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The patent system as an institutional barrier to entry: Priority technologies in China

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Abstract

This paper shows that foreign inventions in technology sectors that China considers as 'strategic' have a particularly low probability of being granted patent protection in China. We interpret this result as evidence that the patent system may act as an institutional barrier to entry.

Jelcodes:O33,K1

Technology protectionism and the patent system

PRELIMINARY DRAFT - PLEASE DO NOT QUOTE

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Abstract

The national treatment principle (NTP) is a centerpiece to many trade-related international law treaties. It states that foreigners and locals must be treated equally, and its violation may lead to retaliation measures by affected countries. The NTP also applies to international patent law. Yet, business and policy circles have voiced concerns about violation of the NTP at the Chinese patent office, although no empirical evidence exists to assert this claim. Using data on about half a million patent applications filed in China we find no, or only weak, evidence of anti-foreign bias in the issuance of patents overall. However, foreign applications in technology fields that are of strategic importance to China are five to six percentage points less likely to be granted a patent than local applications.

Keywords: national treatment principle; patent; technology protectionism; trade-related intellectual property rights

JEL Classification Codes: O34; K11; F52

1. Introduction

> "Industry representatives express mixed opinions on whether there is *antiforeign bias* in the issuance or enforcement of patents in China. However, some non-Chinese firms reportedly find it more difficult to obtain patents in sectors that the Chinese government considers of *strategic importance*."
>
> United States International Trade Commission (ITC) 2010, page xviii (italics added)

As with standard trade barriers, intellectual property (IP) rights may be awarded and exploited in such a way as to discriminate against foreign interests (Maskus, 2000). Governments typically want the strongest possible protection in foreign countries in order to maximize returns to domestic firms, and the weakest possible protection for foreign firms in their domestic markets to facilitate free-riding on foreign technologies (Scotchmer, 2004b). To prevent such opportunistic behaviors, international IP treaties impose the 'national treatment' principle, which means that within each country foreign applicants receive equal treatment to domestic applicants.

Recent evidence by Webster et al. (2014) on a sample of about 50,000 patent applications filed in the years 1990–1995 at the European Patent Office (EPO) and the Japanese Patent Office (JPO) suggests that domestic applicants are more likely than foreign applicants to be granted patent protection, all else equal. One can take this result as evidence that domestic applicants are more skillful at pushing their applications through the patent system than foreign applicants. But one can also view this result as evidence that the patent system serves as a technology protectionism tool, in violation of international IP treaties. Abuses of this sort are widely believed to be pervasive in China, as regularly echoed in the press.[1]

Discussions about unfair treatment of foreign applicants in China are not new, but they have largely focused on issues related to the *enforcement* of IP rights (Love et al., 2015). Yet, enforcement might be thought of as a second order issue. If foreign applicants are unduly denied a grant in the first place, local competitors may legally use, produce, and sell those inventions in their home market. It is thus of primary importance to assess whether the patent system itself, rather than the judicial system, discriminates against foreigners. To date, scholarly evidence on the topic is patchy and inconclusive (Yang, 2008; Liegsalz and Wagner, 2013).

The present paper seeks to provide empirical evidence on the possible existence and the magnitude of anti-foreign bias in the issuance of patents at the State Intellectual IP Office in China (SIPO). The empirical analysis relies on a sample of about half a million patent applications filed at the SIPO in the period from 2001 to 2009. It controls for invention quality by tracking the grant outcome of more than 1.6 million 'twin' patent applications in other jurisdictions where the applicant also sought to protect its technology. We identify 'strategic' areas with the help of patent examiners by linking technologies described in the central planners' long-term development plan to technology classes listed in the patent documents (SCPRC, 2008).

Results suggest no, or a weak, overall discrimination against foreigners at the SIPO. However, foreign patent applications in strategic technology areas are about five to six percentage points less likely to receive a patent grant than otherwise similar applications. To put this figure in perspective, it represents a yearly number of about 7.5 thousands foreign applications that are denied a legitimate grant in China. The result holds with a range of alternative

[1] For a recent example see "U.S. firm alleges China's government colluded with local competitor", Washington Post, September 13th 2015.

specifications and robustness tests.

The rest of the paper is organized as follows. Section 2 briefly describes the Chinese patent systems and the reasons that may lead to differences in the treatment of foreign and domestic applicants. Section 3 describes the empirical strategy and Section 4 presents the data. Section 5 discusses the results of the econometric analysis and Section 6 presents robustness checks. Section 7 concludes.

2. Background

2.1. The Chinese patent system and the national treatment principle

Since Deng Xiaoping took over in 1978, China undertook a series of reforms and transitioned to a 'socialist market economy.' The country joined the World Intellectual Property Organization (WIPO) in 1980 and issued its first patent law in 1984. Since then, Chinese patent law has been revised three times, in 1992, 2000, and 2008, to progressively align with international standards.[2] To date, the SIPO is a major international player on the patent scene. It became the world largest patent office in terms of national applications in 2011 and is the second largest (after the U.S. Patent and Trademark Office, USPTO) for international applications (WIPO, 2012).

