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Are Patent Offices Substitutes?

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Abstract

This paper evaluates whether and to what extent patent offices can substitute for each other. Based on an original dataset comprising 7.200 PCT patents filed simultaneously in Japan, the USA and Europe, the empirical analysis confirms that the degree of substitution is significant. Patent offices search up to 37% less technology classes, generate up to 33% less citations, and send up to 43% less communications when a PCT application was previously processed by another office. They also rely more on international citations and provide more information in the early stage of the examination process. Further substitution may still be leveraged, as around 55% of technology classes searched and up to 70% of backward citations are duplicates -voluntarily or not - of prior examination work.

1. INTRODUCTION

More than 3 million patents are filed each year around the world. About 40% are filed at the Chinese Patent Office, 20% at the US Patent and Trademark Office (USPTO), 10% at the Japanese Patent Office and 6% at the European Patent Office (EPO). Of these, 265,000 patents follow the PCT route, meaning that they probably target at least two jurisdictions. Patent applications which are filed in two or more patent offices, are consequently (re) examined several times by different offices. Although the numbers are small compared to the vast amount of applications filed in one single market, international applications represent tenths of thousands of applications per year. Flows of this magnitude raise a legitimate question related to the duplication of examination work –how to avoid it or at least whether there are synergies and complementarities in the work of different patent offices. Indeed, patent offices perform conceptually similar examination services – consisting in classification, search for prior art, and check for inventiveness. This vast amount of potentially duplicated work calls for more synergies within the global patent system (whereby one office could use or recognize the work performed by another office).

The history of patent systems is actually marked by the will to exploit synergies between patent systems and adopt common legal standards (starting with the Paris Convention in 1883 and the TRIPS Agreement in 1994), supporting international trade and investment in innovation. There are two broad possibilities to generate further synergies. The first one is the ultimate recognition of other patent offices' work, which is synonymous to a perfect substitution. This rather convenient solution is already working in Europe, and in a few countries.[1] The second one consists in the mutualisation of one part of the procedure, by carrying it out according to commonly agreed upon standards and sharing work – with strings attached or not. This is how the Patent Cooperation Treaty (PCT) system works, with a well-structured process and the publication of all prior work made available to other offices, which in turn choose or not to rely on it. The Patent Prosecution Highways (PPH) provides a further incentive (or obligation) to rely on prior work, via accelerated examination services.

What the next step will be raises a polemic yet legitimate question, especially regarding the boom in international patent applications: to what degree are patent offices substitutable? Large firms would love to have a faster, cheaper, and more visible process at the global level, whereby policy makers would surely appreciate a reduction in their operating costs. Four solutions could be envisaged to further leverage synergies amongst the offices performing examination services of identical patent applications, and hence duplicate work: *i)* mutual recognition system; ii) a centralized global patent office; *iii)* joint or collaborative decision processes; and *iv)* "generalized patent prosecution highways" (PPHs),

[1] One key example is the creation of the European Patent Convention (EPC), whereby national patent offices of 36 countries in Europe automatically recognize the patents granted by the EPO if the owner wants protection in their jurisdictions. Other examples of unilateral recognition include 5 countries who grant exclusive rights to the patent granted by the EPO (Cambodia, Georgia, Morocco, Moldova, Tunisia); and two countries who recognize the work of the USPTO (Cambodia and Mexico).

whereby if a search report exist, the receiving office must drastically accelerate its own examination of the patent application.

Mutual recognition at the global level is probably not realistic in the medium term, for several reasons. First of all, large economies (European Union, USA, China, Japan) consider their patent offices as a pillar of domestic industrial policy. These systems differ substantially in their operational design and legal context (see van Pottelsberghe, 2011), and hence would be reluctant to enter into a mutual recognition system. An alternative would be to set up a centralized patent office that would secure examination processes on behalf of its members, similarly to the European Patent Office (EPO) for the 38 European Patent Convention member states. The EPO granted patents are nearly automatically granted – or validated - in national jurisdictions (after validation and renewal fees are paid) targeted by the applicant. The key issue here would be to designate or build a globally centralized patent office, with the challenge of setting up a centralized cost (level of fees) and stringency (selectivity rate) policy, beside creating the impression of losing its own political power). The third possibility would be to enter into joint collaborative decision processes, whereby examiners from different offices would 'debate' on patentability. This third approach would induce more time and resources to proceed with the workload and is probably not the best solution. The fourth way would consist in intensifying the Patent Prosecution Highway (PPH). The idea is that if an earlier search report is available, the receiving office should use it to expedite its own examination services.[2] So far, however, less than 1% of all patent applications are subject to a PPH request, despite its creation in 2007.

Whatever the solution envisaged, and in particular the intensification of PPH, the key issue is to identify whether and to what extent patent offices currently perform similar – or substitutable – work. If their work is actually not substitutable, the PPH is probably not a great option, as its very nature is to induce examiners to effectively rely on an earlier search report produced by another office, and proceed faster. Further, the extent to which their work can be substituted would influence policymakers. For example, with a 100% degree of substitution, the two offices would gain time and resources to enter into a mutual recognition process. On the opposite, if patent offices' work were fully complementary, they would gain in entering into collaborative decision processes, at the expense of more resource and time devoted for each application. In other words, a key issue for further global integration of patent systems is related

[2] One example is illustrated by the EPO and the Canadian Intellectual Property Office (CIPO) that have recently announced that the Patent Prosecution Highway (PPH) program between the two offices became permanent on 6 January 2021, following the completion of a pilot program, which started in January 2015. According to EPO President António Campinos: "*This is another milestone in our co-operation, which is aimed at improving the environment for innovation and streamlining the conditions for expedited prosecution at the two offices. We believe it will further promote cross-filing of patents in Europe and Canada, improve market access and bilateral trade, and benefit users of the patent system in both regions*." The signatory offices expect their examination services to be of higher quality and improved timeliness. The PPH is supposed to increase the efficiency and quality of the patent-granting process by enabling the offices to exploit each other's work. https://www.epo.org/news-events/news/2021/20210120.html.

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to the degree of substitutability of patent offices' examination services. To the best of our knowledge, this issue has barely been tackled in the existing literature.

The main research question addressed in this paper seeks to measure the extent to which three large patent offices (the EPO, the JPO, and the USPTO) could substitute each other and further leverage synergies. This paper contributes to the literature in two ways: it provides the first empirical evaluation of the current degree of substitution that occurs between patent offices. Second, it assesses the extent to which further substitution could still take place. This empirical exercise relies on a unique new database that tracks key examination stages of 7.200 paired international applications – belonging to 2.400 patent families. The detailed examination stages are codified for the EPO, the JPO and the USPTO.

The paper is structured as follows. The next section is devoted to a brief summary of the history of the world patent system. It illustrates its broad evolution and helps to crystallize the very motivation of our research question. Section 3 presents the methodology and original database. The results are displayed and interpreted in section 4. Section 5 concludes and discusses potential policy implications.

2. A BRIEF HISTORY OF THE GLOBAL PATENT SYSTEM

The statutory patent system created by the Republic of Venice in March 1474 was most probably the first codified patent system in the world. In short, a patent was granted for devices that were new to Venice, ingenious and useful. Once granted, the owner would enjoy the exclusive right to exploit commercially the patented invention. This creative industrial policy framed the root of the modern patent system, as it has since then inspired many countries. Indeed, during the subsequent four centuries nearly all countries in the world have established patent systems based on similar principles (Guellec & van Pottelsberghe, 2007). The first industrial revolution that spanned from the 18th to the 19th Century led to an increased globalization of economies. This is probably what pushed its major stakeholders to lobby governments for the design of a more coherent approach towards the international protection for their creative output.

Nowadays, filing a patent abroad is still expensive and complex to enforce, especially in multiple jurisdictions. There is on top of these administrative costs a legitimate – at least from the applicants' viewpoint – willingness to leverage synergies and avoid that several patent offices perform the very same search and examination. Significant progresses have been achieved since the late 19th century, starting with the Paris Convention, followed by the Patent Cooperation Treaty (PCT), the creation of the European Patent Office (EPO), and ended with the Patent Prosecution Highways (PPHs) pilot projects initiated for the first time in in 2007, between Japan, South Korea and the United Kingdom.

The Paris Convention was signed in 1883, it applies to industrial property in general, including patents. The substantive provisions of the Convention fall into three main categories: national treatment, right

of priority, common rules; they are still a fundamental part of the current global patent system.[3] A tangible advantage of the Paris Convention is that applicants gained one year from the priority filing date to gauge in which countries they wanted to seek protection, and hence delayed the substantial costs of this extension by one year. A second advantage was that each country had to treat foreign and domestic applicants the same way, hence forbidding any type of national bias. This more coherent framework has been effective for nearly one century, when further consolidation and economies of scales initiatives crystalized, through the Patent Cooperation Treaty (PCT) and the European Patent Office (EPO). Autonomy has been upheld by most countries, whereby a patent granted by Office A could be refused by Office B, and vice versa. In other words, each country kept its autonomy in granting patent, implicitly suggesting that technological change could have an intrinsic techno-legal national bias. In other words, the stringency gauge can vary across countries; a small inventive step could be granted in some countries and not in others.

