Decoding Patent Examination Services

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Abstract

This paper puts forward a new methodology to characterize and compare the examination practice of most patent offices. The methodology codifies public information into a typology of chronological key examiner actions. This approach translates into a quantitative characterization of search completeness (i.e., classification and citation practices), certainty, speed, and stringency, or grant rate. The methodology is tested on a sample of 100 random families of a non-controversial field, comprising EPO, JPO and USPTO members. The results show profound differences across offices in respect to search completeness, certainty, and speed and indicate heterogeneous levels of stringency.

Disclaimer: Lluís Gimeno-Fabra is a doctoral student at Université libre de Bruxelles and a patent examiner at the European Patent Office. This paper solely reflects the opinion of the authors and does not in any sense reflect the positions of the Solvay Brussels School of Economics and Management of the Université libre de Bruxelles or the European Patent Office.

1. Introduction

Patent systems are being increasingly scrutinized by policy makers, large firms and universities. As patent applications have literally boomed over the past two decades, especially in the USA and China, there is a intensifying political will to make patent systems more efficient. The surge in patent applications is partly due to the globalization of technology and production processes, which leads to an increased size of patent families – patents being filed simultaneously in several countries. Under these circumstances, policy-makers and large firms are somewhat driven by similar objectives, including reducing the cost of patenting to companies and society and exploiting economies of scale. For applicants and policymakers alike, the understanding of procedural practice and the synergies between different patent systems are critical to speed up the global access to intellectual property whilst ensuring high levels of legal certainty. The creation in the 1970's of the European patent system, the impressive development of the Patent Cooperation Treaty (PCT, see footnote 1) witness the internationalization of patent procedures. Additionally, current efforts of large patent offices to develop common standards for classification and to increase the availability of procedural information enhance the public insight into how procedures are carried out by patent examiners.. However, despite the massive amount of available information, no or very scant work has been carried out so far to understand how different patent offices deliver their examination services, and the existing literature is rather qualitative. Van Pottelsberghe (2011) provides evidence of systemic differences in the operational design and legal framework, suggesting that quality of patent systems varies across countries. Many papers compare grant rates, but very little evidence exist so far, to the best of our knowledge, on the procedural differences in examination services delivered by patent offices.

Differences across large patent offices in search and examination practice are actually a pressing concern for patent professionals and policy-makers. Indeed, rights associated to what is "*de facto*" a global technology network are defined "*de iure*" by national or regional patent procedures. Whilst being increasingly interconnected, patent offices operate as autonomous territorial jurisdictions offering distinct levels of thoroughness and certainty. Important differences in scholar views have emerged in the literature, with some economists claiming that the examination process should involve very little initial effort from the administration side (e.g., Lemley, 2001), and other advocating on the contrary for high initial standards in the patent procedure (e.g., van Pottelsberghe, 2011). In addition, noticeable divergences exist between the grant rates of patent offices, linked to legal frameworks and procedural practices. It is therefore important to understand how the *'operational routines'* of patent examiners in various offices affect the characteristics and outcomes of patent procedures.

The present paper aims at reducing this gap. It puts forward a new methodology that indexes major stages in patent examination procedures as implemented by most patent offices , irrespective of whether they are carried out under national, international or Patent Cooperation Treaty (PCT) provisions.[1] The methodology consists in a

[1] Patent applications can be treated as domestic filings under national provisions and as well be the basis of subsequent filings in other patent offices. The latter case defines so-called international patent families and procedures. These international procedures can be carried out directly under the provisions of the Paris Convention that allows a subsequent filing for the same invention to take place within 12 months of the first

typology of key examiner actions at various stages of the patent procedure. These actions relate to the completeness of the search for prior art (including classification and citation practices), certainty, speed and stringency. The novelty of the methodology developed here is related to the systematic characterization of patent examiners' actions. These actions have so for not been thoroughly analyzed, and we rely on complex publicly accessible data released by patent offices to build a robust procedural indexation system.

The methodology is then tested on a sample of 100 triadic patent families, (patents filed simultaneously in Europe, Japan and the United States -EPO, JPO, US-PTO), drawn from a *non-controversial* technical fields. For these 100 patent families the examination procedures performed by the three patent offices have been scrutinized and key procedural actions have been codified. The sample used to test the methodology is in the area of metallurgy, which is 'non-controversial', or not subject to heterogeneous legal provisions.[2]

The present paper contributes to the bridging of two important gaps through its objective and methodology. First, several dimensions of patent systems have been thoroughly investigated so far, but the quantification of how the examination procedure is carried out as a whole has not been tackled, especially across countries. Such a comparative procedural characterization would be a valuable tool to understand the user perceptions of quality in different patent systems. Second, the paper helps to bridge the gap between the complex world of patent professionals (examiners, attorneys and experts) and the world of policy makers, research scholars and potential users. Patent systems are complex because they are located at the interface of legal constraints, economic incentives, scientific and technological advances, and business strategy. At the extreme opposite is the economists' routine that consists in overly simplifying the examination practice under abstract concepts such as patent 'breadth' or 'scope', which are nearly impossible for examiners to implement in practice. By identifying important elements of the operational design of two key legal standards – namely the retrieval of prior art and examination of applications- , the paper achieves a fair balance between complexity and abstract simplification.

The paper is structured as follows. The next section summarizes the economic literature on patent quality. Section 3 describes the new methodology. Section 4 presents a small scale test of the methodology, analyzing 100 patent families filed simultaneously at the EPO, JPO and USPTO. Concluding remarks and policy implications are presented in Section 5. The results suggest that the search completeness, the certainty delivered at different stages of the procedure, the speed, and stringency of examination services vary significantly across the three patent offices.

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filing or under the provisions of the Patent Cooperation Treaty (PCT) which give the applicant up to 31 months to decide on subsequent filings. Patent Applications processed under the provisions of the PCT, are examined by Patent Offices (such as the EPO, USPTO or JPO) that are entitled to act as International Search or Examination Authorities (ISA / IPEA). The administration of PCT procedures is centralized by the World Intellectual Property Organization (WIPO) in Geneva.

[2] for example biotechnology, computer implemented inventions and methods to treat the human body could introduce significant distortions in patent examination metrics, alien to the patent procedure as such.

2. State of the art on patent quality

The term “patent quality” has been used with a variety of interpretations in the economic literature. Put aside the rich and numerous contributions focusing on patent value (see Harhoff et al. 1999 and van Zeebroeck et al., 2011) - which aim at identifying the patents associated with significant economic or strategic value to their owner - one could classify the existing research into four broad methodological approaches: theoretical, organizational, systemic, and output-based.