A landmark change in IP law occurred in 2001 when China joined the World Trade Organization and signed the 'Trade-Related Aspects of Intellectual Property Rights' (TRIPs) agreement. Article 3 of the TRIPs agreement affirms the national treatment principle, stating that "each Member shall accord to the nationals of other Members treatment no less favorable than that it accords to its own nationals with regard to the protection of intellectual property." This provision is a key pillar of international patent law: it is already mentioned in the 1883 Paris Convention for the Protection of Industrial Property (Article 2), to which China became a signatory member in 1984. More generally, the NTP is a centerpiece to many trade-related international law treaties. Numerous scholars consider that the Chinese patent system now largely complies with international standards and does not create any structural barrier for international applicants, at least on paper (Yueh, 2009; Liegsalz and Wagner, 2013). A priori, there are thus no reasons to expect any difference in the treatment of foreign and domestic applications at the SIPO.

[2]See Yueh (2009) and Liegsalz and Wagner (2013) for in-depth analyses of the Chinese patent system and its evolution over time.

However, economic theory suggests that the political incentives to favour domestic firms are particularly strong for a country like China. Scotchmer (2004a,b) explains that, in an international environment regulated by the national treatment principle, intellectual property rights become a strategic instrument that affects profit flows among nations. In this setting, countries want the strongest possible protection in foreign countries in order to maximize returns to domestic inventors, and the weakest possible protection for foreign inventors in their domestic markets to facilitate free-riding on foreign technologies. Scotchmer also stresses that the incentives to deviate from strong harmonized protections across nations are especially high for countries with a large domestic market and weaker innovative capabilities. China, which represents about a sixth of world GDP but embarked only recently in the process of technological catch-up, has thus a lot to gain from discrimination.

2.2. Central planning of technology development

In the context of Deng Xiaoping's *modernizations*, the Chinese government implemented several innovation-related policies aimed to realize Deng's view that Science and Technology (S&T) in China should constitute a primary productive force (OECD, 2008; Liu et al., 2011). From the beginning of the 1980s, S&T and industrial policies were explicitly designed to stimulate the development of advanced technologies for the purpose of rendering China independent of financial obligations for foreign technologies. These policies include the 'Key Technologies R&D Program', the '863 Program'(the State High-technology Program, started in 1986), the '973 program' (the State Program for the Support of Basic Research and Development), and the 'Golden Projects' program.

This agenda has recently received an even more central place in the economic planning strategy of the Central Committee of the Communist Party of China. In January 2006, the State Council issued the 'National Medium and Long-Term Program for Science and Technology Development 2006–2020' (MLP), whose guiding principle is to make China an innovation-driven nation by "fostering indigenous innovation, leapfrogging in priority fields, and leading the future" (SCPRC, 2008, p. 7).[3] The MLP identifies priority areas and topics that the central planner considers as critical for the country's economic and social development. The plan also sets a list of ambitious goals in the S&T domain that the country should achieve by 2020: the

[3]The plan has been implemented first through the 11th Five-Year Guideline of [WHICH YEAR] and is currently implemented through the 12th Five-Year Guideline of the CCP.

gross expenditure on R&D (GERD) must rise to 2.5 per cent of GDP or above; the dependence on imported technology must reduce to 30 per cent or below; and the country must move into the top five countries for the number of invention patents granted to nationals. In fact, IP receives support at the highest level. Hu Jintao, a former president, said on many occasions that "competition in the future is competition in IP" (Economist, 2015)

2.3. Concerns in the developed world

Several observers in the United States and Europe have raised concerns that such policies are hidden forms of technological protectionism. A document from the U.S. International Trade Commission suggests that this "web of interrelated indigenous innovation policies" may work together to favor domestic over foreign companies in the Chinese market, and that such a discriminatory effect could be especially strong for companies operating in sectors considered as strategic by the Chinese government (USITC, 2010). The USITC also reports of a close link between these measures and IP right infringement in China, stating that through indigenous innovation policies China "undermines and displaces foreign IP while promoting its own [Chinese] IP" (USITC, 2010, p. 5-8) . In a report prepared for the U.S. Chamber of Commerce, McGregor (2010) makes the particularly bold claim that "the [MLP] is considered by many international technology companies to be a blueprint for technology theft on a scale the world has never seen before"(McGregor, 2010, p. 26). A report from the U.S. Patent and Trademark Office (USPTO) also echoes this view, stating that "numerous commenters articulated the perception that China's patent system, including enforcement mechanisms, benefits Chinese companies at the expense of U.S. and other foreign companies" (USPTO, 2010, p. 5).

In light if these concerns, it is legitimate to ask whether one can observe discrimination in the patent syste. Yet, as far as we can ascertain, little empirical evidence exists.

