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The Quality Factor in Patent Systems (second and revised version)

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The quality factor in patent systems[↑]

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Abstract: This paper develops a methodology to compare the quality of examination services across patent offices. Quality is defined as the extent to which patent offices comply with their patentability conditions in a transparent way. The methodology consists of a two-layer analytical framework encompassing "legal standards" and their "operational design", which includes several interdependent components that affect the stringency and transparency of the filtering process. The comparison of patent offices in Europe (EPO), Japan (JPO) and the US (USPTO) shows that their operational designs differ substantially: the EPO provides higher-quality and more expensive services than the USPTO, while the JPO is in an intermediate position. These results illustrate that different system designs lead to different outcomes in term of backlogs, patent propensity and the number of dubious patent rights in force. In this respect, they: 1) provide an empirical validation of Jaffe and Lerner's (2004) conjecture of a vicious cycle between quality of examinations and demand for patents; and 2) highlight the need for a multi-faceted convergence of patent systems before mutual recognition is put in place.

JEL Classifications: O30, O31, O34, O38, O57
Keywords: patent system, quality, patent propensity, intellectual property.

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1. Introduction

In recent decades, patent offices around the world have faced a continual increase in patent filings, which has led to backlogs: ever-growing stocks of applications with longer examination pendency, a situation that supposedly generates uncertainty on the market. This general trend led the largest patent offices to enter into collaborative projects, which essentially aim to sow the seeds of an international mutual recognition system. The most desirable outcome would be that the work performed by one patent office would not be duplicated by other patent offices, which would save time and resources. This global convergence process could be welcome, because it is expected to improve efficiency of the patent systems in the most developed economies.[1]

However, although all large economic areas show evidence of an inflationary trend, there are noticeable differences across countries. The situation is more dramatic in the US than in Europe or Japan. The United States Patent and Trademark Office (USPTO) faces a record number of yearly patent applications and the most impressive backlog. On the opposite end of the spectrum is the European Patent Office (EPO), which has the smallest backlog and the lowest number of filings. The Japan Patent Office (JPO) is in an intermediate position. In their in-depth investigation of the US patent system, Jaffe and Lerner (2004) raise the hypothesis of a vicious cycle in which a low-quality examination process leads to the filing of more low-quality applications, which in turn further reduces the examination quality because examiners become overloaded. This “vicious cycle” hypothesis might also help explain the observed structural differences among the three major patent offices: *different patent system designs might lead to different outcomes in terms of backlog and patent propensity*. In order to validate this hypothesis, internationally comparable indicators of quality must be created.

This paper develops a new methodological framework for assessing quality in patent systems. The research intention is to identify the extent to which patent systems differ in the “delivery” or “quality” of patent examination services. *Quality* is defined as the extent to which a patent system complies with its legal standards in a transparent way. Patent systems are characterized on the basis of a two-layer analytical framework. The first layer is composed of “legal standards”, and includes the selection of patentable subject matter, the novelty condition, the required degree of inventiveness and the fee schedule. Two legal standards – fees and the definition of patentable subject matter – are measurable and can be compared across countries. However, most countries have similar “novelty” and “inventiveness” conditions, so that differences can only be observed in the implementation of these two legal standards. Therefore, the second layer encompasses the “operational design” put in place to ensure compliance with each legal standard. Operational designs include several elements that shape the rigour and transparency of the examination processes. The extent to which operational designs differ across countries may ultimately lead to different degrees of rigour and transparency in patent selection processes.

[1] Since 2008, the USPTO has signed many Patent Prosecution Highway (PPH) agreements with Japan, the UK, the EPO and other patent offices, offices that have also entered into other bilateral agreements. These agreements essentially aim to establish work-sharing and mutual recognition among patent offices. Under the PPHs, each patent office agrees to exploit the work previously done by other patent offices and to fast-track the examination of the corresponding patents.

The present paper contributes to the bridging of two important gaps through its objective and methodology. First, quality has not been investigated in the economic literature devoted to the analysis of patent systems. Several dimensions of patent systems have been thoroughly investigated, but quality as a whole has not been tackled. In contrast to much of the existing literature on patent systems, this paper is not about whether a specific dimension of a patent system's design is good or bad for an economy. Rather, it focuses on assessing the extent to which quality varies across countries. 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 an interface of legal constraints, economic incentives, scientific and technological advances, and business strategy.[2] 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, the paper achieves a fair balance between complexity and abstract simplification.

The paper is structured as follows. The next section presents the research motivation, namely the extent to which backlogs occur, and it identifies potential causes and consequences of such backlogs. Section 3 summarizes the economic literature on patent systems, while Section 4 presents the two-layer analytical framework: the legal standards and the components of their operational design. Section 5 compares three offices – the USPTO, the JPO and the EPO – on the basis of the analytical framework. Conclusions and policy implications are presented in Section 6. The results provide evidence that quality varies to a significant extent across the three patent offices.

2. Research motivation: common trends and structural differences

Patent systems around the world are experiencing a constant increase in the number and size of patent applications. At the EPO, 2008 brought a record-breaking number of patent filings – about 226,000, which was an increase of more than 60% from 2000. Figure 1 shows that this is far from an isolated occurrence; patent filings have been increasing in many countries in recent decades. This general trend may be attributable to several factors (see Guellec and van Pottelsberghe, 2007):