The theoretical stream of literature includes scholars who focus on one or two facets of the patent system, such as patentable subject matters, duration of protection, inventive step, geographical scope, or a combination of these. Early investigations were performed by Barzel (1968), Nordhaus (1969) and Scherer (1972), who argued that stronger patent systems would induce more investment in research and development. Since these early theoretical investigations, most landmark papers have focused on three major dimensions of patent policy making: the optimal length (e.g., Gallini, 1992), the optimal breadth (e.g., Klemperer, 1990), the optimal mix between length and breadth of patents (e.g., Gilbert and Shapiro, 1990). Scotchmer (1991) and O’Donoghue (1998) show that a too strong patent protection could lead to socially inefficient monopoly pricing and hence stifle second-stage R&D. But a small inventive step would generate 'hold-up' strategies, whereby a small incremental innovation would provide too much power to the imitator.

A common practice in the literature seems to qualify a patent system as strong (or stronger) when more domains are patentable (Gallini, 2002), when the term of protection is lengthened (Grossman and Lai, 2004), when the geographical scope is enlarged (Scherer, 2002) or when patent holders receive more power in lawsuits (Lerner, 2002). With other words, stronger is very often associated with ‘patent friendly’ policies, or policies that favor patent owners.

Stringency has been tackled as well through organizational and human factors, scrutinizing how patent offices are organized, and how they train and incentivize their examiners. Cockburn et al. (2002) examine the role of USPTO examiner characteristics (age, experience, etc.) on the resistance of granted patents to validity challenges in court. Lemley and Sampat (2008) investigate whether examiner characteristics affect the outcome of the examination process. Friebel et al (2006), and Langinier and Marcoul (2009) consider the organizational practices and incentive mechanisms adopted by patent offices to gauge examiners’ productivity. Lemley (2001) investigates the USPTO resources allocated to patent examination and argues that a patent office should not devote too much resources to ensuring a high-quality examination because there are too many patents with no economic value. As patent litigation mainly arises in relation to high-value patents, the court should be the 'right' place to properly gauge patentability conditions. This argument would be right if the patent Courts would easily challenge patent validity, which is far from being the case.

These facets are almost systematically treated in an abstract way (especially the notion of scope or stringency), which is convenient for theoretical modelling, but less so for concrete policy making. Instead of relying on

abstract theoretical concepts some authors have actually measured several dimensions of patent systems so as to produce synthetic indicators.

Systemic analyses are somewhat scarce. To the best of our knowledge, the first contribution attempting to measure patent systems with multiple components has been performed by Ginarte and Park (1997), displaying an index of 'patent rights' for 110 countries from 1960 to 1990 (with an update made by Park, 2008). These two contributions, and the stream of research they generated, crystallize this tendency of defining 'strong' patent systems as those that are essentially favorable to the patent owner.[3] Amongst the main criteria taken into account in this composite index are the number of patentable subject matters ('fewer' restrictions is synonymous with a 'stronger' system), duration of protection (longer duration leads to stronger patent systems), and enforcement mechanisms for patent holders. For Ginarte and Park compulsory licensing and provisions for protection loss are considered to be a 'weakness', while preliminary injunctions, contributory infringement and burden-of-proof reversal are viewed as a 'strength'. Strong is a wrong qualifier for such policies, as it does not assess the extent to which the patent system fulfills its mission, and whether it performs well its assessment or selection process. The appropriate term should rather be referred to as "applicant friendly" because more domains can be patentable for longer, in more countries and with greater legal power for the patent owner.

An alternative approach is put forward by van Pottelsberghe (2011), with a composite indicator including several systemic components that affect quality. Quality is defined as the extent to which patent systems comply with their own patentability conditions, in a transparent way (transparency is a key dimension of patent systems, whereby monopolistic control is granted in exchange for the diffusion of information). van Pottelsberghe relies on the legal standards that describe patentability conditions and their operational design to gauge quality. The composite indicator comprises legal provisions and patent offices' operational practices that affect stringency or transparency.[4]

The indices produced by Ginarte and Park (1997) and van Pottelsberghe (2011) – and their subsequent works - are displayed in Table 1. The results suggest that the quality of the European patent system is much higher than the one of the US patent system, with the Japanese patent system being in an intermediate position. This would partly explain why the propensity to file patents is much higher in the US than in Europe. The 'ranking' and its impact on the propensity to patent is further validated by de Saint Georges and van Pottelsberghe (2013), with a 9-components index developed for 35 patent systems. Interestingly it is negatively correlated with the patent strength index produced by Ginarte and Park. The higher the 'quality' of a patent system, the weaker the enforcement mechanisms (or the 'strength' of a patent system). This relationship is somewhat counterintuitive

[3] Claessen and Leaven (2003) is one example - amongst hundreds – which relies on the Ginarte and Park index to assess the impact of patent systems on innovation or growth.

[4] These indicators affecting stringency and transparency include the publication of a search report (transparency), the grace period, the budget per examiner, the average working experience of examiners, the easiness to modify the scope of protection, and the workload per examiner. For instance, van Pottelsberghe assumes that a heavy workload would reduce the quality of the examination process. This assumption has recently been empirically validated by Kim and Oh (2017) for the Korean Patent Office (KIPO).

as it could be legitimately be argued – as Lemley (2001) does – that the lower the quality of a patent system should induce lower enforcement mechanisms and hence a smaller 'strength'.

The quality index put forward by van Pottelsberghe relies on organizational routines (experience of examiners, their budget, their wage), some patent application rules (grace period, publication of applications, request of examination, divisional applications, continuation in parts), which obviously contribute to transparency and stringency, but fail to properly quantify the search and examination procedures performed by examiners. The complexity of these procedures and hence the lack analytical approach to measure their impact on quality and transparency may explain this void.

Table 1. Indices of strength, stringency and grant rate of patent systems, USPTO=100

	Ginarte and Park (1997)	**Park (2008)**	**van Pottelsberghe (2011)**	**de Saint-Georges and van Pottelsberghe (2013)**	**'official' Grant Rates published by patent offices**
Focus	**"Strength"**		**"Transparency & stringency"**		**Grant 'rate'**
Year of indicator	**1990**	**2005**	**2008**	**2011**	**2015**
DPA, Germany	82	92	n.a.	130	44.2 %
EPO, Europe	n.a.	n.a.	250	250	47.6 %
JPO, Japan	87	96	185	155	69.3 %
USPTO, USA	100	100	100	100	70.9 %
Grant Rate for EPO, JPO and US-PTO: Source http://www.fiveipoffices.org/statistics/statisticsreports/2015edition/chapter4.pdf Grant Rate DPMA: Source https://presse.dpma.de/presseservice/englisch/unserservice/pressreleases/2march2016/index.html					

This viewpoint is shared by Gallini (2002, p. 147), who argues that "... *the same policies that are perceived to have strengthened patent rights in certain ways also have weakened them*". By 'weakening', Gallini means that patents are granted more easily today than they have been in the past. However, no or little evidence is available to validate this assumption. One of the few authors who explicitly consider patentability requirement is O'Donoghue (1998), whose theoretical model suggests that more stringent selection criteria would create longer incumbency and, thereby, would raise innovation incentives. But stringency is in practice challenging to measure. The most frequently used indicator is the grant rate, although its computation is often significantly biased, and is weakened by a strong timeliness issue related to patent pendency.