2.4. Empirical evidence

Three studies investigate discrimination of foreigners in the Chinese patent system. Yang (2008) compares aggregate issuance rates and pendencies between international and domestic patent applications at the USPTO and SIPO. The author finds no significant difference in the average pendency between national and international applications at SIPO relative to the USPTO, but reports evidence of greater issuance rate for domestic applications at SIPO. However, the study by Yang does not account for unobserved heterogeneity; it uses aggregate data ignoring relevant patent-level characteristics that may affect the grant decision, most notably the quality of

the underlying technology. Liegsalz and Wagner (2013) perform a similar exercise, albeit at a more fine-grained level. They focus on the pendency of applications filed at the SIPO between 1990 and 2002 and account for patent-level characteristics. They show that Chinese applicants receive faster patent grants than foreign applicants and that the difference in the grant lag is particularly strong in technology fields in which China has a relative technological advantage over other nations. Technological advantage is measured by computing the Revealed Technological Advantage based on the number of patent applications by patent classes. However, the study pre-dates China's accession to the TRIPs agreement and it is silent on the grant outcome.

In a nutshell, the Chinese patent system complies—on paper—with international IP law treaties and, therefore, should not discriminate against foreigners. In practice, there are strong political incentives for doing so, and Western companies regularly voice concern that they are being discriminated. Yet, empirical evidence is patchy and inconclusive.

3. Empirical strategy

We are interested in studying whether the probability of being granted a patent at the SIPO differs between foreign applicants and Chinese applicants, all else equal. We pay close attention to the fate of applications that are in areas of strategic importance to China.

3.1. Econometric model

We estimate the following latent variable model with pseudo fixed effect

$$y_i^* = \beta_1 Foreign_i + \beta_2 Strategic_i + \beta_3 (Foreign \times Strategic)_i + \mathbf{X_i}\gamma + c_i + \epsilon_i, \quad y_i = 1[y_1^* > 0]$$

where y_i^* is the latent variable underlying the binary grant outcome y_i of patent application for invention i and c_i is the pseudo fixed effect that captures i's quality. As explained further below, we track 'twin' applications of invention i in other jurisdictions and we measure c_i as the average grant rate of twin applications. Literally, c_i captures other patent offices' assessment of the patentability of invention i. The vector variable $\mathbf{X_i}$ includes control variables that may affect the probability of grant at the SIPO. The dummy variable $Foreign_i$ takes the value 1 if application for invention i is filed by a foreign firm or 0 otherwise. Finally, the dummy variable $Strategic_i$ takes the value 1 if invention i relates to a technology of strategic importance, as defined below. The variables of interest are $Foreign_i$ and the interaction term $(Foreign \times Strategic)_i$. They allow testing whether patent applications by foreign firms are

systematically less likely to receive a grant, all else equal, and whether there is a specific anti-foreign bias in technology fields of strategic importance. We assume that the error term ϵ_i has a standard logistic distribution but we will also estimate a linear probability model for comparison purposes.

It is important to note that a negative coefficient for β_3 would not necessarily be evidence of a systematic anti-foreign bias in strategic fields. Indeed the marginal effect of a change in both interacted variables in non-linear model is not equal to the marginal effect of a change in the interacted variable (Ai and Norton, 2003). As a result, a negative (positive) value for β_3 does not imply necessarily a negative (positive) sign of the marginal effect. One has to look at the marginal effect to get a sense of the overall effect. In addition, because the marginal effect for the interacted term may have different sign for different observations and for different values of the covariates, we will also depict the marginal effects for the interaction term over the range of predicted grant probability scores.

3.2. Controlling for invention quality

We understand the term 'quality' as the technological merit of the invention, which directly affects the probability of grant. A quick look at the data suggests that the grant rate for foreign applications is greater than for local applications. In our study period, the grant rate was 52 per cent for domestic applications and 65 per cent for foreign applications (not reported). This gap would seem to confirm the existence of a fundamental difference in quality between foreign and Chinese filings, in line with existing literature (Gupeng and Xiangdong, 2012; Thoma, 2013; Boeing and Mueller, 2015). Moreover, several authors have proposed that the patent subsidy policies implemented by regional governments in China may have exacerbated this gap in recent years, that is, further reduced the quality of local applications (Liang, 2011; Lei et al., 2012; Boeing and Mueller, 2015). In that sense, not controlling for invention quality is likely to provide a conservative estimate of the anti-foreign bias, should there be one.