The PCT was launched in 1978 to further harmonize and facilitate the international patenting process, securing similar sequences and milestone across offices regarding the identification of prior art and the novelty analysis. The PCT makes it possible to seek patent protection for an invention simultaneously in a large number of countries by filing an "international" patent application. An international search report is carried out by an International Searching Authorities (ISA) in order to assess the novelty of the invention. All PCT applications are published 18 months after the priority date, jointly with the international search report, and a preliminary and non-binding opinion on patentability. An applicant who decides to continue with the PCT process can wait until roughly the end of the 30th month from the priority date to start subsequent national or regional phases – i.e., effectively applying for a patent in all desired jurisdictions, and their market (securing translations, paying application and examination fees, and relying on domestic patent attorneys).

The PCT route offers a series of advantages for its stakeholders. First, applicants have up to 18 months more than with the Paris Convention to gauge their willingness to seek protection abroad, which means that the high costs induced by globalization are delayed by 30 months. Second, applicants receive the international search report and a non-binding opinion to help them better assess the economic potential. Third, there is a potential reduction of work to be performed by subsequent patent offices, as a search report is produced and can be used by national patent offices. The evaluation of this 'reduction of work' or "degree of substitution" is the main research objective of the present paper. The PCT has been very successful, as illustrated by the majority of international patents that rely on this route. It does not reduce

[3] Under the provisions on *national treatment*, the Convention provides that each Contracting State must grant the same protection to nationals of other Contracting States that it grants to its own nationals. The *right of priority* means that, on the basis of a regular first application filed in one of the Contracting States, the applicant may within 12 months apply for protection in any of the other Contracting States. These subsequent applications will be regarded as if they had been filed on the same day as the first application. They are said to have "priority" over applications filed by others during a period of 12 months for the same invention. There are several *common rules*, and the most important one is that the patents granted in different Contracting States for the same invention are independent of each other. See wipo.int/edocs/mdocs/tk/en/wipo_unhchr_ip_pnl_98/wipo_unhchr_ip_pnl_98_6.pdf

the high costs associated with international patenting, but significantly delay these costs, and improves early information on potential patentability.

The willingness to further generate - or even 'force' - synergies and reduce pendency is witnessed by the creation of numerous Patent Prosecution Highway (PPH) agreements since 2007. This set of initiatives provides applications with accelerated patent prosecution procedures amongst signatory offices and facilitates the consideration of the work previously done by other patent offices.[4] On the one hand, proponents of the PPH argue that it improves speed, workload and costs, and leads to better outcomes (Yamazaki, 2012). On the other hand, opponents stress that higher procedural speed may reduce quality (Frakes and Wasserman, 2017) and that PPH limits the claims scope in secondary filings, making it often more optimal for applicants to choose alternative country-specific routes to accelerated examination services (Pitts and Kim, 2009).

Going beyond the PCT to accelerate the global process and further leverage synergies would have required either a centralized patent office, a mutualisation of the procedures or entering into mutual recognition –which would only be possible with a very strong common understanding or procedures, hence a sort of mutualisation. A centralized patent office would perform the examination work on behalf of several countries. The most striking example is the EPO, that was created through the European Patent Convention (EPC) in 1978. The initial objective was to centralize the libraries and resources for the search for prior art and examination of inventiveness. A patent granted by the EPO can be directly validated in all EPC member states, without performing any additional search or examination. Yet European patents must be managed and enforced at the national level, and national patent offices can still grant patents independently from the EPO. The EPC has been highly successful as the vast majority of patent applications aiming at protection in several countries go through the EPO (see Guellec and van Pottelsberghe, 2007).[5] The EPO is as well an example of centralization at the global level, as shown by four "validation states" (Morocco, Moldavia, Tunisia, and Cambodia) which automatically grant patent applications that have been already granted by the EPO.

If Europe has somewhat solved the search and examination issue raised by regional multi-country applications, it remains to be addressed at the global level, as the biggest regional offices, the so-called IP5 (patent offices from the USA, EPC, Japan, China and South Korea), still proceed vast amounts of patent families. Here a centralized patent office would not be backed politically, for obvious reasons. Mutual recognition, whereby a patent granted by office A (e.g., the USPTO), would be automatically granted by offices B (e.g., France, Germany or Japan), is neither an option so far. Yet, the IP5

[4] The Patent Prosecution Highway (PPH) is a set of initiatives for providing accelerated patent prosecution procedures by sharing information between some patent offices. It also permits each participating patent office to benefit from the work previously done by the other patent office, with the goal of reducing examination workload and improving patent quality (cf. https://en.wikipedia.org/wiki/Patent_Prosecution_Highway. The JPO provides useful statistics to assess the impact of PPH: https://www.jpo.go.jp/e/toppage/pph-portal/statistics.html.

[5] The EPC is a success for the examination phase, it is less so for the life after grant, as several incongruities still affect the European market for intellectual property (cf. Mejer and van Pottelsberghe, 2012).

increasingly collaborate, exchange best practices, and actually share their work, especially through the PCT process. Indeed, the search report produced by a PCT search authority can be used by all subsequent patent offices where the patent is filed for the national phase. Given the recent boom in international patent applications the question on whether and to what extent patent offices' examination services are substitute is increasingly relevant.

Unfortunately, due to the lack of detailed data available on examination processes, the literature is very scarce. Most studies focus on comparing or discussing grant rates (Webster et al. (2014); de Rassenfosse and Hosseini (2020); Palangkaraya et al. (2011); Kim and Oh (2017); Lemley and Sampat (2012)). Others focus on qualitative analysis of system designs (Guellec and van Pottelsberghe (2007); de Saint-Georges and van Pottelsberghe (2013); Wada (2016)). Wada (2018) provides interesting insight into discrepancies between the EPO and the USPTO with regards to which "blocking" citations they use to justify not granting a patent. To the best of our knowledge, the only significant evidence on whether patent offices recognize and use the work of each other is provided by Wada (2020). Using "blocking" citations for international PCT families, the author concludes that the USPTO "captures spillovers of search efforts from the EPO" and that international search reports prepared for PCT applications increase "convergence of rejection citations" between these two offices. The present paper contributes to the literature by introducing a unique new database that tracks key examination stages of 2.400 international patent families filed simultaneously at the EPO, JPO, and USPTO. It provides the first empirical evaluation of the degree of substitution between patent offices using both a quantitative and a qualitative approach. Further, it assesses the extent to which further substitution could take place, through an overlap analysis of the IPC classes searched and backward citations.

3. METHODOLOGY

In microeconomics, two services are considered as substitutes if they provide the same level of utility to the consumer. Applied to patent systems, the question of whether the services offered by patent offices are substitutes is more complex. In terms of outcome, the utility that the "consumer" (aka the patent applicant) derives from being granted a patent is clearly different since each patent office can only grant protection in its own jurisdiction, issuing patents associated with heterogeneous market size, hence of different economic value. The examination services provided by all patent offices are theoretically identical: assessing whether or not the invention of the applicant is patentable (i.e. novel and inventive). In practice this assessment depends on both the legal context in which the patent office operates and its operational design.[6] Consequently, this paper defines the degree of substitution between

[6] see for instance van Pottelsberghe (2011), and Lemley and Sampat (2012), or Lemley (2000).

two patent offices as the extent to which their examination processes are equivalent for a given application, independently of the final outcome.

The first subsection summarizes the patent examination process and the second one displays the model used to address the research question. The subsequent subsections detail the sample and database, and present the variables used in the empirical model.

3.1. The patent examination process: of novelty and inventiveness

When an inventor seeks protection for an invention, she must start by submitting a first patent application at a patent office, called the priority application. This document contains a description of the invention and the set of claims through which the applicant defines the scope of the protection she seeks. The date of the first filing, called the "priority date", is the date up to which prior art (all knowledge made public prior to the filing date) can be gathered and codified to assess novelty. About 18 months after its filing, most offices publish the application and categorize it into one or several art units, the so-called international patent classification (IPC) system, and publish a search report with the most relevant prior art. This publication is compulsory for all PCT applications. This is done by allocating a number of technology classes considered relevant to the invention. It is important to secure a high quality classification, because it defines the technical fields that examiners consider relevant to the application and logically influences the subsequent stages.

As the process moves on, the office proceeds in order to examine if the invention satisfies the second condition of patentability: inventiveness (check whether the invention is not obvious with respect to the state of the art).[7] This consists in identifying the most relevant prior art by searching all the prior knowledge (patents, scientific or technical literature, …) that has been 'classified' in the patent's IPCs.