The fourth and last stream of literature focuses on grant rates. Lower grant rates are sometimes considered as indicators of high quality (see Burke (2007) and Reitzig (2000)). Whilst this premise is obviously related to the stringency of a patent system, one must bear in mind that grant rates are from being easy to measure, and most of the published 'official' grant rates are downward biased, suggesting a sharper selectivity rate than the actual one. This is because they are computed by dividing the patents granted in year t by the total number of patent

applications filed in the same year (sometimes including withdrawn or refused patents in the denominator) – in other words, the numerator and the denominator do not include identical applications. As most of the patent offices have seen a sustained growth in patent applications, their published grant rates, shown in table 1, are biased downwards, suggesting a level of stringency that is most probably higher than reality. This is not to say that lower official grant rates are not indicative, amongst other factors, of higher quality, but rather that the determination of the probabilities that a patent application is actually granted is more complex than the ratio of applications versus granted patents in a particular jurisdiction and year.

Much less biased indicators are used in the scientific literature, although the long examination pendency for a few patents generates a systematic – but very small when compared to official grant rates- source of bias. International comparisons of grant rates – for similar patents – have recently been produced to assess the so-called national treatment principle, or whether national patent offices secure equal treatment of patent applications, irrespective of whether they are filed by domestic applicants or international applicants. Webster et al. (2014) analyze the patent application outcomes at the European and Japanese patent offices, relying on a matched sample of 48,000. The authors find that domestic inventors have a higher likelihood of obtaining a patent grant than foreign inventors and that the positive domestic inventor effect is stronger in areas of technological specialization in the domestic economy. Their methodology however does not seem to take into consideration major procedural differences between the Japanese and European procedures, in particular the differentiation that the latter makes between the search and examination phases and the induced withdrawals following the European search report, a bias that the present paper precisely avoids. A more recent investigation performed by de Rassenfosse et al. (2017, forthcoming) on the five largest regional patent offices (China, Europe, Japan, South Korea, and United States) confirm these results, with a mitigating factor for the patents that follow the PCT route.

The analyses of grant rates follow an output-based approach that provides some evidence on the degree of stringency - subject to some downward biases – without taking into account the procedures that lead to the grants.

3. A robust methodology to compare examination procedures

Before entering the methodological framework it is helpful – for the sake of clarity – to briefly describe the life of a patent application as it proceeds towards an eventual grant. Applicants file patent applications to get exclusive rights on an invention. And the sought technological scope of protection is essentially defined by the claims. The patent application also includes a description, an abstract, references to relevant prior art known to the applicant, and formal information about the inventors, applicants and other administrative data, such as related priority filings.

The disclosure of the invention sought is essential to the patent system, which only grants exclusive rights to inventions that have been clearly made available to the public (condition of disclosure) and that are patentable (condition of patentability). The condition of disclosure is basically fulfilled by publishing the patent applications

together with an initial assessment of the technical fields to which they are relevant in one or several classes of an international standard called IPC (International Patent Classification)[5]. The conditions of patentability include novelty and inventive step. Novelty consists in checking whether the submitted invention already exists and has already been publicly disclosed, whereas inventive step, involves an assessment of the obviousness of any eventual differences with the state of the art.

As the patent application progresses from filing towards a decision, the examiner may amend or complete the classification, searches for the existing prior art (i.e., published applications, newspapers, scientific journals, etc...) and reports citations that influence the patentability of all or part of the invention as defined in the claims, which may be amended.[6] The assessment of novelty and inventive step (amongst other issues related to the application) is usually assessed iteratively in a substantive argumentation between the Applicant and the Examiner. This may comprise a number of communications (called substantive communications in order to differentiate them from formal communications related for example to the payments of fees) and can take several years.

The procedure as a whole encompasses a complex range of technical, legal and administrative stages that vary from office to office. Its exhaustive description is beyond the scope of the present paper. It is nevertheless safe to state that these stages are generally structured around the aforementioned underlying principles and lead to a patent that is eventually granted and published, in its initial format, or amended. The other possible outcomes include the refusal of the patent application by the examiner or the withdrawal by the applicant.[7]

The information flows leading to a grant decision are therefore the core of the patent system itself and comprise disclosures of what is claimed at each stage of the procedure as represented schematically in figure 1 and why the examiner considers or not that the application fulfills the requirements of patentability.

The full scope of the subject-matter for which protection is requested is defined during all the stages of the procedure through the claims listed in the patent application, including:

[5]The IPC consists of eight main language-independent groups (A-H) corresponding to different areas of technology. It is further subdivided into about 70.000 classes. The finer the division is, the more digits it comprises (i.e. C corresponds to chemistry, whereas C21B corresponds to steel production and C21B5/00 to steel production in blast furnaces. Although several indigenous classification systems exist, they are often based on the IPC. This is the case for the former European Classification System (ECLA), the Japanese Classification System (FICLA) and the Cooperative Patent Classification System (CPC) that is becoming the modern international standard. One exception to this rule is the former United States Patent Classification (USPC), which was not IPC based.

[6] In the EP and JP procedure, as well as in the PCT procedure irrespective of the Search Authority, citations are usually categorized as 'X' or 'Y' when objecting patentability or A category when simply general –in addition to P, E, T, O, etc... type citations which need not be detailed here. The US national procedure has an analogous categorization, discussing citations in written communications under USC 102 or 103. Irrespective of their categorization citations can be simply divided as "objecting patentability or general state of the art"..,

[7] Lazaridis and van Pottelsberghe (2007) reach the conclusion that in the EPO 30% of applications are withdrawn by applicants after receipt of the Search Report and citations to the state of the art, without a formal 'refusal'). This would not occur in the USA, where all patents are searched and examined automatically, there is no intermediate search report.

- Independent (main) claims that refer to entities (such as products and devices) and/or non-entities (such as methods and uses);
- Dependent (subordinate) claims that do not enlarge the scope claimed but define preferred embodiments thereof.

At its most general procedural level, the patentability of the claimed subject-matter is assessed through a number of stages, including:

- Determination of *technical fields* –at least within the IPC system, but not excluding other systems such as CPC, FICLA etc... see footnote 6- relevant to the application, this classification influences the retrieval of prior art needed to assess novelty;
- *Citation* of the most relevant prior art against the claims, the so-called backward citations, which refer to former patents or scientific and technical literature;
- *Decision* on the outcome of the proceedings, that can be a direct grant or, a grant of amended claims, refusal of withdrawal by the applicant.[8]

The most relevant publicly available milestones and timeline for subsequent procedures that elapse from filing to decision are comprised of:

- The *publication of the patent application* – including information on the technical fields considered relevant by the authority, comprising at least one class in the International Patent Classification (IPC);
- A number of communications between the examiner and the applicant, which encompass legal and procedural objections and importantly, the interpretation of the backward citations;
- The final decision by the examiner that may grant all or part of the claims, refuse the application or its withdrawal by the applicant.

