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Global patent systems: revisiting the national bias hypothesis

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Abstract
This paper revisits the literature providing empirical evidence that patent offices are biased in favour of their national applicants. If true, this "national bias" would be proof of disrespect of several international patent-related treaties. Existing investigations are however subject to an important limitation: they focus only on grant rates – a potentially biased indicator of stringency, since it is influenced by economic forces. It is argued that including a deeper analysis of how the patent examination process is carried out provides a more robust approach. Relying on a unique database of 2400 patent families filed simultaneously in three patent offices (EPO, JPO & USPTO), the paper finds no evidence of national bias throughout the examination process of any of them.

Keywords: Patent systems, TRIPs, national bias, examination, international comparison

1. Introduction

The first industrial revolution intensified technological change and trade, leading to increased globalization of economies and trade flows. This technology-based internationalization explains the pressure from the industry to design a more coherent approach towards the international protection of their creative output. The Paris Convention (PC), signed in 1883, was a major step in establishing structured industrial property and patent regulation at an international level. The substantive provisions of the Convention fall into three main categories: national treatment, right of priority, and common rules. They are still a fundamental part of the global patent system. A tangible advantage of the Paris Convention is that applicants obtained one year from the priority date (date of first filing at a national patent office) to gauge in which countries they wanted to seek protection. This delayed the substantial costs of obtaining a patent and established a universal date up to which any prior art could be considered as relevant. A further advantage of the PC was the guarantee that foreign and domestic applicants would be treated equally. This principle that "national treatment" should be given to foreign inventors aimed at strengthening incentives to internationalise innovation.

Nearly a century after the PC, further consolidations and economies of scales crystalized in the Patent Cooperation Treaty. Signed in 1970, the PCT streamlined formality requirements, delayed the costs of internationalization up to 31 months and provided preliminary opinions on patentability. Regional alliances also emerged; of which the European Patent Convention (EPC, 1973) is probably the most significant. [1] Multilateral regulation also emerged, through the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs, 1995, setting down minimum legal standards in WTO member states). The TRIPs also include a '*national treatment principle*' in Article 3.1, whereby non-domestic applicants should be treated in a similar, '*non-discriminatory*' way, as domestic applicants. This principle was essentially set to foster international flows of knowledge and investments, and help innovators to exploit their IP internationally. TRIPs, the PCT and the PC therefore prevent national examination procedures to be used as trade protection policies.[2]

[1] Other regional collaborations include for instance the Eurasian Patent Convention (EAPO, 1994), the African Regional Intellectual Property Organization (ARIPO, 1976), and the African Intellectual Property Organization (OAPI, 1977).

[2] Indeed, as clearly written by Scotchmer (2004), "... *each country wants the strongest possible protections in foreign countries, and the weakest possible protections for foreigners in its own domestic market*", p. 450.

Patent offices are increasingly investigated and questioned on several facets of the national treatment principle, leading to questions on its actual enforcement. For some authors (e.g., de Rassenfosse et al., 2019, p.3), failure to enforce the principle could "*weaken R&D investment incentives and inhibit international trade flows*". Further, the authors suggest that the WTO should enter in some form of monitoring, hence securing advanced statistical investigations. The small but growing literature aiming at investigating this issue systematically reaches the conclusion that there is a significant national bias in most of the large patent offices.

In this paper, it is argued that these empirical investigations have two main limitations. First, they rely exclusively on output-based indicators to test for the national bias hypothesis (i.e. that domestic applicants are granted more patents and faster than non-domestic applicants). Relying on output-based indicators could be misleading because the grant rate is the result of two broad driving forces: (i) the degree of stringency of an office; and (ii) economic factors, or the willingness of the applicant to maintain its patent active. Second, they rely on samples that are flawed either because data is aggregated at the patent examination office level, or because they are limited to non-PCT filing routes (which represent a minority of applicants aiming at a global protection).

The objective of this paper is to revisit the national bias hypothesis and to contribute to the literature in two ways. First, an alternative empirical approach that focuses on the patent examination process is adopted in order to solve the potential bias associated with output-based indicators. Second, the unique database introduced in Petit et al (forthcoming) and inspired from Gimeno and van Pottelsberghe (2020) is used in the context of the national bias hypothesis discussion because it tracks key examination stages for both PCT and non-PCT applications. The results do not support the hypothesis of national bias. There is no evidence that the national treatment principle is violated in the examination process of the USPTO, the EPO and the JPO. This leaves room for further research on the impact that economic forces have on applicants during the patent examination process.

The next section outlines a critical review of the literature and section 3 is devoted to the empirical methodology, including the hypothesis, empirical model and database construction. The fourth section presents the results and section 5 covers robustness checks and discusses limitations. Conclusions are provided in section 6.

2. Critical review of the literature

The key scholarly contributions on the topic of national bias are described in Table 1; the median estimated bias is of about -10%. In other words, non-domestic applicants have a significantly lower probability to have their patent granted than domestic applicants. However, these studies present two main types of limitations: sampling issues and/or a methodological problem.