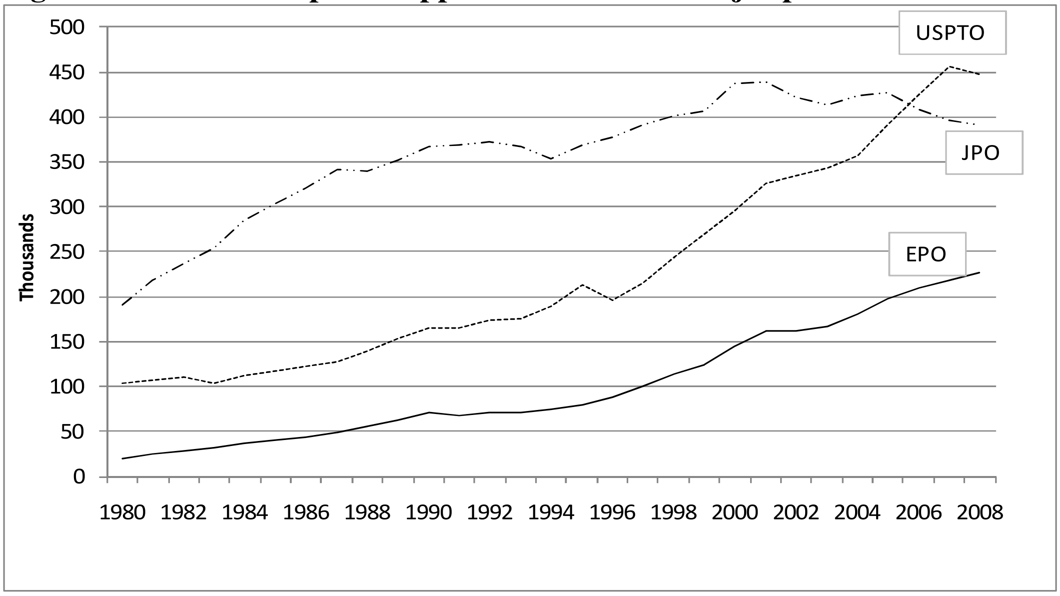
- Higher levels of research and development (R&D) expenditures, fast-emerging technological fields (e.g., nanotechnologies, biotechnologies) and fast-growing countries. Annual R&D expenditure in the OECD region increased from less than USD 300 billion in the early 1980s to more than USD 750 billion in 2008 (in constant 2000 PPP). If countries such as China, Russia, Israel and Singapore are included, the figure rises by another USD 150 billion (compared to USD 50 billion in 2000).

[2] See, for instance, "Guidelines for Examination in the European Patent Office", published by the European Patent Office (2010), which contains nearly 600 pages of laws, rules, practices and exceptions.

- The globalization trend increases the propensity to file patents abroad, as demonstrated by the fast growth of PCT applications at WIPO. Danguy et al. (2010) provide empirical evidence that the sharp increase in applications submitted to regional patent offices (especially the USPTO and the EPO) is essentially the result of a more pronounced globalization factor. In other words, a larger share of domestic priority filings is being transferred to foreign patent offices as second filings.

- New types of institutions are entering the patent arena, such as universities and young innovative companies. For example, academic patent applications now represent more than 4% of total applications, compared to less than 0.5% in the early 1980s.[3]

Figure 1. Evolution of patent applications in three major patent offices



Source: Own calculations from annual reports of the three patent offices. Applications at the EPO include EPO-direct applications and PCT international applications for which search reports must be performed.

- New innovation management practices and patenting strategies are being developed by the business sector. Institutions are not only more likely to seek protection for an invention, they are also protecting those inventions with more than one patent. The patent-to-researcher ratio in the OECD region has more than tripled with EPO patents, from 1.6 patents per 100 researchers in 1980 to more than 5 patents per 100 researchers in 2008. At the USPTO, the ratio was much higher than in the 1980s; it has jumped from about 6 patents per 100 researchers 30 years ago to more than 10 today.[4] New management practices have also

[3] The Bayh-Dole Act of 1980 gave US universities more incentives to commercialize technology: "The act allowed universities to patent the results of federally-funded research and license the resulting technology to businesses and other entities" (Joint Economic Committee US Congress, 1999, p. 31). European countries and Japan adopted similar legislation during the 1990s. See, for instance, Geuna and Nesta (2007) and Lissoni et al. (2008) for recent empirical evidence for European countries. According to Mowery and Sampat (2004), this trend is also evident in applications filed at the USPTO.

[4] Own calculations, based on patent series statistics and R&D expenses (OECD, MSTI, 2008).

improved the productivity of research, which translates into more patent applications per R&D expenditure. These practices are characterized by a new division of labour, whereby some firms specialise in research activities and sell their research output to "producing" firms. According to Kortum and Lerner (1999), the observed jump in patenting in the 1990s reflects an increase in US innovation spurred by improvements in R&D management practices.[5] Companies are also changing their patent management style from a single-patent approach to a portfolio approach, which is based more on quantity than quality. This practice may be attributable to tactics and motivations that are designed to reserve or capture markets for technology, as described in Arora et al. (2002), Guellec et al. (2007) and de Rassenfosse (2010).

The upward trend that characterizes the three offices fails to highlight the important structural differences. The EPO, which processes applications for a region with nearly 600 million inhabitants consistently receives less than half as many applications as the USPTO (with more than 440,000 applications a year since 2006). Furthermore, the high number of patents filed at the JPO fails to indicate that the number of claims it must address is much lower than the number addressed by the USPTO (JPO: average of one claim per patent in the early 1980s compared to nine today; USPTO: average of 24 claims per patent). In other words, if the number of claims rather than the number of patents is taken into account, the JPO is much closer to the EPO than to the USPTO.

Two factors may explain these structural differences across patent offices: cost and quality. The cost of patenting is based on several fees (including filing, search and examination fees; see van Pottelsberghe and François, 2009) and service costs (including searches for prior art, drafting or representation services; see van Pottelsberghe and Mejer, 2010). If total fees are low, one would expect higher demand for patents, assuming that the demand for patents reacts to fees and costs. The empirical survey by de Rassenfosse and van Pottelsberghe (2010) suggests that the fee elasticity of the demand for patent fluctuates by around -0.3. A 10% increase in fees would induce a 3% decline in the number of applications. As the cost per claim per million inhabitants is at least five times higher in Europe than in the US, one would expect higher demand in the US, but this probably does not explain the entire demand difference illustrated in Figure 1.

An additional factor is related to quality: the ease of obtaining a patent should affect demand for patents. This "laxity of patent offices" hypothesis has been raised by several scholars. Encaoua et al. (2006, p. 1430), for instance, argues that the "boom in patent applications [is concomitant with] a general sentiment of relaxation of patentability requirements [...] in certain jurisdictions". This argument is echoed in Gallini (2002), Sanyal and Jaffe (2006), and Bessen and Meurer (2008), who

[5] A more recent trend in innovation management is the "open-innovation" process (see Chesbrough, 2003) through which firms collaborate with other specialised firms on innovative projects in order to widen the scope of their knowledge base, and to speed up their development and market reach. For a firm to opening its own knowledge base to others generally requires sound protection of its own intangible assets, which partly explains the need to rely more frequently on the patent system. For instance, Peeters and van Pottelsberghe (2006) show that three key dimensions of innovation strategy influence the size of a firm's patent portfolio: the relative importance of basic and applied research in total R&D activities, the product or process orientation of innovation efforts, and the extent to which firms enter into collaborative R&D with other institutions. As the propensity to enter into collaborative R&D increases, there is a greater need for patent protection.

suggest that the increase in patenting in the US can partly be attributed to lower examination standards at the USPTO.