During the search and examination stages the examiner and the applicant exchange public communications in which the former might cite prior art that could affect the patentability of the invention and the latter might present additional explanations or modify its claims in response.[8] The nature of those citations of prior art provided by the office, called "backward citations", may provide a qualitative insight into the geographical and scientific scope of the knowledge searched for the identification of prior art. Backward citations that include non-patent literature (mostly scientific or technical journals) witness a search into science-based knowledge, whereas international citations would witness the reliance on a broader (non-domestic) pool of knowledge, and hence a higher quality

[7] It is worth mentioning that in the USA, the USPTO does not distinguish between the search for prior art and the examination, there is no intermediate publication of a search report, except for PCT applications, which are all published 18 months after the priority application, jointly with a search report and non-binding opinion.

[8] The EPO distinguishes between search and examination depending on whether the initial retrieval of prior art has been made. The same applies to the PCT procedure. However, JPO and USPTO do not distinguish the retrieval of prior art from the examination phase.

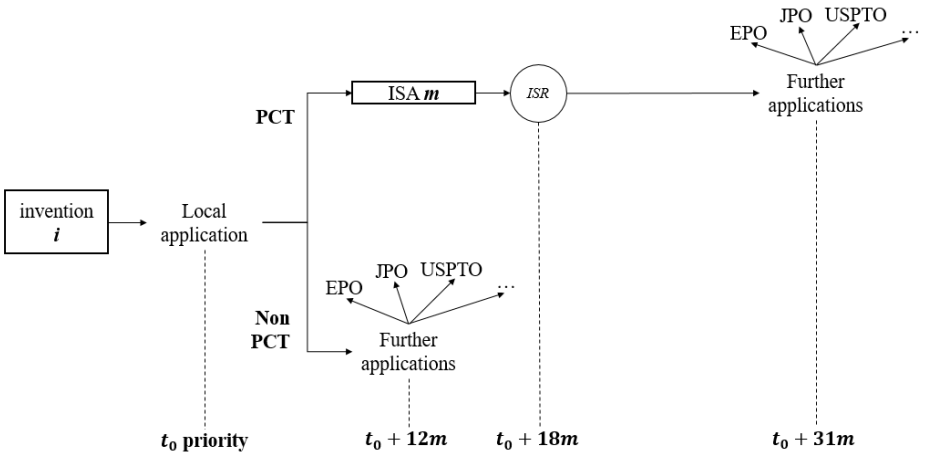
assessment of novelty. The patent examination process can take several years to reach an outcome. Hence, the timing of backward citations delivery also matters. The applicant can better gauge the quality of its invention if all backward citations are delivered and published early in the examination process, as opposed to identification occurring all along the examination process, embedded with a higher degree of uncertainty.

The patent application can eventually be granted and published (with all or only a part of its requested claims), refused by the office, or withdrawn by the applicant. The line between these last two possible outcomes can be thin and vary across patent offices. For instance, at the EPO a significant share of withdrawn patents are actually induced by the office's communication and by the publication of search report (see Lazaridis and van Pottelsberghe, 2007)

If the applicant wants protection in other jurisdictions, the Paris Convention for the Protection of Industrial Property provides her with a right to claim the same priority date in the offices of further filing during a period of 12 months after the priority date. The applicant can also seek international protection through the Patent Cooperation Treaty (PCT). In the "PCT route", illustrated in Figure 1, an International Search Authority (ISA) is requested to perform the search for prior art and publish an international search report (ISR) and a written opinion on patentability, within 18 months of the priority date.[9] The PCT route gives the applicant up to 31 months to decide in which territories she wishes to proceed with her application. The PCT is not a patenting authority on its own right: applicants are still bound to a designated patent office in order to obtain patent protection. However, it is often used as an option for international expansion which gives the applicant more time and more information (search report on novelty) before making the decision of moving into costly regional phases.

[9] Information flows are highly structured in PCT procedures. This is because the search report and non-binding opinions of the offices that treated a patent application in the international route is transferred to national offices. This information has to be as unambiguous as possible. PCT therefore builds on a strict categorization of prior art citations (as for example EPO and JPO do in their own procedures). It also distinguishes between the retrieval of prior art and a first written opinion (Chapter I) and the facultative further exchanges of arguments between the patent office and the applicant (Chapter II), much like the Search and Examination staging in the EPO. Depending on the office of first filing, the ISA can either be chosen by the applicant or automatically assigned. For EPC applicants (or priority filings), the ISA must be the EPO.

Figure 1. Illustration of the PCT route



ISR = International Search Report; ISA = International Search Authority. Non-PCT applications follow the Paris Convention for further applications under the same priority.

3.2. The empirical model

The PCT process has the advantage of providing a structured approach to the examination process, endorsed by all patent offices that act as ISA (International Searching Authority). At the end of the PCT procedure a search report and preliminary opinion delivered by the ISA is made public in the "Global Dossier". Whether subsequent patent offices use it or not in the national phase, and whether it affects their own examination process is the main research question addressed in the present paper.

The model compares two groups of PCT applications: those for which the patent office was also the ISA (and therefore started "from scratch") and those for which another office was the ISA (and therefore the patent office had access to a public search report prior to starting its own examination). Three complementary methods are adopted: quantitative, qualitative and overlap.

Quantitative analysis

The degree of substitution is first gauged with the amount of work carried out by patent office *k* (=1 for EPO, 2 for JPO, 3 for USPTO) for an application: $work^k$. Work is not interpreted in a literal sense, such as the effort or the amount of time invested by the examiner, but rather as the amount of quantifiable and disclosed operational routines carried out by the office. The substitution degree of patent office *k* towards patent office *m* (= 1 for EPO, 2 for JPO, 3 for USPTO, 4 for another patent office), s_{km}, is defined as the relative change in the amount of work carried out by office *k* when applications were previously processed by office m $(k \neq m)$ as ISA.

$$s_{km} = \frac{\overline{work^k_{k \neq m}} - \overline{work^k_{k=m}}}{\overline{work^k_{k=m}}} \qquad (1)$$

where $\overline{work^k_{k\neq m}}$ is the mean of $work^k$ for applications that were previously processed by ISA m ($\neq k$) and $\overline{work^k_{k=m}}$ is the mean of $work^k$ for applications that also had office k as ISA ($m=k$). A negative s_{km} indicates that office k works less for applications that already have a public search report from ISA m.

This statistical definition has the disadvantage of comparing the averages of two different sets of applications, which could have varying examination requirements. An alternative approach is to rely on a multivariate econometric model that controls for several factors, such as the number of claims, the quality of the invention and the broad technology class it belongs to. The amount of work carried out by each patent office k, $work^k$, is modelled separately against the ISA dummies (ISA^m =1 if office m worked as ISA, 0 otherwise), a set of control variables z^j , and other unobserved factors ε^k assumed random and independently identically distributed.

$$work^k = f\left(\propto^k + \sum_{m=1;m\neq k}^{4} \beta^{km} ISA^m + z^{k\prime}\delta^k\right) + \varepsilon^k \quad (2)$$

Since the omitted variable is $ISA^{m=k}$ (the reference category where the patent office is also the ISA), the estimated degree of substitution $\dot{s}_{km}$ is:

$$\dot{s}_{km} = \frac{\dot{\beta}^{km}}{\overline{work^k_{k=m}}} \quad (3)$$

Qualitative analysis

While the first method quantifies the amount of work that is substituted, the second looks into the impact of prior ISA examination on the nature of the work carried out. The patent examination process at patent office k (=1 for EPO, 2 for JPO, 3 for USPTO) is characterized by Y^k , a set of indicators that describe how patent offices cite prior art. These indicators relate to the nature, origin, and timeliness of the backward citations The impact of prior ISA examination is estimated using the same regression model as equation (2), with different dependent variables.

$$Y^k = f\left(\propto^k + \sum_{m=1;m\neq k}^{4} \beta^{km} ISA^m + z^{k\prime}\delta^k\right) + \varepsilon^k \quad (4)$$

Since the omitted variable is $ISA^{m=k}$, a statistically significant β^{km} indicates that patent office k works differently when prior ISA m examination is available, suggesting that there is substitution in their examination practices (part of the work carried out by patent office k is substituted by prior examination work).

Overlap analysis

Finally, the degree of overlap between patent office k and m, o_{km} is introduced as the percentage of examination work provided by office k that was already available in the ISA m search report:

$$o_{km} = \frac{\overline{duplicate^{k}_{k\neq m}}}{\overline{work^{k}_{k=m}}} \quad (5)$$

where $\overline{duplicate^{k}_{k\neq m}}$ is the average amount of work provided by office *k* that was already published by ISA for applications that were previously processed by ISA m ($\neq k$). This indicator is computed for searched patent classifications and backward citations.