This generalization does not hide major procedural differences across patent offices. For instance, some procedures (e.g. EPO or any Office acting under the PCT) are staged in differentiated search and examination phases (corresponding to prior art retrieval and subsequent processing of the application towards a decision, respectively) whereas others (e.g. USPTO) do not make such a distinction, all patent applications being 'searched' and 'examined'. In addition, not all procedures categorize citations used against claims in the same manner as explained in footnote 6 Patent procedures may also use non-IPC classification systems - on top of the standard International Patent Classification (IPC) - to characterize the technical fields that the examiner considers relevant (cf. footnote 5). Practice can also vary from jurisdiction to jurisdiction in terms of how one single patent application can develop into several continuation applications or divisional applications or even add improvements to the original application (the so-called continuations in part, CIPs).

[8] Depending on the office, different terminologies than 'withdrawal' can be used such as abandonment, dismissal, or rejection.

The methodology put forward here consists in the identification of comparable key examiner actions carried out in different offices and allocates to them a non-ambiguous procedural point or date, as described in table 2. Four broad types of indexes have been computed from the key examiners actions: search completeness (computed from classification practice and citations retrieval), certainty (as witnessed by the changes in the allocated IPC classes or the addition of citations against patentability during the examination procedure), speed and stringency in the form of the real grant rate of the applications and claimed subject-matter. This approach allows the examination routines of each office to be compared to one another. Additionally the work carried out by an individual office can be measured against the work carried out by the whole group of offices, as shown in Figure 1 with the 'completeness' formulae for instance

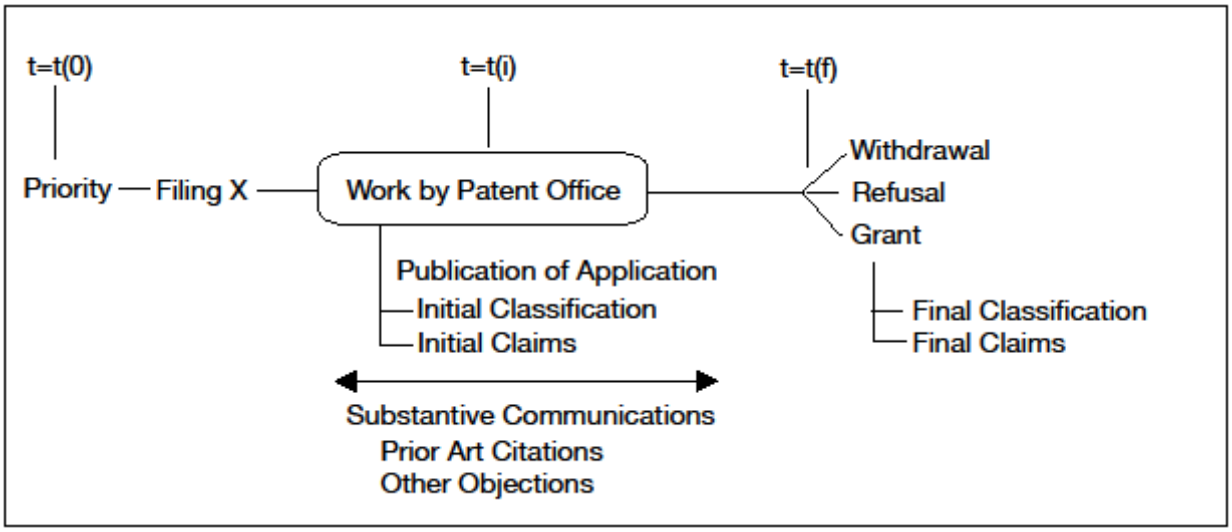

Figure 1: Illustration of key examiners actions and indexation methodology

The various indexes used for the characterization of the whole examination process are defined as follows:

- Search completeness (relies on classifications and on citations)

The technical fields that an authority considers relevant to the application are a first essential element of the patent procedure. In the present methodology, the obligatory minimum IPC classification has been quantified in the form of the number of 4-digit IPC classes, which correspond to distinct technical fields in a reasonably broad sense. A thorough classification of the patent application is indicative that the Examiner will consider all potential prior art during the substantive Examination. As the subject-matter of patent family members under consideration is identical, the allocated 4-digit IPC classes by each office to its published application and published grant are indicative of the completeness and thoroughness in the identification of the technical fields that are relevant to the application.[9] In a perfect world, where patent offices would have a similar approach to

[9] As discussed in footnote 5, the number of digits of the IPC class defines the narrowness of the technical field considered. In principle any arbitrary number of digits could be used here, as long as it is applied equally to all offices. 4 digits have been used as it is the minimum International Standard for a Subclass Symbol, that roughly defines what is considered as a technical field in engineering terms (see http://www.wipo.int/export/sites/www/classifications/ipc/en/guide/guide_ipc.pdf)

the classification of a patent application, the classes considered relevant should also be very similar at the stage of the publication of the patent application, irrespective of the office performing the classification. Different behaviors by patent offices are nevertheless expected because examiners may have different working routines and different interpretations of the subject matter of the application. Therefore it is understandable that of the sum of all IPC classes allocated to a family, each individual office will only allocate a fraction. An office allocating a comparatively larger fraction of the total would logically display a more thorough consideration of the technical fields potentially relevant to an application, irrespective of the fact that different offices may use indigenous classification systems for prior art retrieval.

Table 2: Definition of metrics for key examiner actions

Key Examiner Actions	Characterizing indexes	Measured at (point in time)		
		Publication[1]	Examination[2]	Decision[3]
Workload or input	- Nº of independent claims - Nº of claims	O		O
1. Classification	- Nº of allocated IPC-4 digit - Nº of Searched IPC [4]	O	 O	O
2. Citation of prior art by the examiner	- Nº of citations against patentability - Geographical coverage[5]		O O	O O
3. Speed of key examiner actions	- Time to first citations from earliest priority (number of days) - Number of Communications till outcome [6] - Time to end of procedure from earliest priority (number of days)			
4. Procedural outcome, or grant decision	- Decision to grant, withdraw or refuse			

[1] Publication of the patent application
[2] In the sense of the complete procedure between the publication of the application and the point in time a decision is taken
[3] Decision by the examiner (Grant / Final rejection / Refusal) or the applicant (Withdrawal / Abandonment)
[4] USPTO, which used a non-IPC based system in the period under study hence US Patent Classes (USPC) are considered.
[5] Measured as the publication Country Codes of citation with all of EPC counting as one single code.
[6] European Search Opinions count as the first substantive communication. The notice of allowance or vote are not counted as they are not substantive communications, just informative.

Citations to prior art, and especially those objecting patentability, play a fundamental role in the examination process, as they may affect the novelty and inventiveness assessment of the application. In the present methodology, citations are simply allocated to the point of the procedure in which they were made. This way, it is possible to treat citations made in search reports (the format typical of EPO, JPO or any Office under PCT) or made in office communications (USPTO) in the same manner. A simplified category is then given to the citations, corresponding to whether they prejudice any of the claims on file or not.[10]

[10] It is worth mentioning that the methodology presented here only focuses on actual citations used by the examiner during the procedure, irrespective of who brought them to their attention. Yamauchi and Nagaoka (2015) recognize that outsourcing can increase examination quality by expanding the scope of prior art search, while it may have a negative effect if the synergy between search and examination is important. The authors find that for Japan the outsourcing of prior art search increases quality (reduction of appeals frequency against both rejections and grant decisions, and reduction of examination duration). Complex applications are however not outsourced.