The constant increase in the number of patent filings and in their size (see Archontopoulos et al., 2007) has led to growing backlogs in the form of ever-increasing stocks of pending applications. In theory, these backlogs are detrimental to the economy because they are associated with a longer period of economic and legal uncertainty. In other words, entrepreneurs face increasing monopolistic rights, which constitute potential threats to their businesses venture. In this respect, one might wonder about the extent to which backlogs differ across patent offices. Three measures are put forward and discussed for the EPO, USPTO and JPO in van Pottelsberghe (2009): the number of pending applications (for which examination is requested), the number of pending claims, and the number of working months required to process the entire stock of pending applications. The three measures show that Europe's backlog is similar to the level of the US backlog in the mid-1990s, a period during which it was not an issue in the US. Japan is systematically in an intermediate position.

A fourth indicator – the average pendency or examination time in each office – can be used to approximate the depth of the backlog issue. Increased pendency is the main factor used by patent offices to highlight the negative effect of backlogs. The trends depicted in Mejer and van Pottelsberghe (2010) actually have different trajectories: pendency has substantially increased at the USPTO over the past nine years (from 25 months in 2000 to 35 months in 2009); it has increased slightly at the JPO (from 30 months in 2000 to 32 months in 2008); and it has actually decreased at the EPO (from 51 months in 2001 to 43 months in 2008), although it is still substantially higher at the EPO than elsewhere.[6]

The backlog issue is intensifying in most patent offices. One side effect of this trend is its association with a decline in the average economic value of the filed applications. This is, for instance, evident in indicators based on the geographical scope of protection and duration of renewals in Europe (see, for example, van Pottelsberghe and van Zeebroeck, 2008, or van Zeebroeck, 2010). However, the trend does not reveal the fundamental structural differences observed across patent offices. The backlog is essentially a problem in the US, while it is less of an issue in Japan and definitely much less worrying in Europe.

This paper focuses on structural differences among large patent offices. Identification of the roots of these international differences (such as a large demand for patents at the USPTO compared to a small demand at the EPO) might serve to highlight potential solutions. This paper aims to provide empirical evidence for the idea that the drastic workload disparity between the EPO and the USPTO may be the result of quality and cost differences. In the US, for example, lower quality of the examination process and lower costs for patents could lead to a much higher propensity to file patents, which in turn could further reduce the quality of the examination process. This vicious

[6] The fact that pendency is much higher in Europe is somewhat endogenous. It reflects different processes (applicants have six months to reply to a written communication from the examiner) and voluntary drafting styles that aim at delaying the grant date. This desire to delay is motivated by the sharp increase in patent costs that occur once the patent is granted by the EPO (see Mejer and van Pottelsberghe, 2010).

cycle was highlighted by Jaffe and Lerner (2004) for the US, and by Guellec and van Pottelsberghe (2007) for Europe. It is theoretically illustrated by Caillaud and Duchêne (2009): if more low-quality patents are filed, fewer resources can be devoted to their examination, which makes it easier to have a patent granted. However, formal assessments of the quality of patent systems have only been partially undertaken in the economic literature.

3. The definition gap

When stronger means weaker

Scholars who analyze the effectiveness of patent systems generally focus on one or two facets of the system: patentable subject matters, duration, the inventive step (or its scope), geographical scope, or a combination of these. Most scientific contributions investigate the economic consequences of these four broad features. Four types of economic impact are generally considered (see e.g., Mazzoleni and Nelson, 1998; Gallini, 2002; Encaoua et al., 2006; or Guellec, 2007).

1) Does the patent system lead to more invention?
2) Does the patent system stimulate more innovation?
3) Does the patent system encourage more disclosure of new knowledge?
4) Does the patent system facilitate technology transfer and the creation of markets for technology?

Most scholars implicitly or explicitly rely on a notion of the "strength" of patent systems and analyse the degree to which patent systems, contribute to achieving the ultimate goal of stimulating innovation and diffusing new knowledge.

Early theoretical investigations into the role of patent systems originated with Barzel (1968), Nordhaus (1969) and Scherer (1972), who argued that stronger patent systems would induce more investment in research and development. Following these early theoretical investigations, most landmark papers have essentially focused on three major aspects of policy making: the optimal length, the optimal breadth (or the optimal combination of these two dimensions), and the optimal geographical scope of protection. For instance, Gallini (1992) analyses the optimal length of a patent as a function of imitation costs. Klemperer (1990) examines the optimal scope of protection, whereas Gilbert and Shapiro (1990) identify the optimal mix between length and breadth of patents. Scotchmer (1991) and O'Donoghue (1998) explore how patent scope may affect the speed of generation and diffusion of new knowledge in a context of cumulative innovation processes. Patent protection that is too strong could lead to socially inefficient monopoly pricing and might stifle second-stage R&D. On the other hand, a small inventive step leads to "hold-up" problems, whereby a patent granted for a small increment would actually provide more power to the second inventor.[7] The optimal patent policy should, therefore, balance the research incentives among subsequent

[7] See Chang (1995), Denicolò (2000), and Denicolò and Zanchettin (2002) for a theoretical analysis of optimal patent policies under cumulative innovation processes.

generations of inventors. Scherer (2002) shows that whether stronger protection (where "stronger" is defined as having a larger geographical scope or stronger enforcement mechanisms) stimulates further innovation depends on the degree of research competition in a given technological field. The more competition in the research arena, the lower the expected impact of a stronger patent system.

The results of empirical studies generally lead to the conclusion that "strong" patent systems have, at most, an ambiguous relationship with the rate of innovation and the degree of information disclosure. However, the results show that they do facilitate technology transfer, sometimes at the cost of anticompetitive behaviour. In this literature, the "stronger" terminology is not typically used to echo the degree of quality in the selection process (or its rigour), but rather to reflect its enforcement potential or "leading breadth" (future inventions might infringe on the patented invention). A common practice is to qualify a patent system as *strong* (or *stronger*) when more domains are patentable (i.e., business methods, software or therapeutic methods, as suggested by Gallini, 2002), when the term of protection is lengthened (see Grossman and Lai, 2004), when the geographical scope is enlarged (see Scherer, 2002) or when patent holders receive more power in lawsuits (see Lerner, 2002).