In terms of sample, four of the eight listed articles rely 'only' on non-PCT applications. This is particularly problematic when discussing national bias since the vast majority of patent applications seeking global protection choose the PCT route.[3] Moreover, out of the four papers that use more representative samples, three of them use data aggregated at the patent examination office level. For example, Liegsalz and Wagner (2013) compare the mean grant rate of Chinese applicants with the one of non-Chinese applicants. However, as highlighted by Webster et al. (2014), the aggregate approach is subject to a selection bias since it does not control for differences in overall quality between the set of foreign and domestic patent applications.

In terms of methodology, all existing studies rely on output-based measures, especially grant rates, to show discrimination against foreign applications. The too strong confidence on the reliance of grant rates to assess a potential bias in 'stringency' is illustrated by de Rassenfosse et al. (2019) who interpret their results (non-domestic applications have a significantly lower probability to be granted) as follows (p. 18): *"... it is not clear whether the bias is because foreign applicants are more likely to be incorrectly rejected (Type I error) or whether local applicants are more likely to be incorrectly granted (Type II error)*." There seems to be no or very little room for alternative interpretation of the estimated parameters. Similarly, Webster et al. (2014) interpret a negative parameter as indicating (p. 462) "*patents operating in areas close to the region's area of technological specialization are less likely to be granted*", concluding that the domestic inventor effect is an increasing function of a country's technological specialization.

Focusing on USPTO applications only, de Rassenfosse and Hosseini (2020) provide some evidence that the observed 'bias' are partly due to three differences between foreign and domestic patent applications: differences in patent agents, in financial resources, and in the

[3] In 2002, 64% of patent families comprising EP, JP and US members followed the PCT route (64%). In 2006, this was up to 72%.

relative 'effort' during the prosecution process. The authors conclude that for the US patent system, evidence points to a 'unintentional discrimination' towards foreign inventors.

Table 1. State of the Art on "national bias" investigations

Authors	**Sample**	**Conclusion**	**Bias***	**Limitations**
Kotabe (1992)	All patent applications at the JPO, USPTO, West Germany & Britain from 1963-1988	Foreign applicants get longer pendency at the JPO & lower grant rates at the other offices.		- Aggregated data
Webster et al. (2007)	70k twin applications at the JPO and the EPO from 1990-1995	Non-domestic applicants are 20% to 27% less likely to reach a grant than domestic ones at the JPO, and 4% to 18% less likely at the EPO.	[-4% ; -27%]	- Non-PCT - Output-based - Conditional on USPTO grant
Liegsalz and Wagner (2013)	440k patent applications at the CNIPA from 1990 - 2002	Chinese applicants achieve grants faster than non-Chinese ones.		- Aggregated data - Output-based - One office
Webster et al. (2014)	48k twin patent applications at the EPO and the JPO from 1990-1995	Foreign applicants are 7% to 10% less likely to have their patent granted by the EPO & JPO compared to national applicants.	[-7% ; -10%]	- Non-PCT - Output-based - Conditional on USPTO grant
Yang (2016)	All applications at CNIPA & USPTO from 1985-2014	Foreigners have higher grant rates at CNIPA but no difference at USPTO	+	- Aggregated data - Output-based
de Rassenfosse and Raiteri (2016)	478k patent applications filed at the CNIPA between 2001 and 2009 (with at least one direct equivalent at the CIPO, EPO, JPO, KIPO, RFSIP, TIPO, or USPTO)	Foreign applicants in strategic technology fields for China are 4% to 7% less likely to be granted a patent than local applications	[-4% ; -7%]	- Non-PCT - Output-based
de Rassenfosse, et al. (2017)	1650 standard-essential patent applications filed at the CNIPA from 2001-2009	Foreign firms are 9% less likely to be granted, take longer to examine, and are more extensively amended when their patents are declared essential.	-9%	- Non-PCT - Output-based
de Rassenfosse, et al. (2019)	510k IP5 families from 2000-2006	Foreign applicants are 8% to 10% less likely to be granted a patent in all five offices (even for PCT applications)	[-8% ; -10%]	- Output-based
de Rassenfosse and Hosseini (2020)	1.5 million U.S. patent applications	Foreign applicants are 10% less likely to be granted a patent	-10%	- Output-based

* The column 'Bias' indicates the estimated impact of being a 'non-national' on the grant rate.

