applicant requests examination, and the time of patent grant, so the effect we observe cannot be simply attributed to the lengthy PCT procedure as such, which allows that national phases start as late as 30 months after the priority date of the original patent(WIPO, 2015). Altogether, we only find partial support for Hypothesis 1. Concerning Hypothesis 2, we find a substantial positive and significant effect of our interaction term on the time to grant, that is on average between 8.5 and 12.6 months longer for foreign application disclosed as SEP before the examination process. This effect is always strongly present, and its magnitude is independent of the inclusion of controls. Altogether, this provides strong support for Hypothesis 2.

The third model (Reduced Scope) is estimated through an OLS regression. Results are shown in Table 4. Note that a positive result means that the scope of a granted patent is reduced.

Concerning Hypothesis 1, we observe that the prior availability of search reports (USPTO, or EPO) generally does not have much impact on the scope of the granted patent, compared to the scope of the patent application. While the availability of a PCT search report does impact the $\Delta Scope$ variable.

Table 3: Results for Grant Lag

	OLS					Poisson				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
EPO_sra	-0.610	0.079			-0.025	-0.632	0.019			-0.089
	(0.857)	(0.857)			(0.845)	(0.751)	(0.745)			(0.730)
USPTO_sra	-0.457	-0.317			-0.346	-0.403	-0.364			-0.396
	(1.269)	(1.254)			(1.243)	(1.087)	(1.078)			(1.058)
PCT_sra	8.642***	10.706***			10.478***	7.648***	9.453***			9.181***
	(1.421)	(1.503)			(1.499)	(1.227)	(1.297)			(1.292)
foreign			8.331***	7.716***	5.901**			6.967***	6.464***	4.448*
			(2.429)	(2.461)	(2.444)			(2.510)	(2.505)	(2.458)
known_SEP			-7.831***	-5.761***	-6.748***			-13.120***	-11.089***	-12.080***
			(1.651)	(1.713)	(1.775)			(2.780)	(2.765)	(2.826)
foreign × known_SEP			8.443***	9.090***	9.654***			13.767***	14.233***	14.754***
			(1.943)	(1.917)	(1.959)			(2.904)	(2.865)	(2.913)
exam_request_lag		-0.344***		-0.069	-0.304***		-0.318***		-0.069	-0.277***
		(0.073)		(0.069)	(0.075)		(0.066)		(0.064)	(0.069)
log_fam_size		-1.811*		-2.073**	-2.226**		-1.940**		-2.185**	-2.298***
		(0.947)		(0.983)	(0.951)		(0.858)		(0.904)	(0.860)
log_tot_IPC		1.231		1.750*	1.396		1.240		1.709*	1.391
		(0.915)		(0.919)	(0.902)		(0.862)		(0.876)	(0.847)
nb_inv		0.253		0.448	0.278		0.172		0.368	0.204
		(0.278)		(0.280)	(0.277)		(0.238)		(0.240)	(0.238)
dec_prior_lag		0.030**		0.040**	0.039**		0.027**		0.035**	0.034**
		(0.014)		(0.019)	(0.018)		(0.013)		(0.017)	(0.016)
log_nb_indep_claims		1.469**		1.438*	1.254*		1.399**		1.391**	1.176*
		(0.740)		(0.744)	(0.724)		(0.699)		(0.703)	(0.683)
log_words_claim		-3.419***		-4.007***	-3.510***		-3.459***		-4.009***	-3.501***
		(1.082)		(1.102)	(1.082)		(1.041)		(1.058)	(1.037)
Fixed effects:										
fast	-1.360	-1.495	-2.911**	-2.812**	-1.906	-1.885	-1.988	-3.450**	-3.325**	-2.486*
	(1.268)	(1.225)	(1.239)	(1.207)	(1.192)	(1.377)	(1.320)	(1.354)	(1.313)	(1.280)
slow	2.022	1.507	2.900**	2.404	1.539	1.521	1.014	2.322*	1.806	1.016
	(1.450)	(1.449)	(1.477)	(1.491)	(1.432)	(1.167)	(1.162)	(1.194)	(1.206)	(1.146)
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
_cons	6.300**	68.741***	-2.096	51.533***	63.134***					
	(2.709)	(5.857)	(3.666)	(6.064)	(6.226)					
N	1426	1426	1426	1426	1426	1426	1426	1426	1426	1426
R^2	0.374	0.399	0.362	0.378	0.414	0.223	0.237	0.221	0.230	0.248

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Concerning Hypothesis 2, we see that foreign application disclosed as SEP (our interaction term) also of larger reduction in scope, with an average of 13.4 additional words per independent claim included during the examination process.