Our identification strategy, which aims to obtain an accurate measurement of a potential anti-foreign bias, is twofold. First, we restrict the sample to patent applications with at least one international family member. Patent applications at the SIPO by foreign firms form a selected sample of applications—one for which applicants were willing to incur the substantial cost of international patent protection. By contrast, there is no selection in patent applications by locals, leading to a lower average quality. In order to put locals and foreigners on the same

level, we impose that they have a 'direct equivalent' at selected patent authorities. Imposing the existence of a direct equivalent is similar in spirit to the common support requirement in econometric matching models. We selected seven patent authorities for which we have reliable grant information: EPO, USPTO, JPO, Canadian Intellectual Property Office (CIPO), Korean Intellectual Property Office (KIPO), Russian Federal Service for Intellectual Property (RFSIP), Taiwan Intellectual Property Office (TIPO). These seven offices account for XXX per cent of total patenting activity outside China. A direct equivalent is a patent protecting exactly the same invention at different patent authorities (Martinez, 2010; de Rassenfosse et al., 2013). More specifically, we identify one-to-one equivalent: application B is a one-to-one equivalent of application A if B claims A as sole priority (i.e., no merged patent applications) and A is only claimed by B in B's office (i.e., no split patent applications). In this sense, A and B cover the same technical content and are 'twin' applications.

Second, we use the average grant rate for these equivalent applications as the pseudo fixed effect. In other words, the empirical analysis estimate the determinants of the probability of grant at the SIPO above and beyond the grant rate expected by looking at other offices' grant decision *for the same invention*. The implicit exogeneity assumption that we make is that foreign office do not discriminate based on the applicant country of residence. Should they do so, the fixed effect would be correlated with the variables of interest, leading to a biased estimator. In order to assess the severity of the issue, we will report estimate both with and without the pseudo fixed effect. We will also perform an ad-hoc test of unobserved heterogeneity inspired by Rosenbaum (2002)(TBD).

3.3. Identification of strategic technologies

We use the MLP to identify technologies of 'strategic' importance. The plan describes 27 frontier technologies that should constitute the ''basis on which future high technologies stem out and emerging industries grow'' (SCPRC, 2008, p.33).[4] These frontier technologies belong to eight major technological fields: biotechnology, information technology, advanced materials technology, advanced manufacturing technology, advanced energy technology, marine technology, laser technology, and aerospace technologies.

[4]Frontier technologies are selected in accordance with the following principles: 1) representing the development direction of world high-tech frontiers; 2) having a pioneering role in shaping and developing new industries in the future; 3) being conducive to industrial technology upgrading and for realizing the leapfrogging development; and 4) possessing a strong team of talented personnel and a sound R&D basis (SCPRC, 2008, p.33).

In order to identify patent applications in these strategic areas, we link the 27 frontier technologies to specific patent classes. In particular we work at the main-group level as defined by the International Patent Classification (IPC) taxonomy. The IPC is hierarchical system for the classification of patents according to the different areas of technology to which they pertain. The linking to IPC classes relies on '*IPCCAT - Categorization Assistant in the International Patent Classification*', a tool that allows for automated patent classification based on text analysis.[5] We validated the list with the help of three WIPO examiners, which led to some refinements in the classification. In particular, some IPC classes provided by the classification tool were too broad. At the end of the process, we have identified 99 strategic main-groups out of the 6,812 groups used to describe the technological content of the patents in our sample.[6]

4. Data and sample

4.1. Data sources

The main source of data is the EPO Worldwide Patent Statistical Database (Patstat, April 2015). Patstat contains information on direct equivalents and the grant outcome at the seven selected offices (de Rassenfosse et al., 2014). It also contains most patent-level information used in the empirical analysis. Information on the grant outcome at the SIPO comes from the INPADOC legal stats table, which is an add-on to the Patstat database. We crawled the Google Patent website to recover information on as the number of claims and independent claims at SIPO. We also crawled the SIPO website to recover data on attorneys.[7]

4.2. Sample

The sample is composed of foreign and domestic applications filed at the SIPO between 2001 and 2009 and that have at least one unique direct equivalent in one of the following patent offices: CIPO, EPO, JPO, KIPO, RFSIP, TIPO, and USPTO. We specifically exlcuded utility models and design patents. This selection leads to a final sample of 477,854 patent applications.

It is important to note that we do not attribute any potential ant-foreign bias to the MLP. Rather, we use the MLP to infer areas of strategic importance in a consistent manner. As a

[5]Available at https://www3.wipo.int/ipccat/. Its typical precision scores for English patents are about 90 per cent at Class level, 85 per cent at Sub-Class level and 75 per cent at Main Group level (Benzineb and Guyot, 2011)

[6]The list is available upon request from the authors.

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

matter of fact, the MLP was not the first plan designed to support the development of strategic technological domains in China. Programs undertaken in the 1990s ('Key technologies R&D Program', the '863 program', '973 program', 'Golden Projects') already supported some of the technological areas that are listed also in the MLP, notably biotechnology, IT and energy.

4.3. Dependent variable

The variable y_i, labeled *Grant*, takes the value 1 if the patent application was grant and 0 if if was refused or withdrawn. In order to avoid potential bias related to truncation problems—especially in light of the fact that foreign applications have longer grant lags (Liegsalz and Wagner, 2013)—we exclude pending patents from the sample. We also exclude filings for which the applicant never requested examination because, in such a case, the withdrawal decision is not affected by the SIPO examination process.