The main concern that motivates the present paper is that the observed grant rate of a patent is a potentially biased indicator of a patent office's stringency, because it is not only explained by the examination process but also by economic factors. The idea is that various economic forces shape the expected return to patenting and thereby impact the willingness of the applicant to invest time and resources into its patent, especially abroad. The literature on patent value amply covers the topic (see van Zeebroeck and van Pottelsberghe, 2011, Harhoff et al, 2009, and van Pottelsberghe and François, 2009) and highlights that these forces can be related to market specificities (size, degree of competition and specialization), the design of the patent system (patenting fees and costs), or the patentee (experience, resources, strategies). It is worth noting that the expected return to patenting evolves throughout the examination process. In fact, the scope of the intellectual property might be challenged and narrowed by the patent office. Moreover, market shifts might occur over the course of the patenting process. As a result, the potential value of a patent might decrease while patenting costs keep piling up (Danguy and van Pottelsberghe, 2011).

To avoid the potential bias in grant rates analyses, this paper introduces an alternative methodology where national bias is tested within the examination process itself. The examination process is defined as the work carried out by the patent examination office (to assess if an application fulfils the legal patentability conditions), which is assumed to be (mostly) independent from economic forces. Testing for national bias within the examination process relies on the fact that patent offices are legally required to justify each decision they publish through concrete and transparent evidence. As a result, discriminatory behaviours from patent offices should appear in the way applications are processed. For example, a patent office could favour domestic applicants by carrying out an incomplete search of prior art when asserting the novelty condition.

3. Methodology

This paper puts forward a new empirical approach that consists in studying national bias in the examination process. The metric used to quantify the examination process was inspired by Gimeno and van Pottelsberghe (2020) and introduced in detail by Petit et al. (forthcoming). This metric is composed of four main "process" indicators to quantify key steps of the patent examination as well as three output-based indicators. To test the national bias hypothesis, this paper quantifies the impact of the country of origin of the application on each of these seven indicators.

3.1. Model

Hypothesis: there is no national bias in the patent examination process

In each office separately, the patent examination process Y_i for invention i is modelled as a function of its three non-domestic priority dummies ($EP_i = 1$ if the priority of the application is one of the EPC member states, $JP_i = 1$ if the priority is from Japan, $US_i = 1$ from the US and $OTHER_i = 1$ from elsewhere), a set of control variables z_i, and other unobserved factors ε_i assumed random and independently identically distributed.

- EPO applications: $Y_i = f\big(\propto + \beta_1\, JP_i + \beta_2\, US_i + \beta_3\, OTHER_i + z_i{}'\delta\big) + \varepsilon_i$
- JPO applications: $Y_i = f\big(\propto + \beta_1\, EP_i + \beta_2\, US_i + \beta_3\, OTHER_i + z_i{}'\delta\big) + \varepsilon_i$
- USPTO applications: $Y_i = f\big(\propto + \beta_1\, EP_i + \beta_2\, JP_i + \beta_3\, OTHER_i + z_i{}'\delta\big) + \varepsilon_i$

Since the omitted priority is the domestic one, a statistically significant β would indicate that the office processes non-domestic applications with that priority differently than domestic ones, hence showing a national bias.

The examination process Y_i is characterized by a set of four "process" indicators (technology classes searched, backward patent citations, backward non-patent literature, percentage of citations made in the earliest stage) and three output-based indicators (duration to grant, grant probability and claims allowance).

This methodology differs from the literature on patent families which typically uses a pooled sample with an invention fixed-effect estimation[4] to control for patent quality differences. National bias is then estimated as the overall impact of non-domestic applications on the sample. However, if the impact of non-domestic priorities on the patent examination process is similar in each patent office, these repeated entries artificially amplify the sample size, hence the significance level of the estimated parameters. Also, this methodology does not allow for the national bias hypothesis to be investigated separately for each office, nor does it show how the bias might depend on the origin of priority. Moreover, studies using invention fixed-effects often use them as an estimation of patent quality while it actually covers other unobserved characteristics that differ between applicants. For these reasons, the models used in this paper are estimated separately for each office, and the invention-fixed effect is controlled for via a set of control variables. However, in order to check the robustness of the results, and compare with previous studies, the pooled model with invention fixed-effects is also included in the results. In this model, the patent examination process Y_a^i for application *a* which covers invention *i* is modelled as a function of $NDOM_a^i$, a dummy variable that is equal to 1 if the

[4] This means that observations from each office of the family are included in the same sample and treated as repetitions of the same invention.

application has a non-domestic priority. The unobserved invention fixed-effect is taken into account through $\propto_i$.

$$Y_a^i = f\left(\propto_i + \beta\ NDOM_a^i + z_a'\delta\ \right) + \varepsilon_a^i$$

It is worth noticing that the literature usually uses the grant probability as dependent variable, whereas this paper tests the examination process.

3.2. Data

The database created and described by Petit et al. (forthcoming) is used for the empirical analysis since it uniquely provides the high level of procedural detail necessary to identify examiner behavior. It consists of 2.400 triadic patent families: sets of applications relating to the same underlying inventions and simultaneously filed at the EPO, the JPO, and the USPTO. Patent applications were defined as part of the same family if they share the same set of priorities. Applications who were later separated into divisional applications were treated as separate families. Also, applications subject to continuation-in-parts were not included in the sample selection process as they are unique to the US procedure.