A further element indicative of the thoroughness in the retrieval of prior art is the number of country codes of the documents cited by an office during the procedure. A higher number of country codes in the prior art that has been cited means that the examiner has covered a larger geographical scope and state of the art in terms of Search. This does not exclude other linguistic or citation strategies, but it is a good indicator of the degree of global coverage that a patent office does when searching for prior art. In the present methodology, all EPC member states counted together as one single country code avoiding a heavy bias towards higher numbers of cited country codes by EPO. Additionally WO publication codes, which are characteristics of international publication carried out under the provisions of the PCT counted also as one country code as did the (rare) non-patent citations.

- Certainty

The relevance or the degree of information certainty, of any signal sent by the patent office to the applicant and to society is particularly important in competitive landscapes. For patent procedures, which usually take several years, it is essential that the initial opinion by the examiner can be considered as reliable the applicant, its competitors and society at large. In the present methodology, the reliability or certainty at early stages of the procedure is measured both for citations and for the identification of technical fields along the procedure. To do so the number of citations by the examiner added during the procedure after the initial opinion is calculated. Similarly, the number of technical fields considered relevant by the Examiner for classification purposes at the stage of the publication of the patent application is compared to those of the granted patent and to those used for the retrieval of prior art.

In a nutshell, the timeline conveys interesting information on the procedure, as prior art or different technical fields can be considered very early or all along the examination process until final decision, conveying more or less certainty to the applicant and to the public over time.

- Speed

Applicants, and society at large, often criticize patent offices for their slow practice, handling pending patents for years. Speed is indeed an important factor in the patent procedure, as it clarifies things for applicants, public and competitors. In the present methodology three metrics are computed to assess speed. The first one is the time to first citations. If these citations are relevant and comprehensive, then they provide very useful information to the applicant. The second one is the number of communications between the examiner and the applicant. This parameter is related to the procedural efficiency, as a high number of communications increases costs for office and applicant alike and, when linked to the measure of stringency discussed below, it reflects the impact of examiner opinions on applicant's behavior. The third metric is the time to grant or to decision from the priority date, or the date of first filing.

- Stringency or grant rates

Hypothetically, a higher degree of thoroughness early in the procedure will by definition be more restrictive in the subject-matter it considers patentable and produce less patents from the same set of applications, and intrinsically result in a lower grant rate. In the present work, the real grant rate of the data set has been considered. In addition to the traditional grant rate indicator, it is useful to consider as well the concept of "claims grant rate". This computes the actual percentage of granted claims from the original set of claims. This measure is essential, as it corresponds to the actual percentage of embodiments that are granted from the original application. In combination with the grant rate it refines the information available on the stringency of the procedure.

The next section presents a small scale test of the proposed in the methodology, with 100 triadic patent families in the field of methalurgy.

4. Results and Discussion

A standard technology was chosen to test the methodology developed in the previous section. The technical fields correspond to the IPC four-digit classes: C21B, C21C, F27B, F27D, and B22D representing the heavy metallurgical industry. These fields are not influenced by different legal provisions across patent systems, as opposed to Computer Implemented Inventions or Biotechnology, which are treated differently across jurisdictions. The chosen technology includes a population of about 1,200 patent families with EPO, JPO and USPTO members, and earliest priority dates ranging from 2004 to 2008.[11] Relatively old priority dates were chosen to avoid high pendency rates (patents not yet granted or refused), which would have limited the information available on granted patents. Two samples of 100 patent families were randomly extracted from this population. The metrics system allows treating PCT and non-PCT procedures in the same manner. However as there are strong differences in the share of PCT filings amongst offices with possible related procedural biases, a second sample has been constructed, which includes a similar proportion of PCT filings in each patent office.

Dataset I consists therefore of a purely randomised sample that approximately reflects the workload distribution of the three patent offices for the given population. This translates into the differences in the PCT share as International Search Authorities (PCT-ISA's) across the offices. EPO and JPO have a significantly higher share of applications that they treated as international search authority under PCT (PCT-ISA), with 34 and 18 percent of the sample, respectively, whereas the USPTO only has 12% of PCT applications.

Table 3: Sampling and dataset characteristics (valid as of 15.02.2017)

	EPO	JPO	US-PTO

[11] In the present case the so-called simple DOC-DB family definition has been used. This corresponds to patent applications sharing their priority filings, i.e claiming priority from the same patent applications. The fact that the family is defined by members claiming priority from the same applications, implies that the filings treated by each of EPO, JPO and USPTO in the present work represent the same or very similar technical subject-matter.

Priority Date (earliest)	2004-2007		
IPC-4 digit condition	OR: C21B, C21C, F27B, F27D, B22D		
Nº Families in fields	1434		
DATASET I (Random selection)			
N° of families in Dataset I	100		
Priority distribution:	EPC Member: 42%, JPO: 26%, US-PTO 28%, Others: 5%		
Dataset I: PCT-ISA %	34	18	12
Pending %	8	3	1
DATASET II (Random selection, final selection with equal PCT-ISA share)			
N° of families in Dataset II	100		
Priority distribution:	EPO 35%, JPO 30%, US-PTO 33%, Others 2%		
Dataset II: PCT-ISA %	22	22	22

The PCT procedure comprises a number of provisions that strictly regulate the chronology of events and is structured in clear-cut phases (roughly corresponding to the retrieval of prior art and further examination of the application[12]). Furthermore, after having had an application treated by an office as a PCT-ISA, the applicant may decide to proceed with subsequent patent applications (see footnote 1). This strict chronology of events and the fact that upstream search results are available to the offices of subsequent filing may impact their procedural characteristics. Therefore, in order to identify potential biases linked to the the usual high share of PCT procedures treated by the EPO and ISA reflected in Dataset I a second Dataset II was created with a random selection of procedures and the added condition that the share of PCT-ISA applications is balanced across offices. For both Dataset I and II the PCT-ISA share of the whole sample is 64-66% but in Dataset II all offices have an equal share of applications treated as PCT-ISA. As general note, it is important to remark that the high share of PCT in these populations corresponds to the usual ratio of PCT filings in the high value-added families that comprise (often amongst others) EPO, JPO and USPTO members and that are the object of this study.

Table 4: Key Examiner Actions for 100 patent families, Dataset I.

Patent office	EPO	JPO	USPTO
Initial applications			
Num. of ind. claims of published application	1,9	2,0	2,0
Total number of claims of published application	16,4	17,6	19,7
Search completeness and certainty			
Key Examiner Action 1. Classification practice			
Average number of IPC 4-digit classes in the family	3,3		
% of family IPC allocated to published application	66	61	40
% of family IPC allocated to granted patent	76	65	50
% of family IPC used in search during procedure	75	55	7 (*)

[12] PCT provisions stipulate the publication of a search report and a preliminary opinion on patentability with the relevant prior art against the application within 18 months from the priority date of the application. Additionally the applicant must decide whether to enter further national or regional procedures within 31 months from the priority date of the application.