3.3. Data source and sample

In order to characterize the key procedural steps leading to a decision by a patent office, a new database has been constructed. While the PATSTAT database has vast amount of data for patent applications in 40+ jurisdictions, some key information regarding the work performed by examiners is missing, such as the IPC classes consulted for the retrieval of prior art. Also, PATSTAT aggregates some indexes, such as IPC classifications, so that it is not easy to distinguish the input of each involved office in the examination process. In order to obtain a higher level of procedural detail and identify particular examiner behaviour, the sample from this paper was built via manual extraction of publicly available file wrappers from the EPO, the JPO, and the USPTO, accessed through the Global Dossier in the Espacenet search tool. The sample includes a total of 7.200 patent applications, or 2.400 triadic patent families (TPF): 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 shared the same priority filings.[10] Applications who were later separated into divisional applications were treated as separate families in the database. Also, applications subject to continuation-in-parts were not included in the sample selection process as they are unique to the US procedure. The use of triadic patent families makes the patent examination processes comparable, as they tackle the same invention.

The selection of the 2.400 families was carried as follows: half the sample was randomly selected from families with earliest priority filed in 2003 and the other half in 2006, in order to limit the number of pending applications (with more recent applications, there is a large number of pending applications). About 70% of the families were selected from PCT applications, which roughly represents the population share of PCT amongst triadic families, and allows for comparisons with office behaviour towards non-PCT applications (in 2006, PCT families accounted for 73% of triadic families). In terms of technology classes, the selection of the patent families was carried out separately for each 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.[11] After

[10] This corresponds to the DOC-DB definition of a simple patent family: "*a simple patent family is a collection of patent documents that are considered to cover a single invention. The technical content covered by the applications is considered to be identical. Members of a simple patent family will all have exactly the same priorities*" (see epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families/docdb.html#:~:text=A%20simple%20%patent%20family%20is,have%20exactly%20the%20same%20priorities)

[11] IPC families are defined as such: (A) Human Necessities (B) Performing Operations, Transporting (C) Chemistry, Metallurgy (D) Textiles, Paper (E) Fixed Constructions (F) Mechanical Engineering, Lighting, Heating, Weapons (G) Physics (H) Electricity

selecting the 2.400 families, technology classes for which substantial legal differences exist between patent systems were removed from the sample.[12] Applications for which no search report was published by one of the three offices were removed during the data collection process.[13] At the end of this process, there were 1.762 families left in the database, out of which 1.196 were from the PCT route category.[14]

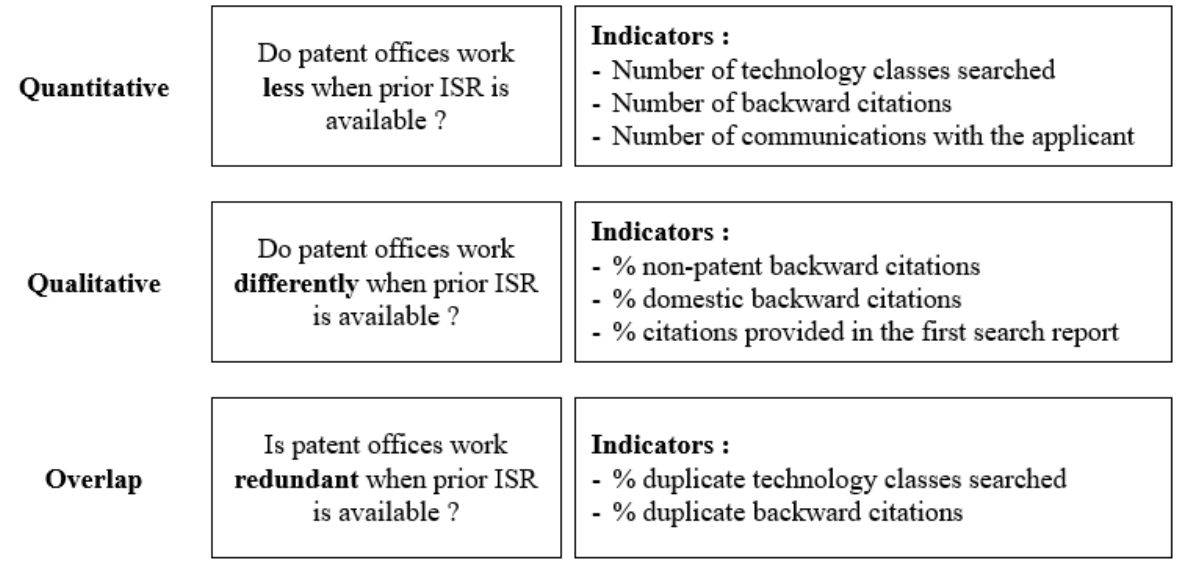
This sample was completed with 600 "domestic only" applications for further comparison purpose (200 applications filed only at the EPO, 200 applications filed only at the JPO and 200 applications filed only at the USPTO).

3.4. Dependent variables

Each of the three methods rely on a different set of indicators, all being publicly available in the "Global Dossier" of Espacenet. In the quantitative analysis, indicators measure the amount of work carried out by the patent office ($work_i^k$) through the number of classes searched, the number of backward citations, and the number of communications with the applicant. In the qualitative analysis, indicators relate to the way the patent office works (Y_i^k), more specifically the type of citations it publishes throughout the examination process. Are they 'patent' citations or reference to the non-patent-literature, witnessing science-based patents? Are they mostly domestic citations or are they tapped into the global stock of knowledge, via international citations? Are they all delivered at once with the first search report - securing a high degree of certainty for the applicant - or are they distilled over time with an intrinsic uncertainty associated with the prior art and the novelty condition? In the overlap analysis, duplicate work is identified for two broad dimensions of the search report: the IPC classes searched and the backward patent citations provided by the examination office and the upstream ISA.

[12] These relate to classes A61K for medical processes and G05N, G06F and G06N, which are known to contain significant numbers of software-based patents.
[13] These applications had no cited relevant prior art from the patent office, nor any disclosed classes searched. The removed families accounted for 25% of the sample, mainly because of applications withdrawals after filing in JPO without any form of examination taking place. They were later replaced. Results using the entire sample are available upon request.
[14] Without applications pending a final outcome: 1.696 families out of which 1.137 are PCT.

Figure 2. Indicators used in each method



Note: "work less" is interpreted as the amount of quantifiable and disclosed operational routines carried out by an office. ISR = International Search Report (written by the International Search Authority).

Quantitative indicators

The amount of work carried out by the patent office is measured with three distinct indicators: how many technology classes it searched into, how many prior art references it cited, and how many substantive communications it exchanged with the applicant.

Classes searched

The technology classes searched by the office are used to gauge how much 'potential' prior art is investigated. The metric used is the number of IPC 4-digit classes disclosed by the office during the search procedure. While IPC 4-digit classes are available in EPO and JPO procedures, USPTO usually discloses technology classes searched in its national classification system (USPC). For that reason, USPC subclasses were retrieved for USPTO applications. For comparability purposes, an alternative normalised measure is also computed: the number of technology classes searched divided by the number of existing classes in each classification system (645 IPC 4-digit classes and 473 USPC subclasses).

A higher number of *classes searched* indicate a more comprehensive search of prior art. If a patent office searches into less classes when applications were already processed by another ISA, it would indicate that the international search report was used and partly substituted for the search work performed by the receiving office.

Backward Citations (BC)

Backward citations are collected to evaluate how much prior art is cited by the patent office when assessing the novelty of the application.[15] The metric used is the number of backward citations published by the patent office. It must be stressed that a higher number of citations does not necessarily imply a more thorough search, as redundant citations could be used simply to show that there is an abundance of prior art related to that invention or be just a common office practice. However, a smaller number of citations provided to applications that have been processed by another ISA would indicate that the international search report was leveraged by the patent office, which did not find it necessary to repeat ISA citations.

Communications to grant

The number of communications provided by the patent office until the grant of the patent is an indicator of the amount of work needed to bring a patent procedure to a decision. Indeed, both the patent office and the applicant need to invest significant resources and time in each communication exchange. The metric used is the number of communications published by the patent office throughout the examination process for applications that were granted a patent.[16] Only substantive communications are considered: formal communications about fees or administrative issues that do not contain any observations about the invention are not taken into account.[17]

The fact that a patent office communicates less when applications have already been treated by another ISA could indicate that prior examination work was used and substituted part of the work of the patent office. The number of communications can also be used as a proxy for the length of the examination process. As such, the qualitative interpretation of this indicator is that less communications indicate a faster examination process, which could be explained by the availability of a prior international search report.

[15] 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). As highlighted by Cotropia et al (2013), applicant citations are less relevant to the examination process.

[16] Restricting the indicator to granted patents is necessary as the final outcome has an impact on the number of back-and-forth between the office and the applicant.

[17] Substantive communications include search reports, "Communication by the examining division" (at the EPO), "Notification of reasons for refusal/allowance" (at the JPO), "List of references cited by examiner", "Notice of allowance", "Non-final rejection" and "Final rejection" (at the USPTO).