The selection of the 2.400 families was carried as follows: half the sample was selected from families with earliest priority in 2003 and half from 2006 to limit the number of pending applications and control for time fixed effects. Furthermore, 70% of the families were selected from PCT applications, representing roughly the PCT share of triadic families. Finally, the selection of the patent families was carried out separately for each technology class, based upon the population distribution: 14% of the sample was selected randomly from IPC A families, 15% from B, 15% from C, 6% from D, 1% from E, 15% from F, 17% from G, and 17% from H.

After selecting the 2.400 families, technology classes for which substantial legal differences exist between patent systems were removed from the sample.[5] Applications for which no search report was published by one of the three offices were removed during the data collection process.[6] At the end of that cleaning process, the database was composed of 1.693 families (out of which 1.134 followed the PCT route).

[5] These relate to classes A61K, G05N, G06F and G06N, which are known to contain significant numbers of software-based patents.
[6] These removed families accounted for 25% of the sample. They were later replaced. Results using the entire sample are available upon request.

3.3. Variables

The examination process Y_i^j is characterized using the four process-based and three output-based indicators inspired by Gimeno and van Pottelsberghe (2020) and introduced in details by Petit et al (forthcoming).

Process-based indicators

- *Technology classes searched:* number of IPC 4-digit classes disclosed by the office during the search procedure. While IPC 4-digit classes were available in EPO and JPO procedures, USPTO usually disclosed technology classes searched in its national classification system (USPC). For that reason, USPC subclasses were retrieved for USPTO applications. This indicator quantifies the completeness of the search carried out by the office. A more thorough search for foreign applicants could indicate a willingness to find more blocking prior art, hence showing a biased behaviour.
- *Backward patent citations (BPC):* number of BPC provided by the patent office.[7] Lemley and Sampat (2012) use their finding that more experienced examiners cite less prior art to support the idea that they are doing less work than junior examiners. Therefore, more BPC for foreign applications could further indicate a willingness to find more blocking prior art.
- *Backward non-patent literature (NPL)*: number of NPL citations provided by the patent office.[5] It is generally understood that NPL citations are a proof of a thorough consideration of various forms of prior art. Therefore, a higher number of NPL for foreign applications could be interpreted as a more stringent approach towards their application.
- *Percentage of citations made in the earliest stage (first BC):* percentage of prior art citations (both BPC and NPL) that came from the first opinion of the office in comparison to the total amount of prior art citations made by the office throughout the entire procedure. Since this is a measure of the degree of certainty provided to the applicant, a lower percentage for foreign applicants could reveal a willingness to continue the search for prior

[7] At the EPO, citations were retrieved from the search report and additional citation from the written substantive Communications. They are used by examiners, and include the citations made by the applicant when considered relevant (EPO Guidelines Part B and C). At the JPO, the retrieval of prior art may be outsourced to an external organization (including retired examiners), and are considered as citations from the office in this paper (JPO Guidelines Part IX-Examination and Decision. At the USPTO, the citations "made by the examiner" were retrieved in the USPTO procedure, when the examiner finds citations that are relevant, irrespective of whether they stem from a foreign reference or are suggested by the applicant, she will cite them (Chapter 900, 1000 and 1100 of the Manual for Patent Application Procedure, Source USPTO).

art in later stages of the process, hence demonstrating a higher procedural stringency against foreign applicants.

Output-based indicators

- *Duration to grant:* number of days from the earliest priority date to the publication of the patent for granted applications. This is a measure of the speed of the process, which affect both the degree of certainty provided to the applicant and the cost of the granting process. It is noteworthy to state that it may be influenced by internal office prioritisation of workload.
- *Grant probability:* variable that is equal to 1 if the patent was granted, and 0 otherwise.
- *Claims allowance:* percentage of claims published at grant (= 0 if the application was not granted) compared to the number of claims in the initial application. This indicator enrichens the information provided by the grant probability in that it also takes into account that, even if a patent is granted, the scope of the intellectual protection sought by the applicant might be reduced.

The main explanatory variable is the origin of priority of the application, which is defined as the country of the office of first filing in the patent family. An application is "domestic" in one office if its priority is from the same country or region: EPC priorities at the EPO, JP priorities at the JPO, and US priorities at the USPTO. While the country of residence of the applicant is widely used in the literature to distinguish between domestic and foreign applications, this paper uses the country of origin of the application instead.The main motivation behind this decision is that it allows for a clear-cut identification of applications which are "from" the jurisdiction of the office under scrutiny versus applications which are "not stemming from that jurisdiction" and is best suited for a procedural analysis that considers how applications are treated by the examination office. [8] However, the overlap between priority and country of inventor as a measure for "patent nationality" is very high, as illustrated in de Rassenfosse et al. (2013). Consistent with the literature, Table 2 shows that non-domestic applications have lower grant rates both at the EPO and the JPO. However, the USPTO has a higher grant rate

[8] Informal discussions with patent examiners confirmed that the most common indicator as from where an application comes is the upstream office rather than the geographical residence of the applicant. Furthermore, the priority filing behavior of applicants is not directly comparable across jurisdictions since some legal systems (such as the US, USPC Section 184) require applicants to first file domestically, whereas others do not have such provisions. Additionally, the origin of multinational applicants, would remain unclear.

for JP priorities than for domestic ones. Looking at the "coherence" amongst the three offices, Japanese priorities had the highest overall grant rate (47%) and US priorities the lowest (25%).