Key Examiner Action 2. Citations	EPO	JPO	USPTO
Number of final citations per procedure	4,5	4,4	5,0
% of citations made after 1st citations	2	4	23
% of procedures with citations added after 1st cit.	3	3	44
Geographic coverage (number of country codes of said citations (All EPC together =1)	2,4	1,3	1,3
Speed			
Time to 1st Cit. (days from earliest priority date)	1055	1702	1420
Time to decision in days	2494	2330	2128
Nº of communication to decision (excl. final notice)	2,0	1,7	2,5
Stringency			
Independent Claims of published patent	1,6	1,5	1,9
Total number of claims of published patent	12,8	13,0	16,2
Grant Rate in % (grants/applications)	54	62	73
Allowance of Claims in %	42	45	60
(*) As discussed under footnote 6, US National Classification (USPC) in period of study was not yet (??) IPC based. 90% of US members has USPC-only Search, 3% has inventor/text only search			

About 8% of the families with a European priority were still pending at the time of data extraction (February 2017), against 1% at the USPTO and 3% at the JPO. The indexes were computed for each family member and aggregated into the Key Examiner Actions corresponding to each patent office, as shown in Table 4 for dataset I (the results related to Dataset II are displayed Table 5).

The file wrappers of the EPO, JPO and USPTO procedures were consulted by means of Global Dossier accessed through the European Patent Register[13]. These are free and publicly available services. The data corresponding to the indexes described in Table 2 was extracted manually from the file wrappers of the respective offices and the facsimile documents were viewed with EspaceNet. The raw data consists of about 12,000 procedural data-points corresponding to the characteristics of 300 members of two sets of 100 patent families.

Table 5: Key Examiner Actions for 100 patent families, Dataset II.

Patent office	EP-bal	JP-bal	US-bal
Num. of ind. claims of published application	2,0	2,0	2,0
Num. of dependent claims of published application	16,2	17,3	18,5
Search completeness and certainty			

[13] Databases used in the data extraction: the Common Citation Document of the world's biggest five patent offices (United states of America, Chinese Patent Office, Japanese Patent Office, European Patent Office and Korean Patent Office, so called IP-5, http://ccd.fiveipoffices.org/CCD-2.1.6/), the Global Dossier (accessible through various patent offices), the Worldwide Patent Statistical Database PATSTAT (https://www.epo.org/searching-for-patents/business/patstat.html#tab1), the Japanese Patent Platform (https://www.j-platpat.inpit.go.jp/web/all/top/BTmTopEnglishPage), the USPTO pair access (https://portal.uspto.gov/pair/PublicPair) and Espacenet by the EPO (www.espacenet.com).

Key Examiner Action 1. Classification practice			
Average number of IPC 4-digit classes in the family	3,3		
% of family IPC allocated to published application	66	48	66
% of family IPC allocated to granted patent	76	51	67
% of family IPC used in search during procedure	73	7 (*)	56

Key Examiner Action 1. Classification practice			
% procedures containing citations objecting patentability anytime in the procedure	85	74	86
Number of final citations per procedure	4,3	4,2	4,6
% of citations made after 1st citations	3	8	22
% of procedures with citations added after 1st cit.			
Geographic coverage (number of country codes of said citations (All EPC together =1)	2,2	1,3	1,3
Time to 1st Cit. (days from earliest priority date)	1186	1703	1461
Speed			
Time to 1st Cit. (days from earliest priority date)	1186	1703	1461
Time to decision in days	2578	2351	2160
Nº of communication to decision (excl. final notice)	2,1	1,7	2,4
Independent Claims of published patent	1,7	1,5	1,8
Number of dependent claims of published patent	13,0	13,0	16,3
Stringency			
Grant Rate in % (grants/applications)	52	62	76
Allowance of Claims in %	41	47	66

NB. Dataset II includes the same data extraction as for dataset I modified with the condition that all offices have an identical 22% share of PCT

The interpretation of the results presented in Table 4 can be structured around the four main pillars of the methodology presented in this paper. First, classification practices give an indication of the breadth of the state of the art considered to assess novelty. Second, backward citations by the examiner provide information on actual prior art used to examine patents. Third, the duration in number of days between the initial application and the first citations, or until the grant decision will give an idea of the speed of examination services. Fourth, the procedural outcome will address the stringency of a patent office, with grant rates of patents and/or claims. Figure 2 below summarizes graphically the data presented in Table 4.

It is worth noticing, in the first lines of Table 4, that even with similar patents (those belonging to a given family, hence claiming priority from the same applications), the drafting style varies across offices, with 16 claims per patent on average in Europe, 18 claims in Japan, and 20 claims in the USA.

Furthermore, a comparison between table 4 and table 5 shows that the condition of a balanced PCT share across offices, does not introduce any significant difference in the characteristics of the patent applications that said offices treat measured in terms of number of independent claims and total number of claims and IPC classes allocated to the family. The impact on stringency and speed is also limited, with the minor differences for some offices as expected in terms of grant rates and speed. Although a detailed individual analysis of both datasets is out of the scope of the present paper, their comparison suggests that the higher share of PCT at EPO and JPO in

Dataset I is not a source of substantial bias for the present analysis. The discussion under points i)-iv) hereunder corresponds therefore to the results of Dataset I, presented in table 4.

i) Number of technical fields considered relevant to the application for classification and search

There are significant differences in classification practice between the EPO and the JPO on the one hand and the USPTO on the other. The sum of relevant IPC four-digit classes allocated by all offices treating the members of this population is 3.3 per family on average. This is where prior art classified by any of these offices may be potentially found. Out of this total the EPO and JPO consider 66% and 61% relevant for their patent applications, respectively. This ratio improves over time, during the examination procedure, up to 76% and 65% at grant, respectively. USPTO is a distant third in classification thoroughness with only 40% of the IPC classes at the early examination stage, and 50% at grant.

The use of IPC in the Search actions was as expected much higher in EPO and JPO than in US-PTO. The latter relied almost exclusively in USPC for the retrieval of prior art during the period investigated. The differences however between EPO and JPO remain interesting and significant. During the retrieval of prior art, EPO consults up to 75% of all family IPC four-digits, whereas JPO consults just about half the classes (55%). This means that although EPO and JPO behave somewhat similarly in terms of classification of applications, but EPO consults a significantly higher number of classes during the retrieval of prior art and examination.

The significant differences between the classification and search behavior of the EPO and JPO on one hand and US-PTO on the other could partly stem from the use of the USPC system (United States Patent Classification System) by the USPTO during the period investigated. USPC is non-IPC based and was superseded by the IPC-based Cooperative Classification System (CPC) in 2010.