4.4. Covariates

As far as the variable of interest are concerned, the binary variable *Strategic* takes the value 1 if a patent application is assigned to any of the relevant IPC main-groups identified through the IPCCAT, and the value 0 otherwise. The variable *Foreign* reports whether the country of residence of the applicant is China or abroad. If a patent belongs to more than one applicant we consider it as foreign only if none of the applicants is in China.

The pseudo fixed effect, labeled *Avg_Grant_Rate*, reports the average grant rate at the family level of the direct equivalent filings applied at other patent authorities. The larger the average grant rate, the more likely it is that also the filing at SIPO will obtain patent protection.

The regression model includes several control variables that account for patent-specific characteristics that may affect the grant probability of an application:

- *Family_Size* accounts for the total size of the patent family to which an application belongs. Patents for inventions covering larger families are particularly valuable, which may affect the probability of grant. In computing the family size we consider every patent authorities for which the information is available in the Patstat database and not exclusively the seven patent offices that we use for searching direct equivalents.

- *Tot_IPC* indicates the total number of four-digit IPC classes to which a patent pertains. Patents covering many IPC classes are supposedly more complex to examine as they may rely on technologically distinct elements (Lerner, 1994; Harhoff et al., 2003).

- *Number of Claims* reports the number of claims listed in the patent application at SIPO. This variable therefore grasps information about the scope of the monopoly power granted to a patent (Hall et al., 2001). It is likely that the breadth of the patent protection requested affects the probability of an application to be granted.For less than one per cent of the patent applications in our sample the information about the number of claims is not available. In such cases we either rely on the average number of claims included in the equivalent applications filed at other patent authorities, or, if the latter is not available and the patent was granted, on the number of claims included in the publication document.[8]

- *Indep_claims_ratio* is defined as the number of independent claims over the total number of claims included in the patent application.

- *Prior_Appl_Lag* reports the lag (months), between the priority date and the application date at SIPO for each filing. Since the priority date should be closer in time to the actual date of the invention, this lag allows to control for the age of the invention at the moment in which it reaches the SIPO. Clearly if the filing at Chinese patent office is the first application ever filed to protect a given invention the lag will be equal to zero.

- *Appl_Ex_Lag* reports the lag (months) between the application date and the request for examination. Chinese patent law requires that the applicant must submit a request for substantive examination within three years after the filing.[9] As suggested by Palangkaraya et al. (2008) the decision of an applicant to delay examination might be correlated with the quality of an application and, therefore, with the probability of grant.

- *RTA* is the Revealed Technology Advantage (RTA) measure first introduced by Soete and Wyatt (1983). In our setting it is defined as a country's share of patents applications filed at SIPO within an IPC subclass (4-digit level of the IPC classification), over the total share of that country's applications at SIPO. The rationale for including this control is that

[8] In this way we recover the number of claims for 91 per cent of the application for which the claims information was missing. In the remaining cases, we impute the number of claims for the missing observations through a Poisson regression on a set of relevant patent-specific characteristics including: IPC (3-digit), application year, number of applicants, number of inventors, the total number of IPCs assigned to the patent, and the nationality of the applicant.

[9] Other patent authorities such as JPO and EPO have a similar rule, whereas at the USPTO no request is required to proceed to examination.

the grant probability of an application might be affected by the degree of technological specialization of the applicant's country.

- *Number of Inventors* reports the total number of inventors listed in the patent document.

- *Number of Applicants* reports the total number of applicants listed in the patent document.

- *Experience* is a binary variable that signals whether the applicant has applied for at least three patents at SIPO during the time period taken into account and thus if it has some experience with the SIPO examination process.[10]

- Dummies for the *Application_year* and for the *IPC_class* as measured at the 1-digit level (8 classes)

4.5. Descriptives statistics

Table 1 displays the descriptive statistics by nationality for our sample.

As Table 1 shows, applications by Chinese firms represent 4.2 per cent of the filings in the sample, witnessing the fact that a limited number of Chinese applications have a direct equivalent application abroad. This strict filters increases comparability between of applicaitons by Chinese firms and applications by foreign firms. About 73.6 per cent of Chinese filing were granted patent protection by the SIPO, whereas the number reachers 70.8 per cent for foreign firms.

The larger grant rate for Chinese applications suggests that when we consider only high-quality patents the substantial gap in the grant ratio between foreign and domestic applications that we observe for the all SIPO filings disappears. On average foreign applications show a higher average grant rate at other patent authorities, belong to larger families, and have more IPC sub-classes assigned to them. Domestic filings at SIPO have on average more inventors listed on the application document and they belong to more applicants. Chinese applications shows shorter lags between priority date and application date and also between application date

[10]We choose three patents as a threshold for the experience variable because in our sample that threshold allows to identify applicants in the upper quartile in terms of number of applications at SIPO.