Table 2. Distribution of outcomes by priority

	% Granted in all three offices	% Granted in none of the three	Grant rate (%) EPO	JPO	USPTO
38% Priority EPC	41	16	69	60	60
21% Priority JP	47	8	59	80	75
34% Priority US	25	19	44	50	67

The set of control variables is composed of:

- *Quality control*: dummy that is equal to 1 if the two other offices granted a patent to the same invention, 0 otherwise. As in Lemley and Sampat (2012), it is used as a control for the quality of the underlying invention.
- *Claims:* number of claims in the published application to control for the size of the protection scope sought by the applicant.
- *Time fixed effects:* the year of the priority date (either 2006 or 2003).
- *Technology fixed effects*: the IPC 1-digit class attributed to the application.

4. Results

Estimations were carried out separately for each office and for each indicator. Non-PCT and PCT applications were also modelled separately since their go through a different procedural route. The results are displayed in Table 3 and 4, respectively.

4.1. Non-PCT applications

With regards to output-based indicators, Table 3 shows results that are consistent with the literature.[9] The likelihood to get a patent at the EPO is 15% lower for Japanese applications and 17% lower for US applications compared to European ones (and in terms of claims, these non-domestic applications have 18% and 23% fewer granted claims than domestic ones). At the JPO, European and US applications are respectively 11% and 15% less likely to get a patent than domestic applications. However, there is no significant differences between domestic and

[9] It is interesting to note that even the R^2 of the grant probability regressions are similar to those from Webster et al. (2014).

non-domestic applications at the USPTO. Interestingly, non-domestic applicants experience a significantly longer time to grant only at the JPO.

Table 3. OLS estimates on non-PCT applications

	Dependent variables						
	Technology classes searched	BPC	NPL	First BC	Duration to grant	Grant rate	Claims allowance
EPO (Priority EPC = reference)							
Priority JP	-0.17	0.32	0.11	0.02	-129.76	-0.15***	-0.18***
	(0.11)	(0.25)	(0.15)	(0.01)	(120.64)	(0.05)	(0.05)
Priority US	-0.00	0.04	-0.09	0.01	115.22	-0.17***	-0.23***
	(0.14)	(0.29)	(0.18)	(0.02)	(150.69)	(0.06)	(0.05)
Priority Other	0.04	0.44	-0.10	0.04**	-93.97	-0.10	-0.19***
	(0.17)	(0.36)	(0.22)	(0.02)	(184.83)	(0.07)	(0.07)
Quality control	-0.10	-0.10	-0.14	0.02	189.58*	0.29***	0.24***
	(0.09)	(0.20)	(0.12)	(0.01)	(108.79)	(0.04)	(0.04)
Claims	-0.01	0.03***	0.01	0.00	18.67***	-0.00	
	(0.01)	(0.01)	(0.01)	(0.00)	(6.25)	(0.00)	
Constant	1.39***	3.66***	0.63*	0.97***	1707.95***	0.69***	0.66***
	(0.24)	(0.53)	(0.33)	(0.03)	(256.15)	(0.10)	(0.09)
Time effects[a]	F = 5.3	F = 0.2	F = 0.6	F = 0.1	F = 4.0	F = 1.1	F = 0.0
Technology class effects[b]	F = 3.1	F = 3.1	F = 0.5	F = 1.7	F = 1.0	F = 4.3	F = 3.1
Identical non-domestic effect?[c]	F = 1.3	F = 0.8	F = 0.9	F = 1.4	F = 1.4	F = 0.5	F = 0.2
Observations	559	559	559	553	367	559	559
R^2	0.054	0.054	0.015	0.032	0.082	0.176	0.163
JPO (Priority JP = reference)							
Priority EPC	0.04	-1.07**	-0.13	-0.00	510.07***	-0.11**	0.04
	(0.11)	(0.45)	(0.12)	(0.02)	(72.14)	(0.05)	(0.07)
Priority US	0.16	-1.00**	-0.08	-0.02	615.75***	-0.15***	-0.08
	(0.12)	(0.49)	(0.13)	(0.02)	(83.40)	(0.05)	(0.08)
Priority Other	0.11	-0.48	-0.08	-0.02	27.10	-0.18***	-0.09
	(0.15)	(0.61)	(0.16)	(0.02)	(109.59)	(0.06)	(0.10)
Quality control	0.04	-0.29	-0.02	0.01	42.88	0.28***	0.32***
	(0.09)	(0.36)	(0.09)	(0.01)	(61.58)	(0.04)	(0.06)
Claims	-0.00	0.03	0.01**	-0.00	2.44	-0.00	-0.01***
	(0.00)	(0.02)	(0.01)	(0.00)	(3.57)	(0.00)	(0.00)
Constant, time & technology class effects are included							
USPTO (Priority US = reference)							
Priority EPC	-0.13	-0.54	0.16	0.02	-15.70	0.05	0.08
	(0.18)	(0.89)	(0.13)	(0.04)	(87.64)	(0.05)	(0.08)
Priority JP	-0.13	-0.31	0.10	0.02	32.94	0.00	0.05
	(0.17)	(0.83)	(0.12)	(0.04)	(82.34)	(0.05)	(0.07)
Priority Other	0.05	-1.06	0.02	0.04	158.34	-0.09	-0.09
	(0.22)	(1.11)	(0.16)	(0.05)	(113.99)	(0.07)	(0.10)
Quality control	0.16	-0.09	-0.14	0.04*	59.26	0.25***	0.23***
	(0.12)	(0.59)	(0.09)	(0.03)	(59.79)	(0.04)	(0.06)
Claims	0.00	0.04*	0.00	-0.00*	-0.17	-0.00	-0.01***
	(0.01)	(0.03)	(0.00)	(0.00)	(2.43)	(0.00)	(0.00)
Constant, time & technology class effects are included							
Pooled model with invention-fixed effects							
Non-domestic applications	0.06	-0.22	0.04	-0.01	49.61	-0.09***	-0.05
	(0.06)	(0.26)	(0.06)	(0.01)	(52.08)	(0.02)	(0.03)
Claims	0.01	0.09**	-0.00	-0.01***	-27.36***	0.00**	-0.00
	(0.01)	(0.02)	(0.01)	(0.00)	(4.88)	(0.00)	(0.00)
Constant, time & technology class effects are included							