The indexes of "patent rights", which have been presented by Ginarte and Park (1997) for 110 countries from 1960 to 1990, and by Lerner (2002) for 60 countries over 150 years, crystallize this tendency of defining "strong" patent systems as those that are essentially "applicant friendly".[8] Among the main criteria taken into account are the number of patentable subject matters (few restrictions is synonymous with "stronger"), duration, and enforcement mechanisms (for Ginarte and Park, the 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"). Lerner adds the total cost for full patent protection (17 to 20 years) and an indicator of discrimination against foreign patent-holders.

Strong is probably the wrong qualifier for such policies, which should rather be referred to as *applicant friendly* because more domains can be patentable for longer, in more countries and with greater legal power. According to Gallini (2002, p. 147), "... 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). His theoretical model suggests that more stringent selection criteria would create longer incumbency (because it takes longer to perform more ambitious innovative projects) and, thereby, would raise innovation incentives. Dewatripont and Legros (2008) investigate the effects of patent races in a standard setting environment. They show that litigation threats contribute to reducing the propensity to file low-quality applications, while they also hinder the production of strong patents. One method of reducing this negative side effect would be to sharpen the filtering process. Farrell and Shapiro (2008) also emphasize the importance of filtering, as they find that determining patent validity prior to licensing is socially beneficial.

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[8] Claessens and Laeven (2003, Journal of Finance) are among the many scholars who use Ginarte and Park's index to evaluate the impact of patent "strength" on economic activity.

Biased grant rates

It might therefore be tempting to formally assess the rigour of the selection process as a factor of the grant rates of patent offices (i.e., the portion of patent applications that are issued after the examination process). However, this indicator can be heavily biased. Indeed, assessing the rigour of patent systems on the basis of their grant rates can be misleading for four main reasons: metrics; patent flooding; divisional and continuation in parts (CIPs); and heterogeneous examination pendency.

In terms of metric issues, patent offices rarely publish real grant rates. For instance, the EPO publishes the share of patents granted for a given year as a portion of the total number of patent "actions" in the same year (i.e., refusals, withdrawals and grants). This practice provides a downward-biased approximation of the grant rate, especially in a period where the number of patent applications is growing quickly, because it does not account for the number of patents pending (see Harhoff, 2009, for a theoretical contribution). In this respect, a cohort approach (i.e., the share of patents granted as a portion of the total number of applications for a given year) is more appropriate. Indeed, official grant rates published by the EPO for 2007 and 2008 were approximately 50%, whereas the cohort approach shown in Lazaridis and van Pottelsberghe (2007) suggests a grant rate that fluctuated between 60% and 65% throughout the 1990s. Despite the significant increase in patent applications since the mid-1980s, the authors show that the EPO's grant rate remained stable at around 65%. This is somewhat worrying: if the permanent increase in the number of patents was associated with a drop in the average quality of these applications, a stable grant rate would mean that lower-quality patents have been granted.

A second source of bias is related to patent-flooding practices, whereby applicants file many similar patents at once. Under such circumstances, there is a high probability that the patents would be allocated to different examining units, and to examiners with heterogeneous skills and varying experience. The grant of only one patent out of 10 would be seen as a 100% grant rate by the applicant, despite the fact that the "official" grant rate would be 10%.

According to Quillen and Webster (2001), and Quillen et al. (2002), grant rates are further biased by the presence of divisional applications or continuation in parts (CIPs). With these procedures, one patent can give rise to one or several subsequent patent applications with additional claims, and which would share the date of the first filing. From the applicant's viewpoint, the granting of only one of these patents could be synonymous with a 100% grant rate, although the "official" grant rate at the patent office would be much lower. When corrected for these sources of bias, the USPTO's grant rate fluctuates between 87% and 97%, making it the most "applicant-friendly" patent office in the world. This can be compared with the corrected grant rates of 67% and 64% for the EPO and the JPO, respectively (1995-1999). These figures indicate that the JPO and the EPO have adopted higher levels of "stringency" than the USPTO.

A fourth source of bias is related to examination pendency. Stevnsborg and van Pottelsberghe (2007) provide an exhaustive list of tactics used by applicants at the EPO to delay the grant date. The grant date, in the case of the EPO, is synonymous with a significant jump in expenses (see van Pottelsberghe and Mejer, 2010, for cost simulations, and Lazaridis and van Pottelsberghe, 2007, or van Zeebroeck, 2007, for evidence on delayed examination). If a patent is pending for 15 years, the assignee might decide to drop it into the public domain, a decision that does not affect its potential use for 15 years (having kept the option to use it). The JPO used to allow for a seven-year lag (now three years) between the filing of a patent and the request for its substantive examination. Such a system provided applicants with ample time to assess the economic and technological potential of their invention. During this period, economically useless patent applications are withdrawn by the applicants, which explains the relatively small grant rate observed by Quillen et al. (2002) for Japan.

Grant rate indicators are, at most, biased approximations of patent offices' rigour in their selection process. In addition, there is little or no information on type I and type II errors (patents mistakenly granted or patents mistakenly refused, respectively), which must occur to a certain extent. It is highly probable that "wrongly" granted patents are more common than patents that are mistakenly refused. This is not only indicated by grant rates that are higher than 60%, but also by the very low proportion of "refused" patents (about 5% at the EPO), with the rest being withdrawn by the applicants (see Lazaridis and van Pottelsberghe, 2007). The RIM versus NTP case is an interesting symbolic example of unfair "forced" settlement. It involved five patents related to Blackberry devices "that should not have been granted at first hand" according to the US Patent and Trademark Office. Apparently, five patents mistakenly being granted to the same owner cannot be categorized as random", but rather as the result of more systematic sources of error. As shown by van Pottelsberghe and Archontopoulos (2010), none of these patents went through the EPO process, and two were actually withdrawn within a short time, probably due to a negative communication from the European examiner.