Table 1: Descriptive statistics by nationality

	Chinese Filings				International Filings				t-test
	min	mean	max	sd	min	mean	max	sd	Diff.
Grant	0.0	0.736	1		0.0	0.708	1		0.028*
Family_size	2.0	3.017	21	1.659	2.0	5.325	65	3.143	-2.308*
Tot_IPC	1.0	2.479	15	1.312	1.0	2.667	21	1.531	-0.188*
Avg_gr_rate	0.0	0.553	1	0.455	0.0	0.578	1	0.385	-0.0247*
Prior_app_lag	0.0	0.995	20	3.120	0.0	10.719	63	2.964	-9.725*
App_ex_lag	3.0	21.363	61	9.438	0.0	22.810	127	8.763	-1.447*
Nb_of_claims	1.0	12.765	200	8.194	1.0	16.864	1299	14.374	-4.099*
Indep_claim_ratio	0.0	0.289	1	0.277	0.0	0.226	1	0.213	0.0629*
Nb_inventors	0.0	2.436	20	1.861	0.0	2.223	33	1.638	0.213*
Nb_applicants	0.0	1.145	7	0.370	1.0	1.029	13	0.200	0.116*
Experience	0.0	0.830	1		0.0	0.903	1		-0.0737*
Strategic	0.0	0.345	1		0.0	0.208	1		0.137*
N	19119 (4.2%)				458735 (95.8%)				

* $p < 0.001$

and request for examination date. Foreign filings includes on average about four more claims than domestic filings but have a lower independent claims ratio.

34.5 per cent of Chinese applications and 20.8 per cent of international filings are assigned to strategic IPCs. Since the distribution of the variables *Family_Size*, *Tot_IPC*, and *Number of Claims* appears to be skewed, they will be log-transformed to avoid bias in the estimation.

Figure 1: Distribution of SIPO applications by 1-digit IPC and nationality

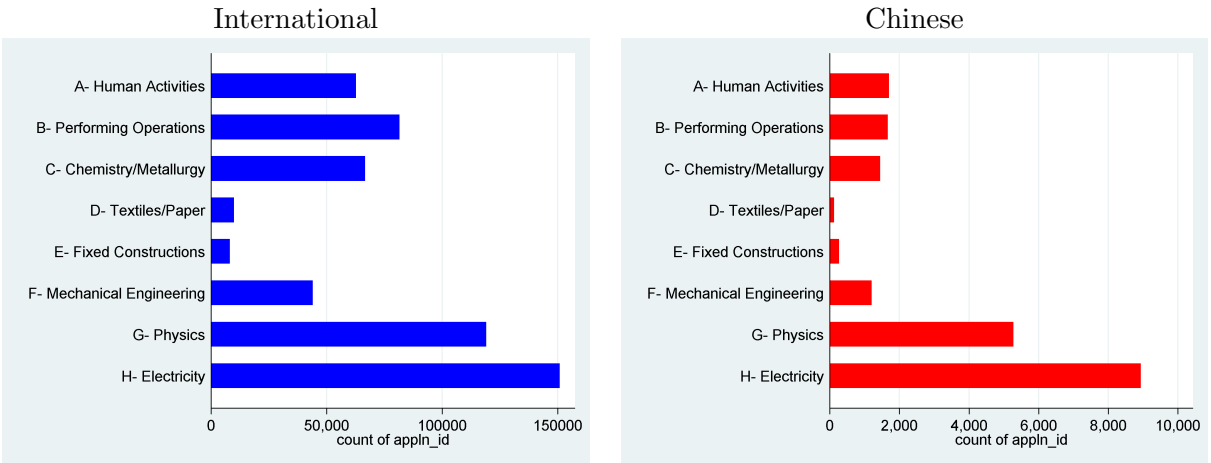


Figure 1 shows the distribution of all filings in our sample by 1-digit IPC.

5. Results

Table 2 presents results from the econometric analysis. Note the strict 1 per thousand probability threshold for declaring statistical significance, as advised by Johnson (2013).

Odd-numbered columns report the coefficient recovered through the linear probability model, whereas the even-numbered columns display the marginal effects at sample means retrieved through the logit regression. The first two columns display the results when the control variables are not included in the regressions. Columns 3 and 4 report the results for the full model, and columns 5 and 6 report the results when the average grant rate at other patent offices is omitted. As discussed in section 3 the average marginal effect for the interaction term is computed through the methodology proposed by Ai and Norton (2003).[11]

As expected, in every specification the family size have a positive and significant effect on the probability of an application to be granted. The total number of IPCs assigned to a patent has instead a small and negative impact. However, the effect is not significant when we do not control for the average grant rate at other patent offices. Both the lags between priority and application date and the lag between application and request for examination have a negative impact on the grant probability. The number of claims and the share of independent claims by applications also negatively affect the probability of a grant. Having more experience with the SIPO, and more applicants and inventors instead positively affect the likelihood of a patent to be issued.

Results for the full model provides only weak evidence that foreign applicants have a lower probability to be granted patent protection by SIPO. Application in strategic field appears instead to have a significantly higher grant probability. The negative and significant impact for the interaction term suggests that foreign applications in strategic fields are indeed significantly less likely to be granted patent protection in China. In particular, foreign applications belonging to strategic IPCs have on average about 5.9 per cent lower grant probability. This result appears to confirm that SIPO assigns a discriminatory treatment to foreign applicants in technology domains that the Chinese government consider as strategic.