Standard errors in parentheses. Asterisks denote statistical significance at *10%, **5%, and ***1%.
[a]Time effects are captured by the year 2006 dummy variable (equal to 1 is priority year is 2006) whose statistical significance is measured by the F-statistic
[b]F-statistic measures if technology class effects are jointly significant.
[c]F-statistic measures if the coefficients of all non-domestic priorities are equal

Based on all four process-based indicators, none of the patent examination processes (at the EPO, the JPO, and the USPTO) are significantly different for non-domestic applications compared to domestic ones. The only exception is that non-domestic applications receive less prior art citations at the JPO; however, this is opposite to being detrimental.

Overall, non-PCT applications show no evidence of national bias in the examination process for all three patent offices.

4.2. PCT applications

Regarding PCT applications, Petit et al (forthcoming) show that the procedural route chosen by the applicant has an impact on the patent examination process of the office. And this procedural route is strongly impacted by the applicant's country of residence. In fact, US and Japanese applicants are free to choose which patent office will act as International Search Authority (ISA) while EPC-based applicants are required to use the EPO. In this sample, 99% of EPC priorities used the EPO as ISA, 88% of JP priorities used the JPO as ISA (while the other 12% choose the EPO) and 29% of US priorities chose the USPTO as ISA (against 69% that chose the EPO). As a result, a difference in patent examination process between non-domestic and domestic applications could be due to a difference in procedural route or selected ISA. To solve this issue, the analysis of national bias for PCT applications is restricted to the patent families that had the EPO as ISA (which account for 63% of the PCT sample).

With regards to output-based indicators, Table 4 shows slightly different results than Table 3: the probability to get a grant is 15% lower for Japanese applications at the EPO, 20% and 25% lower for European and US applications at the JPO, and 11% lower for EPC applications at the USPTO. However, process indicators still show no evidence of national bias in the examination process of all three offices.