Summing up our findings for Hypothesis H1 (related to the availability of search reports), we conclude that the availability of PCT reports lead to higher grant rates (favourable for the applicant), but also to longer grant lags and reduced patent scope (both unfavourable for the applicant). While availability of USPTO reports leads to lower grant rates, the availability of neither USPTO nor EPO search report has any other significant impact otherwise. Altogether, we see mixed and inconclusive evidence, and reject Hypothesis 1.

Table 4: Results for Reduced Scope

	Δ scope				
	(1)	(2)	(3)	(4)	(5)
EPO_sra	-3.717	-2.709			-2.931
	(2.717)	(2.729)			(2.750)
USPTO_sra	5.718	6.034			5.952
	(4.419)	(4.362)			(4.388)
PCT_sra	10.710***	9.792**			9.111**
	(4.003)	(4.289)			(4.290)
foreign			6.583	11.760	10.062
			(7.285)	(7.322)	(7.293)
known_SEP			-14.609**	-13.102**	-13.413**
			(6.468)	(6.607)	(6.622)
foreign × known_SEP			9.895	13.511*	13.425*
			(7.267)	(7.345)	(7.358)
exam_request_lag		-0.009		0.237	0.073
		(0.219)		(0.210)	(0.226)
log_fam_size		-8.290***		-9.170***	-8.776***
		(2.965)		(2.920)	(2.990)
log_tot_IPC		1.914		2.119	1.859
		(3.097)		(3.092)	(3.087)
nb_inv		3.175***		3.310***	3.222***
		(1.194)		(1.219)	(1.202)
dec_prior_lag		0.082*		0.055	0.055
		(0.042)		(0.052)	(0.052)
log_nb_indep_claims		-5.401**		-5.997**	-6.317**
		(2.719)		(2.779)	(2.750)
diff_ic		2.034***		2.144***	2.165***
		(0.701)		(0.733)	(0.710)
Fixed effects:					
Firm Effects	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes
_cons	137.539***	166.949***	126.817***	143.175***	156.256***
	(13.129)	(19.724)	(15.468)	(19.931)	(21.305)
N	1436	1436	1436	1436	1436
R^2	0.126	0.149	0.126	0.149	0.153

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Summing up our findings for Hypothesis H2 (related to the timing of disclosure as SEP), we conclude that in all aspects (grant rate, grant lag, and reduced scope), the outcomes for foreign applications of essential patents are less favourable than those for domestic, Chinese applicants. Thus, we find strong support for Hypothesis H2.

6. Robustness

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

6.1. Time window

We ran the above regression models on a 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. The rationale for conducting this test is to reduce potential confounding effects. It is indeed less likely that an application for which the examination process at SIPO begins immediately after it has been declared as essential at ETSI, could be already publicly known as a SEP application. In the same way, it is more likely that an examiner could identify as SEP an application that is declared as essential soon after the start of the examination process at SIPO. Excluding applications in this three months time-window should then mitigate the potential bias introduced by this confounding factor.

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. Also the effect on the grant lag increases in size and is now on average between 9.9 and 15.1 months longer for foreign application disclosed as SEP before the examination process. The results on the reduction in scope is similar in magnitude but loses statistical significance.

6.2. Larger sample

We also ran the analysis on a larger sample that is not restricted to applications that have a direct equivalent at other specific patent authorities. The new sample is composed of applications that belong to an international family (i.e., we do not consider families composed exclusively of the one application filed at SIPO) that have a unique application in China (i.e., we do not consider continuations and divisional applications). In this way our larger sample counts to 2,764 patent applications filed at SIPO, of which 2,207 are filed by foreigners and 557 by Chinese firms. 872 applications belong to families declared as SEP before the start of the examination process at SIPO and are hence flagged as *known_SEP*.

Table 6 reports the results of the analysis conducted on this enlarged sample. As the table shows, this robustness check confirm the direction and the significance of the effects that we find in the main analysis.

6.3. Measuring change in scope

Although it is clear that an increase in the number of words per claim implies as reduction in scope, it would be wrong to interpret a decrease in the number of words per claim as an increase