As columns 5 and 6 show, this result holds when we exclude the average grant rate of the patent family at the other authorities. The average effect of the interaction term is still

[11] Inteff command (Norton et al., 2004)

Table 2: Results

Estimator	LPM	Logit	LPM	Logit	LPM	Logit
	(1)	(2)	(3)	(4)	(5)	(6)
Foreign	-0.001	-0.025*	-0.011	-0.028*	0.039*	0.042*
	(0.004)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)
Strategic	0.091*	0.111*	0.075*	0.093*	0.045*	0.054*
	(0.007)	(0.009)	(0.006)	(0.008)	(0.006)	(0.007)
Foreign x Strategic	-0.074*	-0.092*	-0.063*	-0.059*	-0.049*	-0.057*
	(0.007)	(0.009)	(0.007)	(0.009)	(0.007)	(0.007)
Control variables:						
Log_fam_size			0.048*	0.034*	0.072*	0.072*
			(0.001)	(0.002)	(0.002)	(0.002)
Log_ipc			-0.004*	-0.006*	-0.001	-0.001
			(0.001)	(0.001)	(0.001)	(0.001)
Priority_app_lag			-0.002*	-0.003*	-0.008*	-0.008*
			(0.000)	(0.000)	(0.000)	(0.000)
App_ex_lag			-0.001*	-0.002*	-0.005*	-0.005*
			(0.000)	(0.000)	(0.000)	(0.000)
Nb_inventors			0.025*	0.031*	0.031*	0.036*
			(0.000)	(0.001)	(0.000)	(0.001)
Nb_applicants			0.078*	0.154*	0.116*	0.191*
			(0.003)	(0.006)	(0.003)	(0.006)
RTA			-0.001	0.001	0.001	0.002
			(0.000)	(0.001)	(0.000)	(0.002)
Experience			0.046*	0.044*	0.101*	0.091*
			(0.002)	(0.002)	(0.002)	(0.002)
Log_nb_claims			-0.008*	-0.009*	-0.031*	-0.031*
			(0.001)	(0.001)	(0.001)	(0.001)
Indep_claims_ratio			-0.018*	-0.025*	-0.079*	-0.081*
			(0.003)	(0.003)	(0.003)	(0.003)
Fixed effects:						
Avg_gr_rate	0.588*	0.609*	0.551*	0.549*		
	(0.001)	(0.002)	(0.002)	(0.002)		
App_Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
1-digit IPC Effects	Yes	Yes	Yes	Yes	Yes	Yes
_cons		0.272*		0.251*		0.598*
		(0.006)		(0.007)		(0.008)
N	477854	477854	477854	477854	477854	477854
pseudo R^2		0.218		0.228		0.045
R^2	0.254		0.258		0.051	

Standard errors in parentheses

* $p < 0.001$

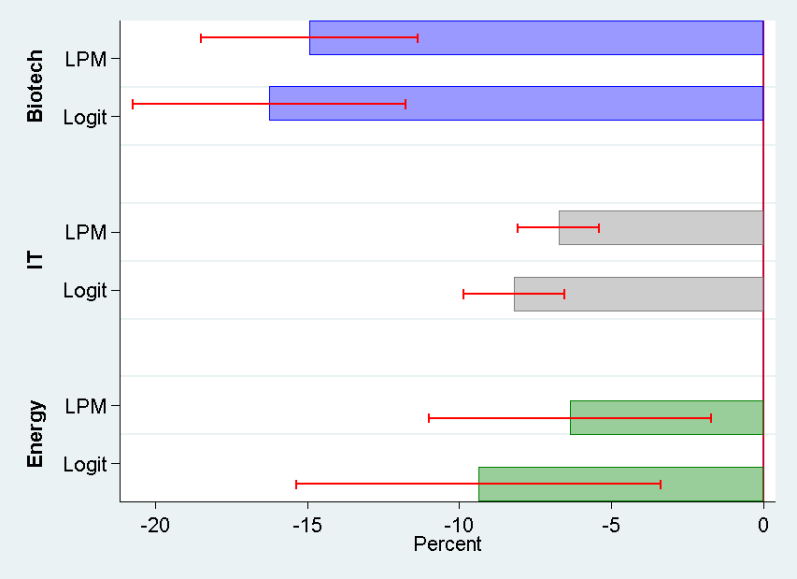
negative and significant, although somewhat reduced in magnitude. As anticipated, omitting this variable that grasps the invention fixed effects, also substantially reduces the predicting power of our model.

Figure 2: Average interaction effect by grant probability

As discussed in 3, the marginal effect for the interaction term in a non-linear model may have different sign for different observations and different values of the covariates (Ai and Norton, 2003). Figure 2 displays the median spline plot of interaction effect as a function of the predicted probability of being granted patent protection. As the graph shows, the effect is negative everywhere when plotted against predicted probability, and the result appear to be strongest in magnitude for patents that have a lower predicted probability of being granted.