Qualitative indicators

Three indicators are used to describe the way that patent offices cite prior art. They relate to the nature (patent or non-patent literature), origin (domestic or international) and timeliness (early or late disclosure) of the backward citations.

Non-patent literature (NPL)

Two main types of backward citations are available for the examiner in search of prior art: *backward patent citations (BPC)* and *non-patent literature (NPL)*. The latter includes articles published in scientific and technical journals, public conferences, or anything else that is not a patent. This distinction provides more insight into the type of prior art cited by the patent office. The share of "non-patent literature" in total backward citations is used in the empirical model. A lower percentage of NPL cited for applications that have prior examination work from the ISA would suggest that the patent office recognizes NPL citations provided in the international search report and hence does not need to add them.

Domestic backward patent citations (domestic BPC)

Backward patent citations are categorized by country of origin (determined by the office of first filing – the priority) to examine if the search for prior art was international or domestic. It is measured with the share of backward patent citations with the same country code as the citing patent office in all backward patent citations. A lower percentage of domestic BPC provided to applications that were previously examined by another ISA would indicate that the patent office uses prior art published in the earlier ISA search report instead of "its own", hence leveraging previous knowledge at the international level.

First citations (first BC)

All backward citations are ordered sequentially to distinguish those coming from the first search report of the patent office to those added in later communications during the examination phase. The indicator is the number of backward citations published in the first search report of the patent office as a share of the total number of citations published by the office during the examination. It provides an indication on the degree of certainty provided to the applicant in the early stage of the examination process (Gimeno and van Pottelsberghe (2021)). A higher percentage of *first citations* for applications that were already processed by another ISA could reveal that the first search report of the patent office is more complete because it uses prior ISA examination work.

Overlap indicators

The overlap method consists in comparing the exact classes that have been searched, and the citations that were listed by examiners, with the idea that the number of classes and citations might be similar, but their nature could still be different.

Overlap in classes searched

The manual extraction of IPC 4-digit classes searched allowed to identify exactly which classes were searched by the patent office and compare with those searched by the ISA. As a result, the degree of overlap in patent office *k* with regards to office *m*, is the percentage of IPC 4-digit classes searched by office *k* that were already searched by ISA m $(\neq k)$ (see eq.(5)).[18]

Overlap in backward citations

While manual extraction of backward citations from the patent office and the ISA was carried out such that the exact reference of each citation is available, it is more difficult to identify if two backward citations are identical or not. In fact, even if two citations have different references, they might belong to the same family and therefore refer to the same prior art. However, the number of backward citations can still be used to compute the maximum overlap in patent office *k* with regards to office *m*: the maximum number of citations provided by office *k* that were already published by ISA m $(\neq k)$ is the maximum between the number of citations from office *k* and the number of citations from ISA *m* (see eq.(5)).[19]

Outcome indicators

To discuss the effects of substituted work on the final outcome of the patent examination process, two outcome indicators are collected. First, the most widely used variable to compare patent office practices: *grant probability*, equal to 1 if the patent is granted, 0 otherwise. However, this metric does not distinguish between an actual refusal from the office based on unfulfilled patentability conditions and a withdrawal from the applicant (which can be based on its experience, resources, or potential economic value). As a result, a lower probability to reach a grant in a patent office is not necessarily driven by the office itself and should be interpreted carefully (see Petit et al, 2021).

Because some offices might opt for a reduction in scope or claims number instead of refusing to grant a patent, an alternative variable is collected: *claims allowance*, the number of claims published at grant (= 0 if the application is not granted) divided by the number of claims in the initial application.

[18] Unfortunately, when the USPTO is the patent office or the ISA, classes searched are rarely disclosed in the IPC classification system, making it difficult to apply the definition above. To solve that issue, overlap is extrapolated based on IPC 4-digit classes published in the application instead. With on average 0.27 USPC subclasses searched in addition to the number of USPC subclasses disclosed in PCT applications at the USPTO, these two indicators are quite close. Also, this methodology can only be used if the ISA is either the EPO, the JPO or the USPTO since search reports were not collected for other patent offices in this database.

[19] For example, if ISA *m* published 8 backward citations in its international search report and patent office *k* provided 10 backward citations during its examination process, the maximum number of citations that could be identical between the two is 8. In reverse, if ISA *m* published 10 and patent office *k* 8 backward citations, the maximum number of citations that could be identical between the two is 10. Of course, since citations from office *k* might be different than those from ISA *m*, the real number could be lower.

3.5. Independent variables

Several control variables are used in the multivariate econometric models (2) and (4). The main explanatory variables are the ISA dummies (ISA_i^m =1 if office *m* worked as ISA for invention *i* - 0 otherwise -, with *m* = 1 for EPO, 2 for JPO, 3 for USPTO, 4 for another patent office). It is worth noting that 63% of the PCT applications in the database designate the EPO as ISA, 22% the JPO, and 10% the USPTO.

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. This is particularly relevant since the two sets of applications that are being compared in each office (previously processed by another ISA or not) might be heterogeneous.

Chapter II. Dummy variable that is equal to 1 if the applicant entered Chapter II of the PCT procedure, 0 otherwise. Chapter II adds a further stage to the PCT procedure in which the applicant and the examiner have an additional interaction after the international search report. This implies an additional cost and therefore could be used as a control for the potential economic value of the patent (Guellec & van Pottelsberghe, 2000). As for the quality control, it is particularly relevant when comparing two different sets of applications. In the present database, around 20% of the PCT applications entered Chapter II.

Claims. The number of claims published in the application is used to control for the scope of the protection sought by the applicant.

Year06. Dummy variable that is equal to 1 if the year of the priority date is 2006, 0 otherwise (which means 2003). It is used to control for time fixed effect.

Technology fixed effects. Set of 8 dummy variables that represent in which IPC 1-digit class[20] the application belongs. It is used as a control because examiners and processes are broadly organised around technology classes.

4. RESULTS

The results are structured as follows. First, descriptive statistics of the variables provide a first glance on how patent offices compare in their examination processes (the EPO, the JPO, and the USPTO). Second, substitution degree estimates for quantitative indicators are presented. Third, results from qualitative indicators are discussed. Fourth, overlap estimates are provided for *classes searched* and *backward citations*. Finally, the impact on the final outcome (decision to grant) is discussed.

[20] The IPC 1-digit class used is the first (considered the "main" one) when several classes are included.

4.1. Descriptive statistics

Table 2 displays the mean of each indicator by procedural route in each of the three patent offices (using the same set of underlying inventions - same patent families).

Table 2. Descriptive statistics by patent office and procedural route

	ONLY DOMESTIC			Triadic NON-PCT				Triadic PCT			
Mean	**EPO**	**JPO**	**USPTO**	**EPO**	**JPO**	**USPTO**	p [3]	**EPO**	**JPO**	**USPTO**	p [3]
Quantitative indicators											
Classes searched	1.9	1.5	1.8[1]	1.8	1.5	1.8[1]	.00***	1.8	1.7	1.7[1]	.02**
Classes searched (pp) [2]	*0.3*	*0.2*	*0.4*	*0.3*	*0.2*	*0.4*	*.00****	*0.3*	*0.3*	*0.4*	*.00****
Backward citations (BC)	4.9	5.7	7.9	4.9	5.2	7.0	.00***	4.8	4.7	6.8	.00***
Communications to grant	3.1	2.3	2.9	2.1	1.2	2.4	.08*	2.2	1.3	2.6	.00***
Qualitative indicators											
Non-Patent Literature (% of BC[4])	9	2	5	10	3	4	.00***	17	7	7	.00***
Domestic BPC (% of BPC[4])	47	97	98	36	93	94	.00***	30	84	94	.00***
First Citations (% of BC[4])	97	98	84	95	96	71	.34	88	91	65	.53
Outcome indicators											
Grant probability (%)	40	61	61	65	70	75	.00***	54	60	66	.00***
Claims allowance (%)	36	58	55	54	64	73	.00***	44	55	62	.00***
Number of observations	200	200	200	566	566	566		1196	1196	1196	

Domestic filings are 'only' domestic; whereas triadic patent families are used for PCT and NON-PCT applications (the same application is filed in the three offices). (1) USPC subclasses instead of IPC 4-digit classes. (2) Classes searched divided by number of existing classes in the classification system (IPC 4-digit classes for EPO and JPO, USPC subclasses for USPTO; in percentage points). (3) p-values computed by ANOVA comparison of the indicators at the EPO, JPO, and USPTO: at least two offices have significantly different indicators at ***1%, **5%, and *10%. (4) Percentage computed as the ratio of the two means.