Litigation and opposition rates are also biased indicators. According to Hagel (2008) judicial review can provide the argument relevant for a thorough determination of validity. Hagel concludes that the only reliable assessment of quality occurs during infringement proceedings, when a litigated patent is held valid. But it could as well be argued that validation (and survival to litigation) rates are also biased and imperfect, for two reasons. First, the European experience, with its fragmented market, provides ample evidence of heterogeneous validity assessment.[9] Second, litigation proceedings occur only for a minority of patents and no information is available on private settlements (it can be cheaper to settle than to go to court, even for low-quality patents), or on the number of patents wrongly granted that are licensed to third parties.

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[9] Indeed, Mejer and van Pottelsberghe (2009) provide numerous examples where parallel litigations reached opposite outcomes (a patent held valid in one country and held invalid in the other).

Theoretical concepts versus day-to-day practice

There is a definition gap in the literature, which focuses on the breadth or scope of patent systems. Even when authors converge on what these abstract concepts mean, their definitions rarely refer to a day-to-day practice that is easy to implement, especially when compared to fees or length. For instance, Gilbert and Shapiro (1990) define breadth as the ability of the patentee to raise prices. For Klemperer (1990), a wider breadth corresponds to "a larger region of the product space" that is included in the patent grant. Many other examples could also be listed. Although these definitions undoubtedly contribute to a better theoretical understanding of how patent systems work, the "breadth" or "scope" concepts are not easy to crystallize.

Gallini's idea that patentability standards have fallen is driven by one main observation – there are more (new) patentable subject matters, which has lead to a sharp increase in patent filings "...for which the US patent office has limited expertise or access to prior art .... most notably in the area of business methods" (Gallini, 2002, p. 148). If a decline in a patentability standard is observed over time for a given patent office due to policy changes regarding patentable subject matters and a sharp rise in patent applications, one might wonder whether international differences occur in patentability standards or in the way they are met. If patentability standards are the legal conditions under which a patent should be granted, an examination failure by the patent office would be a failure to comply with those standards.

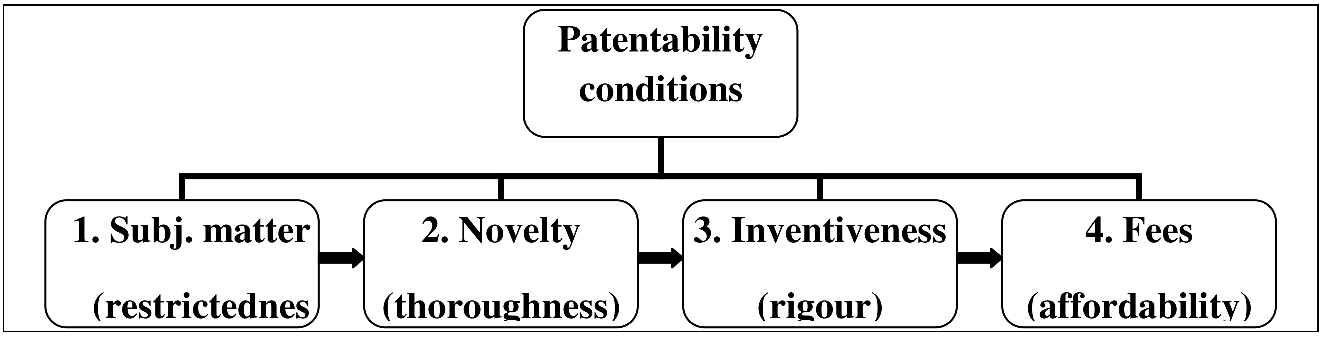
Few authors have investigated the operational routines put in place by patent offices to comply with patentability standards and, when they do, they tend to focus on one specific dimension of a multifaceted selection process. For instance, Scotchmer and Green (1990) suggest that novelty requirements and ownership rules ("first-to-file" versus "first-to-invent") are interrelated concepts that affect the speed of innovation. Yamauchi and Nagaoka (2009) measure the impact of shortening the period (from seven to three years) allowed for requesting an examination at the Japan Patent office (JPO). They find that the primary impact is an increase in the workload of examiners with lower-quality patents. The consequences of the grace period in the United States are scrutinized by Franzoni and Scellato (2010). The role of pre-grant fees and post-grant renewal fees has been analysed in several respects over the past ten years (see de Rassenfosse and van Pottelsberghe, 2010). Organisational and human factors have also been investigated. Cockburn et al. (2002) examine the role of USPTO examiner characteristics (age, experience, etc.) on the resistance of 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 organisational 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 many 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. Pre-grant opposition processes, as opposed to litigation, are investigated by Graham and Harhoff (2006), and Graham et al. (2002), who explore how a pre-grant opposition process would improve the US patent system. Along a similar vein, Shapiro (2007) assesses how reforms related to the US patent litigation system (including procedures for patent re-examination and damage assessment practices) could improve the effectiveness of the patent system in fairly rewarding innovators.

These theoretical and empirical contributions are part of a wide research field that focuses on the effectiveness of patent systems. Since they are focused, their implications are contextual and often fail to integrate complementarities with other features of the system. Scholars have rarely investigated the entirety of the processes put in place to check the patentability criteria in a systemic or comprehensive approach. In addition, most contributions explore only one patent office.

4. Quality analysis: a two-layer framework

This paper adds to existing literature by providing a more systemic analytical approach, which is then applied to three patent offices. Comparing the level of quality in different patent systems is challenging. As explained in the previous section, selection rates (e.g., grant rates or litigation rates) are affected by systemic differences and heterogeneity in the propensity to rely on the patent system across countries (see de Rassenfosse and van Pottelsberghe, 2009). Therefore, this paper explores the quality issue from a different angle. *Quality* is defined as the extent to which patent systems comply with their own patentability conditions in a transparent way. This definition makes it possible to gauge quality using a two-layer framework: the first layer is composed of the legal standards that describe the patentability conditions of a national patent system. The second layer is characterized by the operational design put in place to meet those legal standards.

Figure 2. First layer: legal standards for patentability



The first layer reflects the broad dimensions of patent policy making. Four interdependent legal standards shape the main conditions for the granting of a patent (Figure 2): patentable subject matter, the identification of prior art (novelty), the examination process (inventiveness), and the fees to be paid (if fees are not paid, no patent is delivered). A "classical" legal standard could have been added, namely the maximum duration of a patent. It is knowingly kept out of this analysis, however, because it is relatively homogenous across the US, Japan and Europe, and its implementation is clear-cut (i.e., number of years). In addition, the length of a patent is not really a patentability condition, but a time limit that is applied if a patent is granted.