In order to shed more light on the nature of this effect we also run the analysis by stratifying the variable *Strategic* and the interaction term by the eight macro-technological areas identified by the MLP: biotechnology, information technology (IT), advanced materials technology, advanced manufacturing technology, advanced energy technology, marine technology, laser technology, and aerospace technologies. Figure 3 displays the results for the macro-areas for which we find a significant effect. Foreign applications in the biotech, IT, and advanced energy fields appear to drive the main result obtained through the full model (table 2).The graph report the effect of the interaction term and the confidence interval (99%) recovered both from the logit regression and the linear probability model. Non-domestic filings in the field of biotechnology have a particularly low probability of being granted patent protection in China, between 14 and 15 per cent (depending on the model) lower than what they would achieve if the national treatment principle was upheld.

Figure 3: Effects for the main macro-areas



6. Robustness checks

6.1. Grant outcome at the EPO and USPTO

One of the main concern that may rise in interpreting our result as a proof that SIPO accord discriminatory treatment to foreign inventors in strategic fields, is that our control variables are not fully grasping the application quality dimension. If that was the case, Chinese applications in strategic sectors might be indeed of better quality, exactly because of the implementation of the MLP, and thus have a legitimate higher grant rate than foreign filings.

In order to account for this possibility we run a robustness check in which we run the analysis in a similar setting as the one described above but looking at the grant outcome for the direct equivalents of the focal patent applications at the USPTO and at the EPO. To further improve the comparability between Chinese and non-Chinese filings at EPO and USPTO we consider only filings by applicants from South Korea, Japan, Russia, Taiwan, and, clearly, China.If the higher quality of Chinese filings in strategic sector was driving the result of the focal analysis, we should find a negative and significant effect on the grant probability for non-Chinese applications in strategic IPCs also at EPO and USPTO.[12] Table 3 reports the results of this robustness check. Columns 1 and 2 display the result for the grant outcome at

[12]Note that 6,000 of the Chinese filings in our sample have an equivalent at EPO, and about 15,000 an equivalent at USPTO

the USPTO (logit and linear probability model), whereas columns 3 and 4 for the EPO.

For both USPTO and EPO we do not find a significant difference in the grant probability between Chinese and non-Chinese applications in strategic fields. Chinese filings in sectors deemed as crucial by the Chinese government thus do not seems to be of superior quality compared to foreign applications in the same fields.

Table 3: Results

	(1) USPTO	(2) USPTO	(3) EPO	(4) EPO
Non-Chinese	-0.042	-0.026	0.035	0.026
	(0.023)	(0.017)	(0.071)	(0.057)
Strategic	-0.082	-0.059	0.022	0.012
	(0.050)	(0.041)	(0.151)	(0.125)
Non-Chinese x Strategic	0.009	-0.001	-0.030	-0.026
	(0.050)	(0.041)	(0.151)	(0.125)
Control Variables				
Log_fam_size	0.049*	0.051*	0.402*	0.321*
	(0.004)	(0.003)	(0.006)	(0.005)
Log_ipc	0.034*	0.027*	-0.014*	-0.013*
	(0.002)	(0.002)	(0.003)	(0.003)
Prior_app_lag	-0.000	-0.000	0.054*	0.042*
	(0.002)	(0.002)	(0.006)	(0.005)
Nb_inventors	0.005*	0.005*	-0.004*	-0.003*
	(0.001)	(0.001)	(0.001)	(0.001)
Nb_applicants	-0.020*	-0.015*	-0.026*	-0.022*
	(0.005)	(0.005)	(0.007)	(0.006)
RTA	0.241	0.183	0.420	0.238
	(0.146)	(0.116)	(0.207)	(0.153)
Log_claims	-0.013*	-0.011*	-0.028*	-0.023*
	(0.002)	(0.002)	(0.003)	(0.002)
Fixed Effects				
Avg_gr_EPO			0.647*	0.484*
			(0.006)	(0.004)
Avg_gr_US	0.614*	0.596*		
	(0.004)	(0.003)		
App_Year Effects	Yes	Yes	Yes	Yes
1-digit IPC Effects	Yes	Yes	Yes	Yes
_cons		0.158*		-0.136
		(0.020)		(0.088)
N	169035	169036	92044	92044
pseudo R^2	0.196		0.188	
R^2		0.238		0.218

Standard errors in parentheses

* $p < 0.01$

7. Concluding remarks

Most of the political efforts in the area of international IP rights have been geared towards ensuring better enforcement. Yet one can really think of this issue as a second order issue. If technologies are not granted patent protection in the first place, they can be legally copied by local competitors. Whereas discriminating against foreign inventors is forbidden by international treaties, it remains a practice that is difficult to identify. Our results appear to confirm the hypothesis that China actually uses the patent system as an informal barrier to entry in sector that the Chinese government deems as strategic.

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