The conclusions for the period and sample of investigation are nevertheless clear-cut: EPO and JPO applications are more thoroughly classified upfront only seeing minor adjustments of the classification during prosecution, noting that international classification is obligatory for all offices. USPTO applications have a smaller number of classes at the date of publication, with a significant increase during prosecution, which remains however at much lower level than EPO and JPO. With other words, despite the compulsory classification in IPC, the USPTO considers a lesser number of technological fields being relevant than the JPO and EPO.

ii) Number of citations and country codes of prior art

The staged procedure of the EPO comprises the publication of an upfront search report providing backward citations at the publication of the application. PCT procedures also publish an upfront search report irrespective of the office treating the application. In terms of substantive practice, this so-called “staging” of search and examination is obviously the most differentiating feature across the procedures investigated in the present work. Indeed national US-PTO procedures do not differentiate the Search and Examination phases. The JPO practice is

perhaps the clearest case of a deferred procedure, in which once the application enters substantive examination, a search is carried out upfront internally or by an external body and discussed in an office communication.

The differentiation between upfront search and substantive examination seems to impact the approach that examiners take in the retrieval and use of prior art. USPTO cites on average 5 prior art references, against 4.5 at the EPO or JPO. Compared with the classification practice it seems that the US refers to a bit more references from a smaller number of classes. However EPO and JPO examiners introduce few citations into the procedure after the first citations are made. In the case of the EPO this amounts to only 2% of citations, slightly below JPO with 4% of citations. US-PTO examiners added 23% of citations during prosecution of patent applications. The difference increases when one takes into account the share of patent applications in which citations are added, which in the case of USPTO reaches 44%.

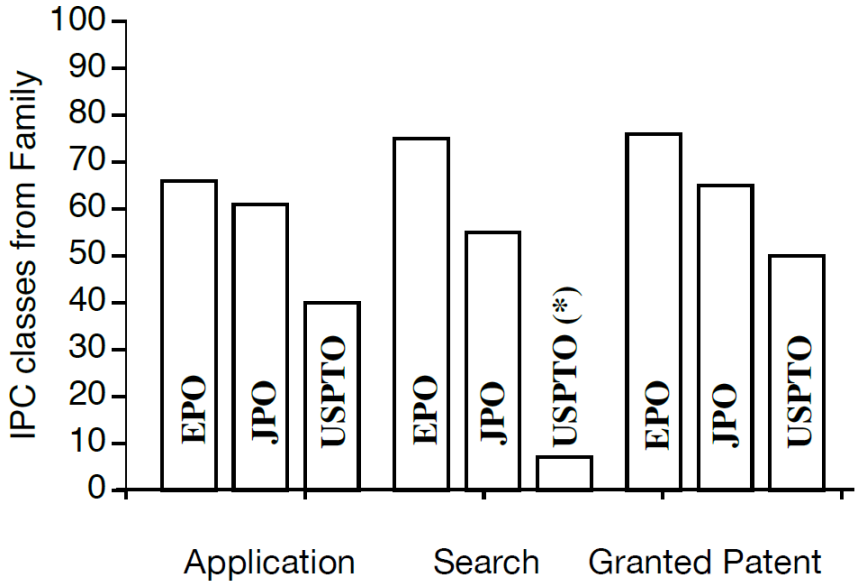

Figure 2: Percentage of IPC classes of the patent family individually allocated by each patent to patent applications and grant upon publication as well as the percentage consulted during search. * For the US the data only includes IPC, and does not include search in the US classification system

These results mean that EPO and JPO provide the applicants and society a strikingly more stable first opinion on the patentability of the applications, with a comprehensive search for prior art right at the beginning of the process. At the USPTO new citations are added along the procedure, hence reducing the degree of certainty provided to applicants and society.

There are also major differences in terms of "searched" geographical scope – hence in the knowledge codified in other languages- of the prior art cited by each office. Even considering all EPC Country Codes of citations as only one single count as discussed above, EPO cites on average 2.4 country codes per procedure, with JPO and USPTO a distant 1.3. This means that EPO examiners consider almost twice as much geographic territories (outside

Europe) of prior art when assessing patentability. US-PTO and JPO show a clear tendency toward the citation of own national prior art. In other words, patent offices in the US and Japan seem to implicitly favor a definition of innovation which is "new to their country or language" as opposed to a "new to the world" concept favored by the EPO, with an explicit investigation of prior art published in other languages.

iii) Speed

With just above 1000 days to 1st citations, the EPO is the fastest office to offer information on existing prior art and hence on the novelty condition in the patent procedure. USPTO at 1420 days comes second and JPO at 1702 a distant third, most probably due to the so-called deferred examination practice that characterizes the Japanese patent system.[14] Although recent procedural changes in Japan seem steer away from this practice, JPO allowed lapses of up to three years between the filing of the application and the actual examination procedure.

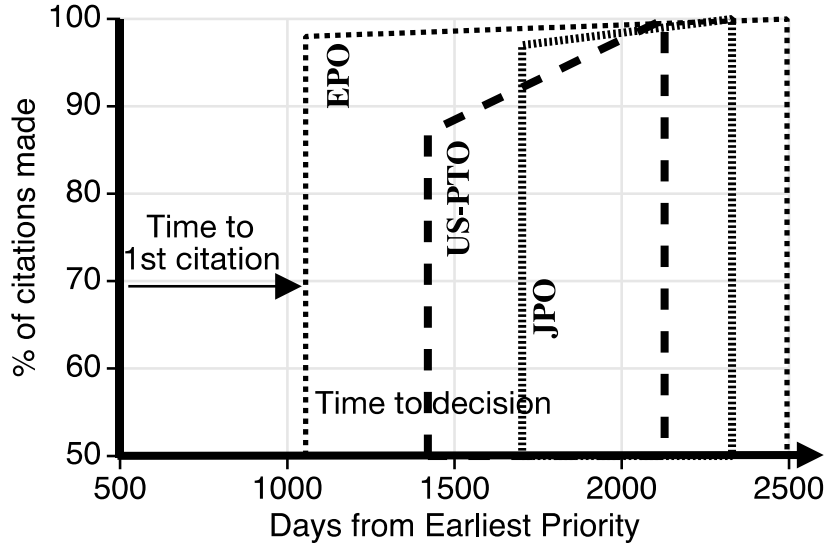

Figure 3: Schematic representation of the speed of delivery of the first citations and time to decision in the procedure, as well as the percentage of citations added during the procedure.

In a nutshell, it is clear that the EPO possibly due to its combination of staged and non-deferred practice cites fastest and is also more thorough and stable in doing so. This means that in terms of consultation and citations (i.e. analysis of patentability) EPO procedures are basically complete after the 1st citations are made. In contrast USPTO shows an additive approach to the retrieval of prior art, meaning that certainty from first citations is

[14] The fact that EPO processes a significant amount of PCT actions (followed by JPO and with US-PTO a distant third) may impact the time to 1st citation index. However, Table A1 in appendix shows that even with the balanced sample EPO is faster to deliver the first citations to prior art. Recent efforts in the Early Certainty for Search initiative may have further improved the time to first citations by EPO.

comparatively low. JPO has a deferred practice producing searches chronologically later but with quite a high degree of thoroughness and stability, albeit lower than EPO.