The four legal standards that compose the first layer constitute the foundation of all patent systems. If fees and patentable subject matters are relatively easy to identify and measure (see Ginarte and Park, 1997, and Lerner, 2002), two "key" legal standards – novelty and inventiveness – are less easy to compare across patent offices. Indeed, these two legal standards might be similarly codified in several patent offices, but their implementation, or the extent to which they are fulfilled, might vary drastically. This paper puts forward that the degree to which a legal standard is satisfied depends on the "operational design" put in place by the patent office. Significant divergence in operational designs could lead to different degrees of quality (or rigor) in complying with patentability conditions. Table 1 lists the four main legal standards (LS) and describes the main components of the operational designs (OD) for the novelty and inventiveness conditions. It also briefly explains why each of these components might eventually affect quality and transparency in patent systems.

The two-layer analytical structure has two main implications for the investigation of the degree of rigour (or quality) of the patent selection process. First, the four main legal standards should be considered as a whole, as they clearly interact with each other and form a coherent system. For instance, the quality of the search for prior art (the novelty legal standard, LS2) can be viewed as one component of the inventiveness legal standard's (LS3) operational design, because the quality of the search report will *de facto* influence the quality of the examination. Along a similar vein, high fees would generate higher budgets (the elasticity of demand for patents with respect to fees is negative but much smaller than one) to secure high quality search and examination services. Second, the degree to which legal standards are met depends on the components of their operational design, especially in terms of the novelty and inventiveness conditions.

Some of these components are more important or relevant than others in securing a transparent and thorough selection process. A relevance scale can therefore be used to gauge each component's relative importance. Two approaches were used to build this relevance scale. The first method consists of allocating a relevance level on a 1 to 3 scale. A value of "1" means low relevance, "2" means medium relevance and "3" means high relevance. For instance, the grace period concept (relevance: 1) is less important than the opposition process (relevance: 3). The second method consists of pair-wise comparisons of all of the components of an operational design. If component A is considered to be more relevant than component B, the former receives one point (see the comparison matrices in Appendix 1, Tables A.1 and A.2). The sum of the points received by each component creates a relevance scale. This second method shows more variance in the relevance level. For instance, for the novelty legal standard, the relevance metric varies from 0 for the grace period to 8 for the controlled adaptability component.

A third alternative would be to ask experts or professionals (patent attorneys, patent lawyers, examiners) for their views on relevance. Such a survey could, however, be biased by institutional and geographical characteristics. Patent attorneys and patent lawyers would most likely favour few restrictions on subject matter and welcome high flexibility to adapt a patent over time. Examiners, in contrast, would opt for more decision power and less flexibility towards the applicants. Whereas such a survey would help to gauge the relevancy of the components in this analysis, the preference is put in this paper on the assessment based on logical considerations regarding the extent to which each component improves stringency and transparency.

Table 1. Quality in patent systems: legal standards (LS) and operational designs (OD)

System design	Importance for stringency and transparency
(LS1) Patentable subject matter	Some fields are less appropriate for patent protection, especially when alternative protection mechanisms exist, like copyrights (e.g., software), plant variety protection or trademarks. Other fields are not patentable for ethical or security reasons (e.g., the human genome, weapons).
(LS2) Novelty condition	In most systems, novelty is the first condition that must be met for granting of a patent. It must be assessed with respect to the state of the art (published material or public disclosure at conferences prior to the filing date). Novelty concerns the description of a patent and its claims. The extent to which the novelty condition is properly assessed can be gauged through nine components of its operational design (OD2.1-OD2.9).
- OD2.1. Subject matters - *Relevance (2, 3)*[b]	If the prior art is not codified, cannot be easily identified or is part of common tacit knowledge, then the novelty condition cannot be properly assessed. This is typically the case with subject matters such as software, business methods or traditional knowledge.
- OD2.2. Ownership - *Relevance (1, 2)*	The ownership of a patented invention can be allocated under a "first-to-invent" principle or a "first-to-file" principle. The former aims at being fair under a "natural rights" umbrella, whereas the latter aims to stimulate the inventor to apply for a patent as soon as possible in the invention process. The chosen system may affect quality, as the "first-to-invent" rule not only discourages disclosure but also allows the first inventor to keep a claim on the market. In addition, litigation must start with the identification of the person who was "really" the first inventor of the product or process.
- OD2.3. Identification - *Relevance (2, 3)*	Relevant prior art should be listed to properly delineate the scope of protection being sought. The person that is primarily in charge of identifying prior art might affect the quality of the search report. If it is the applicant, one might expect to see strategic listings to a much greater extent than if it is the examiner.
- OD2.4. Search report - *Relevance (1, 2)*	Producing and publishing a search report makes the information public. The report provides the applicant with a first assessment of the patentability of the invention (related to the novelty condition) and allows third parties to identify the filed invention in a transparent way.
- OD2.5. Language(s) - *Relevance (2, 5)*	The ability to read and understand several languages *de facto* enlarges the stock of codified knowledge to which an examiner has access. The likelihood of retrieving additional relevant documents increases as the number of understood languages increases, which provides a better basis for the examination.

Table 1 (cont.). Quality in patent systems: legal standards (LS) and operational designs (OD)