For the same set of underlying inventions, the JPO searches the smallest number of classes and has the lowest number of communications exchanged with the applicant. The USPTO publishes the highest number of backward citations (up to 50% more), dispersed over a higher number of communications. The EPO shows the highest share of non-patent literature (up to 17%) and international prior art (up to 70% against no more than 16% for the JPO and USPTO). In terms of outcome, the EPO is consistently the most stringent, with the lowest grant rate, while the USPTO is the least, and the JPO fits in between. In all three offices, PCT applications have a 10% lower probability to reach a grant (or 10% fewer claims allowed) than non-PCT triadic applications.

In a nutshell, for the same set of underlying inventions, the three patent offices operate with substantial and highly significant differences.

4.2. Quantitative analysis

Using PCT applications and the three quantitative indicators, Table 3 displays the simulated (eq. 1) and estimated (eq. 3) substitution degrees between each patent office – ISA combination. Full estimation results of the multivariate econometric estimates used in substitution degree (3) are available in Annex 1. For instance, the parameters presented in column 5 suggest that when a triadic application is filed at the JPO after having been processed by the EPO (USPTO) as ISA, the JPO searches 33% (35%) less

IPC classes, generates 15% (17%) less backward citations, and communicates 31% (34%) less than the applications processed by the JPO as ISA.

Table 3. Substitution degree s (eq. 1) and $\dot{s}$ (eq. 3) based on quantitative indicators

	1	2	3	4	5	6	7	8	9	10	11	12

3a. Classes searched

	Mean			**S (eq. 1) (%)**			$\dot{\beta}_{km}$			**Ṡ (eq. 3) (%)**		
	EPO	JPO	USPTO(1)	EPO	JPO	USPTO	EPO	JPO	USPTO(1)	EPO	JPO	USPTO
ISA^{EPO}	**1.84**	1.51	1.65		-33***	-25***		-0.78	-0.54		-34***	-25***
ISA^{JPO}	1.85	**2.27**	1.56	1		-29***	0.04		-0.63	2		-29***
ISA^{USPTO}	1.81	1.47	**2.19**	-2	-35***		-0.02	-0.84		-1	-37***	
ISA^{OTHER}	1.61	1.83	1.53	-13*	-19**	-30***	-0.19	-0.44	-0.70	-1	-19***	-32***

3b. Backward Citations

	Mean			**S (eq. 1) (%)**			$\dot{\beta}_{km}$			**Ṡ (eq. 3) (%)**		
	EPO	JPO	USPTO	EPO	JPO	USPTO	EPO	JPO	USPTO	EPO	JPO	USPTO
ISA^{EPO}	**5.22**	4.59	6.30		-15***	-31***		-0.94	-3.01		-17***	-33***
ISA^{JPO}	3.98	**5.42**	7.13	-24***		-22***	-1.00		-2.22	-19***		-24**
ISA^{USPTO}	4.69	4.52	**9.16**	-10*	-17**		-0.7	-1.00		-13**	-18**	
ISA^{OTHER}	3.48	4.42	6.53	-33***	-18**	-29**	-1.78	-1.13	-2.65	-34***	-21**	-29**

3c. Communications to grant

	Mean			**S (eq. 1) (%)**			$\dot{\beta}_{km}$			**Ṡ (eq. 3) (%)**		
	EPO	JPO	USPTO	EPO	JPO	USPTO	EPO	JPO	USPTO	EPO	JPO	USPTO
ISA^{EPO}	**2.27**	1.17	2.47		-31***	-40***		-0.41	-1.55		-24***	-38***
ISA^{JPO}	1.89	**1.69**	2.29	-17***		-44***	-0.17		-1.79	-7		-43***
ISA^{USPTO}	2.32	1.25	**4.12**	-2	-26***		0.31	-0.20		14*	-12	
ISA^{OTHER}	1.95	1.12	2.61	-14**	-34***	-37***	-0.10	-0.55	-1.05	-4	-33***	-25***

Asterisks denote if substitution degree is significant at ***1%, **5%, and *10% via a two-group mean comparison student test for s (eq. 1) and via significance of the ISA dummies in the regression model for $\dot{s}$ (eq. 3).
(1) USPC subclasses instead of IPC 4-digit classes.

Three main observations can be drawn from Table 3. First, the two ways to measure the degree of substitution (eq. (1) and eq. (3)) lead to similar – hence more robust - results. Second, there is a significant degree of substitution that takes place through the PCT process. When a patent office receives a PCT application that has been searched by another ISA, its own work is reduced by 20 to 30%, on average. For instance, the JPO and the USPTO search 25 to 37% less classes when they are not the ISA. The three offices rely on 13 to 30% less backward citations when they are not the ISA. A similar scheme is observed for the number of communications, which drops substantially for the JPO and the USPTO when another ISA produced the PCT search report. Third, it seems that the USPTO and the JPO benefit from stronger synergies - or rely more on previous work - than the EPO. Indeed, their workload is particularly smaller when other ISAs perform the international search report, especially regarding the number of classes searched and the number of communications.

In short, the JPO and USPTO search up to 37% less classes and the three offices provide up to 33% less citations. Also, granted applications in the US and Japan receive up to 43% less communications when another ISA was involved on the early phase of the PCT process. There is a significant substitution

degree between patent offices: they work up to 43% less when applications were already examined by another office.

4.3. Qualitative analysis

Table 4 presents the results of equation (4), which provides a qualitative assessment of the substitution degree. It evaluates the impact of prior ISA examination work on patent offices via three qualitative indicators, related to the nature, origin and speed of citations. Full estimation results for the multivariate estimates are available in Annex 2. Three main observations can be drawn from Table 4.

First, there are almost no changes in the percentage of NPL (reliance on non-patent literature) in total backward citations in any of the three patent offices, whatever the ISA that performed the international search report. Second, regarding citations to non-domestic patents, it clearly appears that the three patent offices rely significantly more (up to 13%) on international technical knowledge when another ISA performed the international search report. This result reveals a tendency to use the citations provided in the ISR instead of starting from scratch, and essentially domestically. Third, the JPO and especially the USPTO provide more certainty early on (more comprehensive first search reports) when there is prior ISA examination work available. The EPO does not benefit from similar effects, but secures the highest degree of certainty with its own services.

In a nutshell, the reliance on NPL does not seem to be affected by the PCT process. But patent offices, and in particular the USPTO, deliver more certainty, and rely on more international technical knowledge for search for prior art when applications are previously processed by another ISA in the PCT process. In other words, on top of the degree of substitution revealed by the lower numbers of IPC classes searched and backward citations, a significant level of substitution occurs in that the patent examination process is quicker to provide more complete search reports with a higher tendency to cite international prior art. This suggests that prior ISA examination work is recognized and used by patent offices in the PCT route. Besides these quantitative and qualitative indicators, the ultimate measure of the degree of substitution can be gauged with the very nature of classes searched and citations, as you may have the same number of classes searched, but they might all differ from each other.

Table 4. Multivariate estimates (eq.4) based on qualitative indicators

4a. Non-patent literature (%)

	Mean[(2)]			$\dot{\beta_{km}}$		
	EPO	JPO	USPTO[(1)]	EPO	JPO	USPTO[(1)]
ISA^{EPO}	**14**	7	9		0	2
ISA^{JPO}	10**	**6**	8	-3		2
ISA^{USPTO}	19*	13***	**9**	3	5**	
ISA^{OTHER}	14	7	9	3	2	3

4b. Domestic citations (%)

	Mean[(2)]			$\dot{\beta_{km}}$		
	EPO	JPO	USPTO	EPO	JPO	USPTO
ISA^{EPO}	**31**	78***	92		-8***	-4*
ISA^{JPO}	27***	**88**	87	-6**		-9***
ISA^{USPTO}	19***	72***	**94**	-9***	-13***	
ISA^{OTHER}	31	78***	92	-5	-7	-2

4c. First citations (%)

	Mean[(2)]			$\dot{\beta_{km}}$		
	EPO	JPO	USPTO	EPO	JPO	USPTO
ISA^{EPO}	**92**	95***	79***		12***	33***
ISA^{JPO}	93	**83**	77***	0		29***
ISA^{USPTO}	90	93***	**43**	-6***	10***	
ISA^{OTHER}	92	95***	79***	-1	13***	27***