USPTO Examiners interact more frequently with applicants during the procedure, with about 2.5 substantive communications on average. JPO and EPO Examiners communicate with applicants 1.7 and 2.0 times, respectively.[15] Linked to the higher grant rate of USPTO discussed below, it appears that examiners' communications have on applicant's behavior is lower in the USPTO than in the EPO and JPO.

iv) Stringency: real grant rates

One could legitimately wonder whether the examiner's practice in terms of classification and search for prior art would impact the procedural outcomes, or the grant rates, displayed in the bottom of Table 4. One can hardly disagree with the fact that EPO has the highest level of procedural stringency. This is witnessed in the lowest 'real' grant rate of the group of about 54%. JPO and USPTO have grant rates of 62% and 73%, respectively.

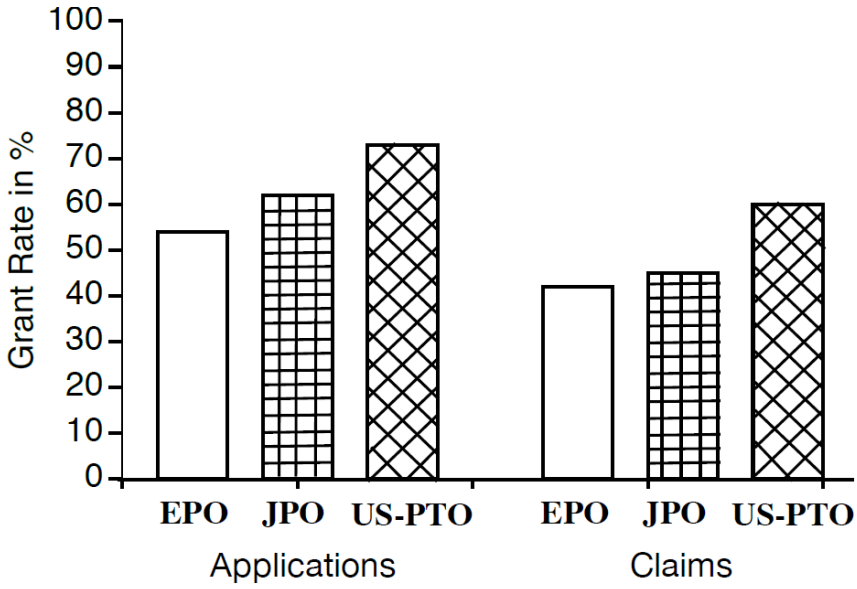

Figure 4: Summary representation of the grant rate of patent applications and claims per patent office.

The examination procedure actually affects both the grant rate of a patent application and its 'size' in terms of number of claims upheld at grant. Indeed, the substantive examination frequently leads to drop some claims, about 4 on average with the sample used in this paper. When the number of claims is taken into account instead

[15] This count excludes the final notices of allowance and formal communications, which are considered in all cases informative letters, rather than substantive communications.

of the number of patents, the grant rate falls by 10 to 17 percentage points. The EPO and JPO have very close degrees of stringency, with 42 to 45% “claims” grant rates, against the USPTO with a much higher rate of 60%.

Taking into account the findings discussed above, it can be concluded that a more limited consideration of technical fields and the reliance on a smaller number of geographical areas or languages to object patentability limits the probability to identify prior art and hence would result in higher grant rates.

5. Concluding remarks

This paper puts forward a new methodology to interpret the procedural information published by patent offices and translate it into measureable key examiner actions. Four broad dimensions of the patent procedure are measured irrespective of the patent office that is carrying them out: the search completeness via classification and citation practices, the upfront certainty of information delivery, the speed of information delivery and the relative stringency assessed via grant rates. The methodology is applied as a test for a sample of 100 patent families filed simultaneously at the USPTO, the EPO and the JPO.

Importantly, in terms of applicability of the methodology, the results clearly show that the procedural information rendered available by patent offices since 2004 largely allows a thorough comparative characterization of their examining practice. Additionally, the broad definition of indexes used herein allows a straightforward comparison of main examiner operation routines, with the caveats discussed previously with respect to heterogeneous classification systems.

From a procedural perspective and the sample used to test the methodology the results indicate that there are major differences amongst the three patent offices:

- EPO shows an 'Upfront' behavior providing the applicant and society as a whole with very high level of completeness and procedural certainty from its 1st citations. Although for both EPO and JPO the usage of IPC-based systems was as expected the highest of the group, it is to be noted that EPO scores highest in-terms of classification in IPC. It is also noteworthy that the EPO cites the highest amount of Country Codes in its procedures making it the only office effectively considering prior at a global scale. This leads the EPO to perform the highest stringency of the group, as witnessed by its lowest grant rate or claims grant rate.

- USPTO practice is characterized by an incremental approach to certainty, coming to relative procedural completeness at the end of the procedure. USPTO has the highest grant rate of the three offices and in the period investigated a relatively limited use of IPC when retrieving prior art. Cited prior art is essentially national, with about 1.2 country codes on average cited per procedure.

- JPO has a similar classification practice than EPO and a somewhat more limited consideration of IPC technical fields during search. Citation practice is stable yet essentially national. Its grant rate is intermediate between those of EPO and USPTO.

These differences in terms of substantive processing seem to impact the claim trees and grant rates of the applications. USPTO has the highest allowance rate of 60% when computed with the number of claims, with EPO and JPO scoring basically identically just above 40%. The results match well with the general assumptions that EPO has highest levels of stringency and quality, which the present work links to a thorough classification, broad

consideration of technical fields when retrieving prior art and the ability to cite and consider prior art from multiple territorial origins.

To the best of our knowledge this is the first time that a methodology is presented to link quantitatively stringency with concrete examination practices, or key examiner actions, on the basis of publicly available data. There are interesting needs for further research in this area. It would certainly be beneficial to expand some of the methodological elements and further develop the analytical framework. From the methodological perspective in addition to the increase of the sample size and technological scope, it would be interesting to measure office-specific practices such as the usage of non-IPC classification systems and develop a consistent model to treat divisional, continuation and continuation in part applications.

As for the analytical framework, the impact of priority origin and patent application characteristics on the outcomes of the procedure should be considered. In parallel, econometrics and cost models could be used to quantify the relationships between key examiner actions and the structural costs of patent procedures. With the present metrics system it seems clear that EPO produces 'more procedure' earlier and that the information given by EPO upfront is stable during the further prosecution. In this sense, the upfront costs of the EPO fall into a different light than those of less onerous procedures (for evidence on relative patent fees and costs, see van Pottelsberghe and François (2009) and de Rassenfosse and van Pottelsberghe (2013)). In other words, a further development of the present methodology could measure the patenting costs in terms of level and schedule of the selected jurisdiction against the procedural return at each stage of the procedure. As the patent examination process essentially consists in information search and information diffusion, it would be interesting to compare the "informational" return to investment conveyed by patent offices.

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