Table 5: Results with a time window

	Grant		Grant_lag		Δ scope
	OLS	Probit	OLS	Poisson	OLS
EPO_sra	-0.022	-0.006	-0.048	-0.138	-3.823
	(0.018)	(0.011)	(0.887)	(0.750)	(2.868)
USPTO_sra	-0.085***	-0.052***	0.053	-0.006	4.686
	(0.032)	(0.017)	(1.170)	(0.954)	(4.205)
PCT_sra	0.376***	0.188***	16.769***	14.786***	10.659**
	(0.031)	(0.023)	(1.789)	(1.486)	(4.505)
foreign	-0.006	0.009	6.815***	4.945*	11.610
	(0.073)	(0.029)	(2.553)	(2.533)	(7.589)
known_SEP	0.067*	0.092***	-7.177***	-12.600***	-12.419*
	(0.038)	(0.031)	(2.001)	(3.060)	(6.790)
foreign × known_SEP	-0.118***	-0.130***	9.985***	15.110***	11.526
	(0.042)	(0.033)	(2.146)	(3.115)	(7.588)
exam_request_lag	-0.007***	-0.003***	-0.403***	-0.370***	0.084
	(0.002)	(0.001)	(0.083)	(0.074)	(0.234)
log_fam_size	-0.010	0.005	-1.725*	-1.834**	-7.812**
	(0.020)	(0.013)	(1.012)	(0.895)	(3.138)
log_tot_IPC	-0.022	-0.022*	1.538*	1.472*	2.784
	(0.019)	(0.012)	(0.920)	(0.850)	(3.209)
nb_inv	0.017***	0.015***	0.534*	0.409*	3.532***
	(0.006)	(0.004)	(0.295)	(0.243)	(1.255)
dec_prior_lag	-0.001**	-0.001***	0.031	0.027	0.055
	(0.000)	(0.000)	(0.020)	(0.017)	(0.056)
log_nb_indep_claims	0.012	0.015*	1.218*	1.137*	-6.796**
	(0.014)	(0.008)	(0.730)	(0.668)	(2.840)
log_words_claim	0.048**	0.038***	-1.914*	-1.806*	
	(0.022)	(0.014)	(1.074)	(1.010)	
diff_ic					1.984***
					(0.707)
Fixed effects:					
PFE	0.185***	0.104***			
	(0.028)	(0.019)			
fast			-3.228***	-4.187***	
			(1.246)	(1.366)	
slow			1.714	1.066	
			(1.410)	(1.103)	
Firm Effects	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes
_cons	1.103***		60.456***		147.813***
	(0.139)		(6.521)		(22.085)
N	1536	1313	1214	1214	1336
R^2	0.299		0.473		0.162

Standard errors in parentheses

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

in scope. Indeed, an increase in scope between the application and the grant is by definition not possible in patent law. Looking manually through several cases of patent applications having experienced a decrease in the number of words per claim, we almost invariable came to the conclusion that the changes were also associated with a reduction in scope. Again, using a

Table 6: Results with larger sample

	Grant Probit	Grant_lag Poisson	Δ scope 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)
log_fam_size	0.025**	-1.647***	-9.359***
	(0.011)	(0.620)	(2.820)
log_ipc	0.034***	1.192***	-1.567
	(0.008)	(0.427)	(1.858)
dec_prior_lag	-0.000	0.015	0.053
	(0.000)	(0.012)	(0.046)
PCT_sra	0.223***	12.439***	9.518***
	(0.016)	(1.032)	(3.314)
log_nb_indep_claims	-0.005	1.588***	-6.806***
	(0.008)	(0.443)	(2.170)
log_words_pc	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
_cons			95.285***
			(24.841)
N	2617	2467	2465
R^2			0.130

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

simplified example, think of 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. The rationale here is that any significant change, be it adding or removing parts of the claim text, leads to a reduction in scope. We call this variable *Absolute* $\Delta Scope$.

Table 7 reports the results of the analysis when the variable *Absolute* $\Delta Scope$ is used to measure reduction in scope.

As the table shows, as in the case of the $\Delta Scope$ used in the main analysis, prior availability

Table 7: Results for Absolute reduction in scope

	Absolute Δ Scope				
	(1)	(2)	(3)	(4)	(5)
EPO_sra	-2.815	-2.138			-2.104
	(2.503)	(2.534)			(2.554)
USPTO_sra	6.268	6.553			6.588
	(4.072)	(4.005)			(4.021)
PCT_sra	7.421**	6.216			5.665
	(3.662)	(3.862)			(3.854)
foreign			0.754	5.124	4.108
			(6.679)	(6.808)	(6.857)
known_SEP			-18.496***	-16.649***	-16.788***
			(6.047)	(6.156)	(6.176)
foreign X known_SEP			16.767**	20.877***	20.834***
			(6.718)	(6.737)	(6.755)
exam_request_lag		0.068		0.221	0.116
		(0.205)		(0.198)	(0.213)
log_fam_size		-6.674**		-7.615***	-7.364***
		(2.818)		(2.760)	(2.838)
log_tot_IPC		-0.638		-0.475	-0.652
		(2.868)		(2.847)	(2.847)
nb_inv		3.002***		3.113***	3.044***
		(1.144)		(1.164)	(1.153)
dec_prior_lag		0.084**		0.080*	0.081*
		(0.038)		(0.048)	(0.048)
log_nb_indep_claims		-6.283**		-7.021***	-7.285***
		(2.472)		(2.483)	(2.480)
diff_ic		1.779***		1.895***	1.923***
		(0.580)		(0.589)	(0.582)
Fixed effects:					
Firm Effects	Yes	Yes	Yes	Yes	Yes
Agency Effects	Yes	Yes	Yes	Yes	Yes
App_Year Effects	Yes	Yes	Yes	Yes	Yes
_cons	103.777***	133.860***	97.257***	116.912***	125.796***
	(12.110)	(18.348)	(14.191)	(18.617)	(19.949)
N	1436	1436	1436	1436	1436
R^2	0.114	0.138	0.117	0.142	0.145