Table 4. OLS estimates on PCT applications with EPO as ISA

	Dependent variables						
	Technology classes searched	BPC	NPL	First BC	Duration to grant	Grant rate	Claims allowance
EPO (Priority EPC = reference)							
Priority JP	0.03	-0.89**	-0.17	-0.04	224.91	0.03	-0.03
	(0.19)	(0.45)	(0.35)	(0.03)	(184.75)	(0.08)	(0.08)
Priority US	0.01	-0.39*	-0.26	-0.03	-199.70*	-0.15***	-0.17***
	(0.09)	(0.22)	(0.17)	(0.02)	(115.29)	(0.04)	(0.04)
Priority Other	0.22	-0.46	-0.12	-0.04	183.53	-0.07	-0.05
	(0.17)	(0.40)	(0.32)	(0.03)	(194.39)	(0.07)	(0.07)
Quality control	-0.02	0.19	-0.01	-0.00	174.83*	0.37***	0.32***
	(0.08)	(0.19)	(0.15)	(0.01)	(91.00)	(0.03)	(0.03)
Claims	0.00*	0.01**	0.02***	0.00	6.63*	-0.00	-0.00***
	(0.00)	(0.01)	(0.00)	(0.00)	(3.56)	(0.00)	(0.00)
Constant	1.66***	3.75***	1.00***	0.96***	2444.41***	0.54***	0.42***
	(0.12)	(0.29)	(0.23)	(0.02)	(147.16)	(0.05)	(0.05)
Time effects[a]	F=0.5	F=0.2	F=0.1	F=1.6	F=1.6	F=0.4	F=3.7
Technology class effects[b]	F=3.3	F=3.7	F=4.4	F=1.8	F=1.6	F=2.0	F=2.7
Identical non-domestic effect?[c]	F=0.7	F=0.6	F=0.1	F=0.2	F=3.0	F=2.2	F=2.2
Observations	714	714	714	699	446	714	714
R^2	0.043	0.053	0.072	0.030	0.049	0.199	0.194
JPO (Priority JP = reference)							
Priority EPC	0.05	-0.24	-0.02	0.04	361.43***	-0.20**	-0.11
	(0.17)	(0.62)	(0.20)	(0.03)	(85.69)	(0.08)	(0.09)
Priority US	-0.03	-0.36	-0.15	0.06*	349.64***	-0.25***	-0.14
	(0.18)	(0.66)	(0.21)	(0.03)	(96.79)	(0.09)	(0.10)
Priority Other	-0.30	-0.99	0.55**	0.07*	239.67*	-0.31***	-0.02*
	(0.22)	(0.81)	(0.26)	(0.04)	(128.02)	(0.10)	(0.12)
Quality control	-0.02	0.06	0.05	0.00	-6.65	0.40***	0.34***
	(0.07)	(0.26)	(0.08)	(0.01)	(48.02)	(0.03)	(0.04)
Claims	0.00	0.01	0.02***	-0.00	4.01**	-0.00	-0.00**
	(0.00)	(0.01)	(0.00)	(0.00)	(1.95)	(0.00)	(0.00)
Constant, time & technology class effects are included							
USPTO (Priority US = reference)							
Priority EPC	-0.21	-0.75	-0.15	0.04	501.32***	-0.11***	-0.09
	(0.14)	(0.57)	(0.15)	(0.03)	(77.13)	(0.04)	(0.09)
Priority JP	-0.67**	-1.32	-0.02	0.13**	357.72**	0.00	-0.21
	(0.30)	(1.23)	(0.32)	(0.06)	(146.50)	(0.09)	(0.20)
Priority Other	-0.19	-2.12**	-0.27	-0.05	495.67***	-0.07	-0.15
	(0.26)	(1.07)	(0.28)	(0.06)	(144.51)	(0.08)	(0.17)
Quality control	0.09	1.24**	-0.04	-0.04*	138.03**	0.34***	0.38***
	(0.12)	(0.49)	(0.13)	(0.02)	(65.92)	(0.04)	(0.08)
Claims	-0.01	-0.02	0.00	-0.00*	0.51	-0.00	-0.01***
	(0.00)	(0.01)	(0.00)	(0.00)	(2.45)	(0.00)	(0.00)
Constant, time & technology class effects are included							
Pooled model with invention-fixed effects							
Non-domestic applications	-0.20***	-0.30	-0.34***	0.02*	236.19***	-0.13***	-0.08***
	(0.06)	(0.21)	(0.06)	(0.01)	(45.85)	(0.02)	(0.03)
Claims	0.00	0.02	-0.04***	-0.00	-9.95**	-0.00**	-0.01***
	(0.01)	(0.02)	(0.00)	(0.00)	(4.18)	(0.00)	(0.00)

Standard errors in parentheses. * stands for a statistical significance at 10%, **5%, and ***1%.
[a]Time effects are captured by the year 2006 dummy variable whose statistical significance is measured by the F-statistic
[b]F-statistic measures if technology class effects are jointly significant.
[c]F-statistic measures if the coefficients of all non-domestic priorities are equal.

5. Robustness and limitations

To check the robustness of these results, several additional models are tested on both non-PCT and PCT applications. First, the pooled model with invention fixed-effects confirms the previous conclusions (no evidence of national bias in process-based indicators for non-PCT filings; a favourable bias for a few significant process-based indicators for PCT filings) and the output-based results from the literature (a 13% lower likelihood to get a patent for non-domestic applications in the PCT sample – 9% lower for non PCT filings). It is worth noting that *claims* is the only control variable in the pooled model since all the other controls are invention-specific and therefore included in the invention fixed-effect.