System design	**Importance for stringency and transparency**
- OD2.6. Opposition - *Relevance (3, 7)*	Given the possibility of filing an opposition, third parties can submit new, previously unidentified published material and documents to challenge the patentability of an invention for a much lower cost than litigation would entail. Post-grant oppositions frequently lead to revocation or amendments of granted patents.
- OD2.7. Grace period - *Relevance (1, 0)*	The grace period allows applicants to file a patent for a certain number of months after a scientific publication of the invention. High "flexibility" could generate complex litigation, as scientific publication formats differ significantly from a patent format, and as authors/inventors may vary. For instance, the fabrication mode and the patent-related prior art are rarely included in scientific publications. In systems relying on a strong novelty condition, the grace period is problematic, as the claims' wording might substantial diverge from the wording of a scientific paper.
- OD2.8. Controlled adaptability - *Relevance (3, 8)*	Applicants frequently want to adapt their patent by modifying or enlarging the scope of protection (modifying or adding claims). This can be done by either splitting the patent into one or several smaller subsequent patent, or by filing new patents with the same priority date as the original application [i.e., divisional applications and continuation in parts (CIPs), respectively]. These routines are increasingly used to delay the examination process and adapt the patented invention to existing technologies. They increase the degree of uncertainty in the system. If patent claims can be adapted and significantly modified, the relevant prior art might change, making the search report less relevant.
- OD2.9. Hidden patents - *Relevance (2, 6)*	If the submitted patent can be hidden from third parties for a long period, there is more uncertainty on the market. Furthermore, this keeps other patent offices from identifying the patent as part of the prior art. Access of the file by third parties allows them to submit observations on the patentability of the invention.
(LS3) Inventiveness	Novelty, as such, is not enough to grant a patent. An invention should be significantly novel or improve significantly upon the state of the art to the extent that it maintains market competition, reduces uncertainty and ensures sufficient protection for the inventors (Guellec, 2007, p. 134). The extent to which the inventiveness condition is properly assessed can be gauged through seven components of its operational design (OD3.1-OD3.7).
- OD3.1. Novelty - *Relevance (3, 4)*	If the novelty condition is not properly assessed, the quality of the examination might be undermined. The more comprehensive and relevant a search report is, the better the basis for the evaluation of inventiveness.
- OD3.2. Request exam - *Relevance (2, 2)*	Whether the applicant has to request examination within a specified period from the application date affects the workload of examiners and the quality of pending patents.

Table 1 (cont.). Quality in patent systems: legal standards (LS) and operational designs (OD)

System design	Importance for stringency and transparency
- OD3.3. Definition - *Relevance (1, 0)*	The legal standard might be more or less stringent, which influences the degree of inventiveness required for the granting of a patent.
- OD3.4. Incentives[a] - *Relevance (2, 3)*	Motivational aspects, such as social recognition, remuneration, working environment, good management and fair evaluation processes, play an important role not only in terms of ensuring a serious work but also in terms of keeping experienced examiners in-house. Weak incentives might ultimately increase the turnover of employees.
- OD3.5. Skills, expertise[a] - *Relevance (3, 6)*	The education, experience and training of examiners influences an examiner's ability to perform his/her task. Scientific and legal skills are required to carry out an examination. An examiner's skill is also affected by the degree of interaction with other examiners.
- OD3.6. Low workload[a] - *Relevance (3, 4)*	If examiners are subject to a heavy workload, and have insufficient resources to perform searches and examinations, quality might be affected. A high workload per examiner might mean that examiners perform their tasks faster, which could result in a less thorough examination.
- OD3.7. Opposition pr. - *Relevance (2, 2)*	The opposition process allows third parties to intervene and present potentially relevant arguments against patentability.
(LS4) Fees	Fees affect the patenting propensity (see de Rassenfosse and van Pottelsberghe, 2010). High pre-grant fees reduce the propensity to file applications of dubious quality, but they might also reduce accessibility for young, innovative firms. High fees also contribute to the financial sustainability of the patent office, especially if high-quality examinations are correlated with high fees. High renewal fees lead to a higher drop-out rate of patents in the public domain, and contribute to the financial sustainability of the patent office.

a. Indicates transversal components that might affect the operational designs of the two legal standards (novelty condition and inventiveness).

b. The parentheses include two measures of the relevance of each component. The first is based on a 1-3 relevance scale. The second is based on a bilateral comparison of all of the components of a given operational design. The number indicates the number of times one component was perceived to be more important than the others (see the main text and Appendix 1 for a more detailed description).

5. International comparison

This section provides a systematic comparison of the legal standards and their operational design in three major patent offices – the USPTO, the JPO and the EPO. As the purpose of the paper is to assess relative degrees of quality, the three patent offices are ranked for each component of the operational design of their legal standards. Ranks range from one to three, which indicate a low and a high level of rigour or transparency, respectively. Different scores are used when the component of an office's operational design has an obvious effect on the selection process (e.g., better identification of prior art or a more rigorous approach in the examination process) and on the transparency of the system (e.g., effective diffusion of information, and ease with which third parties can identify the patent) when compared to another office.

LS1. Patentable subject matters

Policies regarding patentable subject matters partly explain the difference in the number of patent applications among countries. In the US, the relatively few restrictions on patentable subject matters should, logically, lead to more applications. This is particularly striking for subject matters such as software, business methods, mathematical formulae, scientific discoveries and gene-related patents, as well as many other technological and scientific domains with lax patentability restrictions.

According to Gallini (2002), patent policy changes in the US started in the early 1980s with the Supreme Court's decisions on *Diamond v. Chakrabarty* (1980) and *Diamond v. Diehr* (1981), in which the Court extended patentability to genetically engineered bacteria and software, respectively[10]. In the late 1990s, the patentability of business methods and financial service products were confirmed by the Court's decision in *State Street Bank and Trust v. Signature Financial Group*. These decisions paved the way for the patentability of Amazon.com's one-click internet ordering process, and other online auction or booking methods. As of April 2010, the US government was discussing whether to pass a law that would restrict the patentability of software and business methods, especially following the US Supreme Court's *Bilski* decision (October 2008), which restricted the patentability of business methods.[11] Whatever the final outcome of to this specific case, the US system, in which "everything under the sun can be patented", is recognized as much less restrictive than other systems in terms of patentable subject matter.[12] The

[10] Genetic engineer A. Chakrabarty (General Electric) had developed a bacterium capable of breaking down crude oil for the treatment of oil spills. He requested a patent from the USPTO but was turned down by an examiner on the basis of the law prescribing that living things were not patentable. The United States Court of Customs and Patent Appeals eventually overturned the case, writing that "the fact that micro-organisms are alive is without legal significance for purposes of the patent law". Sidney A. Diamond, Commissioner of Patents and Trademarks, appealed to the Supreme Court, which in June 1980 ruled that a live, human-made micro-organism is patentable subject matter under Title 35 U.S.C. 101. The micro-organism constitutes a "manufacture" or "composition of matter" within that statute.

[11] *Bilski* (Fed. Cir. 2008) is a decision of the United States Court of Appeals for the Federal Circuit (CAFC) on the patenting of method claims, particularly business methods. The court affirmed the rejection of the patent claims involving a "method of hedging risks in commodities trading".