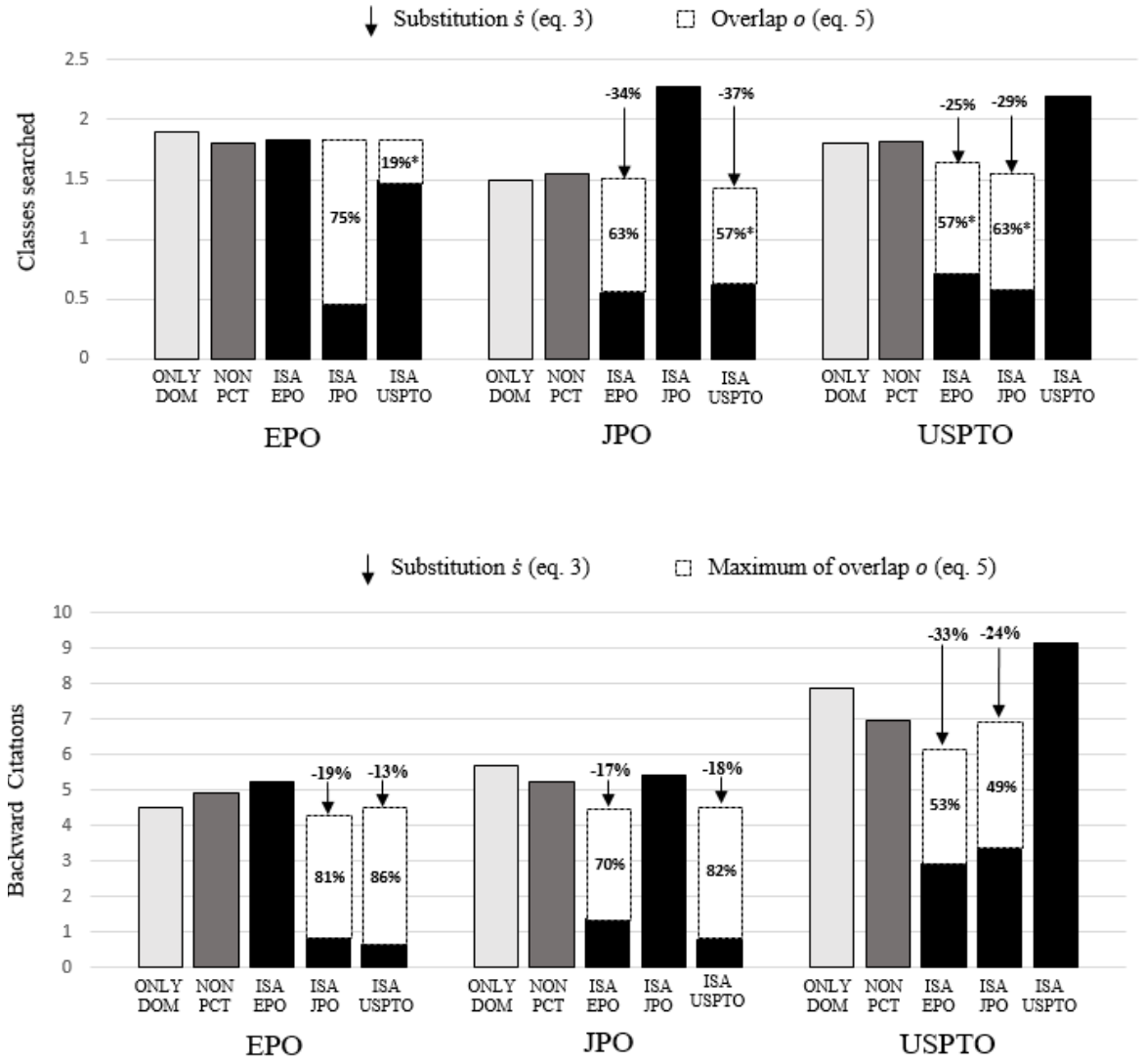
Asterisks denote if substitution degree is significant at ***1%, **5%, and *10% via two-group mean comparison test for the means and via significance of the ISA dummies in the regression model (eq. 4). (1) USPC subclasses instead of IPC 4-digit classes. (2) Mean of percentage indicators since percentage indicators are used in equation (4).

4.4. Overlap analysis

The results for overlap estimates via *classes searched* and *backward citations* are displayed in Figure 3. The arrow represents the quantitative effect estimated earlier with the multivariate model (eq.3). For instance, having an ISR produced by the EPO reduces the number of IPC searched at the JPO by 34%, and by 25% at the USPTO. But the dotted white areas representing the overlap show that 19% (at the EPO) to 75% (at the USPTO) of the *classes searched* for applications that were previously processed by another ISA were already published in the international search report, suggesting that the degree of substitution could be substantially higher than the one observed with the quantitative estimates.

In terms of *backward citations*, the maximum overlap ranges between 49% at the USPTO (which tends to have a higher number of backward citations, cf. table 1) and 86% at the EPO, witnessing the very high degree of substitution that could be reached. At the EPO, very little or no effect was observed with the quantitative indicators, but there is an overlap of 19% (with respect to the USPTO) and 75% (with respect to the JPO) regarding the number of classes searched. With citations of prior art the overlap is above 80%.

Figure 3. Overlap in Classes searched & Backward citations (eq. 5)



Note: Comparison of the technology classes searched by each patent examination depending on the procedural route followed by an application: only domestic (light grey), non-PCT (dark grey), and PCT (black; including the overlap measure as the dotted rectangle when ISA is different from the patent office). * Overlap is extrapolated based on IPC 4-digit classes published in the application instead of the search process when the USPTO is the patent office or the ISA.

To sum up, the results presented in this subsection show that there is already a significant degree of substitution between patent offices for PCT applications (both in terms of quantity – up to -43% – and quality of the work carried out), and that there are still significant overlaps in *classes searched* and *backward citations,* suggesting that the degree of substitution that could be reached is much higher than what is suggested by the previous quantitative analyses.

4.5. Discussion on grant rates

Previous results suggest that subsequent patent offices use prior international search reports for PCT applications and are more efficient in carrying out their examination. This implies that the PCT route increases efficiency and work sharing. However, the outcome of a PCT application related to the same underlying invention is still very different in the three patent offices (cf. Table 1), despite them having

access to the same prior ISA report. Table 5 further illustrates outcome variations for both PCT and non-PCT applications: in both cases, only half the patent families have the same outcome in all three offices. Inventions that reach a grant at the EPO are the most likely to also reach a grant at the other two offices, while those that are granted at the USPTO have the lowest grant rates in the other two. In terms of ISA, patent families that go through the USPTO as ISA are the least likely to get the same outcome in all three offices as well as the least likely to be granted in all three offices. Overall, applications that were processed by another ISA have lower grant rates and claims allowance, especially at the EPO. Statistical inference using the multivariate model from equation (4) shows that this negative impact on grant rates is significant at the EPO and JPO, but is only significant at the USPTO towards applications previously examined by the EPO as ISA.

Table 5. Outcome comparison

	Same triadic outcome(1) (%)	**Triadic grant(2) (%)**	**Grant probability (%)**			**Claims allowance (%)**		
			EPO	JPO	USPTO	EPO	JPO	USPTO
Non-PCT applications	54.2	44.9	64.8	70.5	74.9	54.3	64.0	72.7
Granted at the EPO			**100**	80.9	83.1	**83.7**	74.7	79.6
Granted at the JPO			74.4	**100**	82.4	62.2	**90.8**	79.8
Granted at the USPTO			71.9	77.6	**100**	60	72	**97.1**
PCT applications	51.7	34.6	54.2	59.7	66.0	44.4	54.6	62.2
Granted at the EPO			**100**	75.8	79.3	**82**	69.7	77.6
Granted at the JPO			68.8	**100**	79.7	56.4	**91.4**	76.4
Granted at the USPTO			65.1	72.1	**100**	53.4	65.8	**94.3**
ISA^{EPO}	52.8	34.0	**59.3**	54.5***	63.4***	**49.6**	50.0***	59.3
ISA^{JPO}	52.5	43.2	52.9***	**80.7**	72.6	43.2***	**74.9**	72.7
ISA^{USPTO}	43.8	22.3	33***	47.9***	**68.6**	21.9***	42.4***	**62.7**

(1) Same triadic outcome means that all three offices have the same outcome (grant or no grant; hence the same value for the grant dummy) (2) Triadic grant means that the patent family received a grant in each of the three offices
Asterisks denote if the grant rate is significantly different than the reference domestic ISA applications at ***1%, **5%, and *10% via significance of the ISA dummies in the regression model (eq. 4). Full estimations results are available in Annex 3.

One could argue that lower grant rates for non-domestic ISA are the result of a double layer of examination carried out both by the ISA and the subsequent patent offices. However, these results should be interpreted with a degree of cautiousness, as grant rates are also driven by economic factors not related to the office (strategic consideration, expected return, as explained in Petit et al. (2021)).

5. Conclusions and policy implications

Recent history has shown a tendency to exploit synergies between large patent offices and further harmonize the global patent system. While many regional initiatives have emerged over the last two decades, the question of how far patent offices can substitute each other's work remains. The present paper aims at contributing to the literature by providing a first estimation of the degree of substitution between the EPO, the JPO, and the USPTO. The paper relies on a unique database that quantifies key stages of the patent examination process for both PCT and non-PCT applications.