Second, removing the quality control variable still leads to no evidence of national bias in the process indicators, but shows even lower grant probabilities for non-domestic applicants (around 3 points lower in non-PCT applications) with up to a 29% and 38% lower likelihood of a grant for Japanese and US priorities at the EPO. This is not surprising since the quality control variable in Table 3 has no significant impact on the examination process, but estimates suggest 25% to 40% higher grant probabilities for inventions that received a grant in the two other offices.[10]

Third, two alternative definitions of "quality control" are tested: splitting the variable into two grant office dummies (for example, EPO regressions included a dummy that is equal to one if the invention received a patent from the JPO, and another dummy that is equal to one if the USPTO granted the patent) and splitting the variable into two claims allowance variables (for example, EPO regressions included the claims allowance of that invention at the JPO and at the USPTO). Both alternative models provide consistent results to those from Table 3 & 4. However, it is interesting to note that having another grant at the EPO or at the JPO has a greater (and similar) impact on the grant probability of an invention than a grant at the USPTO, suggesting that the latter is less indicative of patent quality.

Finally, logistic estimations are carried out on grant probabilities and provide consistent results. With regards to the other indicators, OLS estimates are sufficient to test for national bias.

These results may however be subject to two limitations. On the one hand, because the examination process is complex and driven by human interactions, the quantification exercise has its challenges. The unique extraction of detailed steps of the process requires great resources and well-trained data collectors, which ultimately limits the final size of the database. Moreover, the fact that priority country of PCT applications is extremely correlated to the office acting as ISA makes it particularly difficult to isolate national bias from the impact of the procedural route. While this paper solves the issue by restricting the sample to applications who chose the EPO as ISA, this might also lead to some form of selection bias in the estimates.

[10] There is no time dimension to this statement: the other grants were not necessarily attributed prior to the examination process of the office; they simply represent the quality of the invention in that it is deemed patentable by two other patent offices.

However, the potential bias in the estimated parameters is not particularly relevant since this paper only focuses on testing for statistical significance.

On the other hand, the empirical approach introduced in this paper is based on the assumption that the patent examination process is not impacted by economic forces. This hypothesis might be challenged because the examination process is the result of an interactive relationship between the patent office and the applicant. For example, an applicant with limited resources and experience might drop out of the process as soon as the patent office starts suggesting alterations; thereby potentially leading to an unfinished examination process. However, the process indicators used in this paper being predominantly office-driven, economic forces should play no role – or a minor one. This is consistent with the fact that the four process indicators are not significantly different for non-domestic applications; unlike outcome-based ones.

As a first step to control for economic forces in PCT applications, the dummy variable *Chapter II* is introduced: it is equal to 1 if the applicant entered Chapter II of the PCT procedure, 0 otherwise. A Chapter II procedure in PCT is both onerous and demanding for the applicant, but it provides easier access to several subsequent patent offices with a stronger International Preliminary Report on Patentability. As a result, it is used as a proxy for the potential economic value of the patent for the applicant. However, *Chapter II* does not significantly impact any of the indicators (both process and output-based ones). This could be explained by the fact that Chapter II is an accelerated process that results in a faster patentability report, which, if negative, might be more detrimental to the patent applicant. As a result, entering the Chapter II procedure is a gamble that might not accurately portray the potential economic value of a patent.

6. Concluding remarks

Over the last two decades, several studies have emerged questioning whether the national treatment principle was upheld and respected by patent offices. This principle is firmly anchored in the Paris Convention and its subsequent treaties, including the TRIPS. The vast majority of scholars converges towards one conclusion: foreign applicants have a lower probability to be granted a patent than domestic ones, witnessing a worrying national bias in patent offices' examination practice. And the present paper confirms this lower probability for international applicants to get a patent granted in three major patent offices (EPO, JPO and USPTO). The paper however argues that output-based indicators may induce misleading conclusions on national bias, mainly because grant rates are not only determined by the patent office stringency but also by economic forces, which affect the willingness of the applicant to maintain its patent active.

This paper contributes to the literature through the use of an alternative empirical approach to test for national bias at the EPO, the JPO, and the USPTO, and through a unique database that quantifies the key patent examination processes for both PCT and non-PCT filing routes. The results show no evidence of national bias throughout the work of these three offices. This lack of evidence reopens a debate that seemed to have reached a consensus in the last few years. In fact, this paper suggests that lower grant rates for foreign applications are not caused by discriminatory behaviors from patent offices but possibly come from various economic forces that shape the willingness and capacity of the applicant to maintain its patent active. In other words, there is a clear need for further research into the economic factors and their impact on the patent examination outcome.

The results of de Rassenfosse and Hosseini (2020) with patent applications filed at the USPTO hint to some extent at this economic factor, as they illustrate an unequal access to the patent system for foreign applications compared to domestic ones. Indeed, accessing a foreign market is always more complicated and costly, be it for systemic, languages, or market differences. In order to hold patent protection in international markets significant additional costs are legitimately born, and surely reduce the propensity to maintain a patent active. Should this be a 'policy' concern for patent office? We believe it should not, as it is not the role of a patent system to support or help international applicants in their attempt to adapt to their local economy.

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