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

of search reports does not affect the change in scope of the granted patent. A foreign application disclosed as SEP (our interaction term) experience a larger reduction in scope, with a change of up to 21 words per independent claim 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 SIPO and declared as standard essential to two of the world's economically most important standards: the 3G WCDMA and 4G LTE standards for mobile

communications. The choice of standard-essential patents is particularly suited because of the 'strategic' importance of such patents for China's indigenous innovation program. Furthermore, this choice allows us to exploit information on the timing of disclosure as SEP to infer the likely presence of discrimination.

Our findings can be summarised as follows. First, the availability of search reports before substantive examination at the SIPO has a mixed and inconclusive effect on the outcome of the prosecution process. The largest effect come from the PCT search report, although we find both favourable and unfavourable effects of PCT search report on the prosecution process. Second, standard-essential applications disclosed as SEP before the entrance into substantive examination phase at the SIPO are significantly less likely to receive a grant when the patent owner is foreign. Domestic patent owners do not experience such a drop in the likelihood to obtain a patent . Besides, if such foreign-owned patents do receive a grant, the grant decision arrives substantially later and the scope of the application is significantly reduced.

We come to these findings after extensively controlling for a number of alternative explanations, including year effects, firm fixed effects, and patent attorney agency fixed effects, as well as for the examination request lag, patent family size, number of technology classes, number or inventors, time lag for essentiality declaration, number of independent claims, and difference in the number of independent claims between the patent application and the granted patent.

Our findings have considerable implications, as China is not only one of the world's largest markets for products based on technical standards, but also a country where many of such products are manufactured for other markets. A weaker patent position of non-Chinese firms is detrimental to innovative companies that have developed the underlying technology. An immediate application of our results is that foreign firms should disclose their SEPs after the patent has entered the substantive examination phase in order to increase the chance of a faire prosecution process. Yet, doing that would be acting in conflict with the ETSI disclosure rules, that stipulates such disclosures be made in a "timely fashion".

More generally, our findings suggest that China breaches the national treatment principle, one of the pillar of the international patent system that states that the prosecution process may not depend on the nationality of the applicant. An interesting question is whether the observed effect should be seen as a part of China's policy concerning technical standards, and its goal to strengthen its position in patents for such standards. Should this be the case, this finding may

help explain the rise of Chinese global champions.

References

Barboza, D. (2016). How china built 'iphone city' with billions in perks for Apple's partner. *New York Times*.

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

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. (2013). The rise of china in technology standards: New norms in old institutions. *Prepared for the US-China Economic and Security Review Commission*, 16.

de Rassenfosse, G., Jaffe, A. B., and Webster, E. (2016). Low-quality patents in the eye of the beholder: Evidence from multiple examiners. Technical report, National Bureau of Economic Research.

de Rassenfosse, G. and Raiteri, E. (2016). Technology protectionism and the patent system: Strategic technologies in china. *Mimeo, EPFL*.

Ernst, D. (2011). *Indigenous innovation and globalization: The challenge for China's standardization strategy*. East-West Center.

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.

Lexology (2015). Qualcomm to pay the highest fine ever imposed in china for violation of chinese antitrust laws in patent licensing practices.

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.

Martinez, C. (2010). Insight into different types of patent families.

Orrick (2014). Chinese court publishes decisions finding that interdigital violated AML through discriminatory pricing, sets FRAND rate for licensing interdigital SEPs under chinese standards.

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.

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.

WIPO (2015). Protecting your inventions abroad: Frequently asked questions about the patent cooperation treaty (PCT).

Yoshimi, O., Yusuke, N., and Sadao, N. (2016). Claim length as a value predictor of a patent. Technical report, Institute of Innovation Research, Hitotsubashi University.

Appendix A: Details of disclosed essential patent identification

To establish which patents are believed to be essential to the WCDMA and LTE standards, we used the ETSI disclosure database[8]. In 2012, this database underwent a significant upgrade, known as project 'DARE'. In collaboration with EPO, patent declarations were as much as possible 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[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% could be identified in PATSTAT by the data in the 'Patent Number' field provided by ETSI. Another 1.1% could be identified using the 'Application Number' field (which follows the so-called EPODOC formatting). Another 3.3% was identified using the 'Patent Family' field. So, in total, we matched 88.2% 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 which ETSI and 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 if family members are included. Using PATSTAT, we found the patents in the list to belong to 12,692 unique DOCDB patent families.

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

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