This paper confirms that the EPO, the JPO, and the USPTO operate with significant differences, which makes it impossible to fully substitute for each other's work. However, PCT applications show that there is a significant substitution degree between the three offices (both in terms of quantity and quality of the work carried out). When PCT applications are already examined by another office as ISA, subsequent searches are narrower: up to 37% less technology classes are searched, up to 33% less backward citations are made, and there are up to 43% less communications with the applicant. In other words, PCT applications actually reduce the total workload and allow for substantial synergies. Moreover, patent offices work differently when prior ISA examination work is available: they rely more on international citations and provide more complete (ie, more information on patentability) reports upfront. This suggests that prior international search reports are taken into account by subsequent offices, which supports and generalizes the results from Wada (2020): "*USPTO examiners rely on prior art information collected and disclosed by the EPO" and "International Search Reports (ISRs) (…) play important roles for the convergence of rejection citations between the two patent offices*".

Furthermore, this paper shows that there is a high level of overlap between the three offices (19% to 75% of the *classes searched* by an office were already searched by the ISA and there is a 49% to 86% of *backward citations* overlap). These overlaps suggest that the degree of substitution between patent offices could be much bigger than currently measured. Whether this calls for further effective substitution or not depends on whether the overlap is a "superficial" duplication of prior ISA examination work (such as a copy-paste practice) or a true repetitive and hence redundant examination work. Such distinction would require an in-depth inquiry into how examiners work that goes way beyond the information that is publicly available.

Finally, this paper highlights that the PCT route is successful in encouraging collaboration between patent offices but that this increased efficiency does not translate into more coherent outcomes. To move the discussion forward, it becomes increasingly necessary to better understand the factors driving the outcome of the patent examination process. This will require metrics that are better equipped to distinguish between office-driven refusals and applicant-driven withdrawals.

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7. Annexes

Annex 1. OLS estimates on PCT applications for quantitative indicators (eq.2)

	EPO	JPO	USPTO(1)	EPO	JPO	USPTO	EPO	JPO	USPTO
	1a. Classes searched			**1b. Backward Citations**			**1c. Communications to grant**		
ISA^{EPO}		-0.78***	-0.54***		-0.94***	-3.01***		-0.41***	-1.55***
		(0.08)	(0.15)		(0.28)	(0.74)		(0.08)	(0.22)
ISA^{JPO}	0.04		-0.63***	-1.00***		-2.22**	-0.17		-1.79***
	(0.08)		(0.17)	(0.23)		(0.86)	(0.12)		(0.26)
ISA^{USPTO}	-0.02	-0.84***		-0.70**	-1.00**		0.31*	-0.20	
	(0.11)	(0.13)		(0.30)	(0.43)		(0.19)	(0.15)	
ISA^{OTHER}	-0.19	-0.44***	-0.70***	-1.78***	-1.13**	-2.65**	-0.10	-0.55***	-1.05***
	(0.14)	(0.16)	(0.23)	(0.39)	(0.52)	(1.16)	(0.24)	(0.17)	(0.35)
Quality control	-0.03	0.05	-0.02	0.17	0.09	0.76*	0.11	-0.21***	0.26*
	(0.06)	(0.07)	(0.09)	(0.18)	(0.22)	(0.45)	(0.10)	(0.07)	(0.14)
Chapter II	0.02	0.10	-0.02	-0.06	0.45*	-0.77	-0.09	-0.05	0.23
	(0.08)	(0.08)	(0.11)	(0.22)	(0.27)	(0.56)	(0.11)	(0.09)	(0.17)
Claims	0.00	0.00	-0.00	0.02***	0.02**	-0.01	0.01**	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Year06	0.10·	0.07	-0.06	-0.39**	0.84***	-0.68·	-0.04	0.20***	-0.15
	(0.07)	(0.07)	(0.09)	(0.18)	(0.22)	(0.45)	(0.09)	(0.07)	(0.14)
Intercept	1.72***	2.07***	1.93***	5.04***	5.06***	9.68***	2.43***	1.72***	4.12***
	(0.10)	(0.12)	(0.19)	(0.28)	(0.39)	(0.94)	(0.15)	(0.13)	(0.30)
Class effects(2)	p=.00***	p=.00***	p=.00***	p=.19	p=.01**	p=.37	p=.00***	p=.00***	p=.00***
Same non-ISA?(3)	p=.65	p=.56	p=.39	p=.39	p=.86	p=.16	p=.02**	p=.11	p=.14
Observations	1137	1137	1137	1137	1137	1137	647	669	742

Standard errors in parentheses. Asterisks denote statistical significance at *10%, **5%, and ***1%. (1) USPC subclasses instead of IPC 4-digit classes (2) p-value measures if technology class effects are jointly significant (3) p-value measures if the impact of having one of the other two triadic offices as ISA is identical: $\beta_1 = \beta_2$

Annex 2. OLS estimates on PCT applications for qualitative indicators (eq.4)

	EPO	JPO	USPTO	EPO	JPO	USPTO	EPO	JPO	USPTO
	2a. Non-patent literature (%)			**2b. Domestic BPC (%)**			**2c. First citations (%)**		
ISA^{EPO}		-0.00	0.02		-0.08***	-0.04*		0.11***	0.35***
		(0.02)	(0.02)		(0.02)	(0.02)		(0.01)	(0.03)
ISA^{JPO}	-0.03·		0.02	-0.06**		-0.09***	0.01		0.32***
	(0.02)		(0.03)	(0.02)		(0.03)	(0.01)		(0.03)
ISA^{USPTO}	0.03	0.05**		-0.10***	-0.13***		-0.04*	0.09***	
	(0.03)	(0.02)		(0.03)	(0.04)		(0.02)	(0.02)	
ISA^{OTHER}	0.03	0.02	0.03	-0.05	-0.07·	-0.02	-0.01	0.13***	0.28***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.03)	(0.02)	(0.03)	(0.04)
Quality control	-0.01	0.00	-0.03**	0.01	-0.00	-0.01	-0.01	0.00	-0.04**
	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Chapter II	0.01	0.00	0.03*	-0.02	0.00	-0.01	0.00	0.02*	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Claims	0.00**	0.00·	0.00***	-0.00***	-0.00***	-0.00*	-0.00	0.00	-0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Year06	0.01	0.01	0.03*	-0.04**	-0.01	-0.01	-0.01	0.11***	0.02
	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	0.01	(0.01)	(0.02)
Intercept	0.18***	0.15***	0.12***	0.29***	0.79***	0.95***	0.92***	0.84***	0.40***
	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.04)
Class effects(2)	.00***	.00***	.00***	.00***	.00***	.00***	.01**	.94	.00***
Same non-ISA?(3)	.04**	.02**	.94	.32	.14	.00***	.04**	.20	.19
Observations	1126	1059	1055	1097	1037	1024	1126	1059	1055

Standard errors in parentheses. Asterisks denote statistical significance at *10%, **5%, and ***1%. (1) USPC subclasses instead of IPC 4-digit classes (2) p-value measures if technology class effects are jointly significant (3) p-value measures if the impact of having one of the other two triadic offices is identical: $\beta_1 = \beta_2$

Annex 3. OLS estimates on PCT applications for outcome indicators using eq.4

	EPO	JPO	USPTO	EPO	JPO	USPTO
	3a. Grant probability			**3b. Claims allowance**		
ISA^{EPO}		-0.21***	-0.12***		-0.19***	-0.13.
		(0.03)	(0.04)		(0.04)	(0.09)
ISA^{JPO}	-0.17***		-0.05	-0.172***		-0.06
	(0.03)		(0.05)	(0.032)		(0.10)
ISA^{USPTO}	-0.24***	-0.19***		-0.223***	-0.18***	
	(0.04)	(0.05)		(0.042)	(0.06)	
ISA^{OTHER}	-0.22***	-0.13**	-0.10	-0.181***	-0.16**	-0.16
	(0.06)	(0.06)	(0.07)	(0.055)	(0.07)	(0.14)
Quality control	0.41***	0.38***	0.34***	0.330***	0.33***	0.36***
	(0.03)	(0.03)	(0.03)	(0.025)	(0.03)	(0.05)
Chapter II	-0.02	0.02	0.01	-0.012	0.03	-0.04
	(0.03)	(0.03)	(0.03)	(0.031)	(0.04)	(0.07)
Claims	-0.00***	-0.00**	0.00	-0.006***	-0.00***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.001)	(0.00)	(0.00)
Year06	-0.00	0.09***	0.02	-0.040.	0.09***	-0.08.
	(0.03)	(0.03)	(0.03)	(0.025)	(0.03)	(0.05)
Intercept	0.51***	0.57***	0.53***	0.479***	0.54***	0.62***
	(0.04)	(0.05)	(0.06)	(0.039)	(0.05)	(0.11)
Class effects(2)	.00***	.36	.00***			
Same non-ISA?(3)	.22	.61	.04**			
Observations	1137	1137	1137	1137	1137	1137

Standard errors in parentheses. Asterisks denote statistical significance at *10%, **5%, and ***1%. (1) USPC subclasses instead of IPC 4-digit classes (2) p-value measures if technology class effects are jointly significant (3) p-value measures if the impact of having one of the other two triadic offices is identical: $\beta_1 = \beta_2$

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