[12] In the US, the main article related to patentable subject matter is Article 35 U.S.C. 101 "Inventions patentable". Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new

“only” fields that are not patentable are those related to abstract ideas, laws of nature, natural phenomena and human beings. Databases as such, including those covering gene expression profiles, are not patentable.

Europe is much more restrictive and denies the patentability of many subject matters. The European Patent Convention (EPC) defines the concept of a patentable invention and details those fields that do not correspond to that definition, such as discoveries, scientific theories, mathematical methods, aesthetic creations, and methods for performing mental acts, doing business, or presenting information. Exceptions to patentability include inventions that are contrary to “ordre public” or morality, plant or animal varieties, biological processes for the production of plants or animals, methods for treatment of the human or animal body by surgery or therapy, and diagnostic methods practiced on the human or animal body.[13]

Japan’s patentability restrictions fall somewhere between those of the other two systems, but it is closer to Europe. For example, the transgenic mouse is patentable but business methods, software and mathematical formulae are not eligible for patent protection.

Subject matters, as such, cannot be taken as indicators of quality or rigour in patent systems. The only certainty is that fewer restrictions on patentable subject matter would automatically lead to more patent filings. However, some subject matters might be characterized by unclear or difficult to identify state of the art, which would affect the quality of the search report.

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and useful improvement thereof, may obtain a patent thereof, subject to the conditions and requirements of this article. The Office requires that the claimed invention must produce a “useful, concrete and tangible result”. The purpose of this requirement is to limit patent protection to inventions that possess a certain level of “real-world” value, as opposed to subject matter that represents nothing more than an idea or concept, or is simply a starting point for future investigation or research. Subject matter found to be outside of, or exceptions to, the statutory categories of invention listed within 35 U.S.C. 101 includes abstract ideas, laws of nature, natural phenomena and the claimed invention that encompasses a human being.

[13] In Europe, two important EPC articles related to patentable subject matter are Articles 52 and 53. Article 52, “Patentable inventions”, includes the following points: (1) European patents shall be granted for any inventions, in all fields of technology, provided that they are new, involve an inventive step and are susceptible to industrial application. (2) The following in particular shall not be regarded as inventions within the meaning of paragraph 1: (a) discoveries, scientific theories and mathematical methods; (b) aesthetic creations; (c) schemes, rules and methods for performing mental acts, playing games or doing business, and programs for computers; (d) presentations of information. (3) Paragraph 2 shall exclude the patentability of the subject-matter or activities referred to therein only to the extent to which a European patent application or European patent relates to such subject-matter or activities as such. Article 53, “Exceptions to patentability”, stipulates that European patents shall not be granted in respect of: (a) inventions the commercial exploitation of which would be contrary to “ordre public” or morality; such exploitation shall not be deemed to be so contrary merely because it is prohibited by law or regulation in some or all of the Contracting States; (b) plant or animal varieties or essentially biological processes for the production of plants or animals; this provision shall not apply to microbiological processes or the products thereof; (c) methods for treatment of the human or animal body by surgery or therapy and diagnostic methods practiced on the human or animal body; this provision shall not apply to products, in particular substances or compositions, for use in any of these methods. Rule 27, on patentable biotechnological inventions, includes the following: (a) biological material isolated from its natural environment; (b) plants or animal if the technical feasibility of the invention is not confined to a particular plant or animal; (c) microbiological process other than a plant or animal variety.

LS2. The novelty condition

If the content of a patent application has been published (or presented at a conference) prior to the filing date (often called the priority date), the "novelty" condition is not met and a patent should not be granted. Theoretically, this rule is straightforward and should normally be applied quite stringently. However, identifying the relevant state of the art is not always straightforward. A patent office's ability to comply with this legal standard can be gauged through nine interrelated components of the standard's operational design.

OD2.1. Subject matters. The legal standard on patentable subject matters affects the quality of the search for prior art, especially when the subject matter includes non-codified but well-known processes. For instance, software and business methods are technological areas for which it is much more difficult to properly identify the relevant prior art because of a lack of codification of previous "inventions" or because inventions are hidden in a source code. The USPTO, therefore, is less able to secure a complete list of prior art for the technological areas that are related to software, business methods and subject matters with incomplete codifications of their state of the art. As a result of these "unclear" subject matters, the USPTO would have a lower rank (1) than the JPO and the EPO (2) in terms of rigour (Table 3 lists the quality rankings for all components of the legal standards' operational design).

OD2.2. Ownership. The USPTO is one of only a few patent offices worldwide to give the ownership of a patented invention according to the "first-to-invent" principle. In the rest of the world, including Europe and Japan, the "first-to-file" principle prevails. This peculiarity affects quality in two ways. First, the "first-to-file" principle has the advantage of stimulating an early disclosure of an invention, which makes it accessible to the public faster. With the "first-to-invent" rule, an inventor does not need a patent in order to maintain a claim on the market related to an invention.[14] Second, in cases of litigation, patent disputes will often start with the right of ownership issue, whereby the "true" first inventor must be identified. Scotchmer and Green, (1990) argue that, in case of a technological race, the "first-to-file" principle might create excessive incentives for firms to stay in the race. In this respect, assuming that their theoretical model is supported by empirical evidence, the "first-to-invent" rule could be more effective in reducing duplicative research efforts, but this is not related to the quality of the patent system.

OD2.3. Identification of prior art. The person that is in charge of identifying the prior art will *de facto* influence the quality of the search report (comprehensiveness and relevance) and, therefore, the degree to which the novelty condition is met. The three offices have adopted different strategies for the implementation of the search report, although the strategies followed by the JPO and the USPTO tend to converge. In the US and Japan, a comprehensive list of prior art must be submitted by the applicant. In Europe, an examiner must undertake the relevant search report, which does not

[14] An example (taken from Scotchmer and Green, 1990) is provided by Yoshikawa (1987), who describes a patent dispute between the Japanese firm Sankyo and the US firm Merck. The dispute, related to an anti-cholesterol drug, was settled differently in Japan and the US because of the different ownership rules. Sankyo had the first patents on the two markets, but the patent was issued to Merck in the US because the firm could document prior invention.

prevent the applicant from including a list of prior references in the submitted document. In Japan, the undertaking of search reports has been outsourced to the private sector for many years.

In the US, an applicant is legally bound to disclose any prior art known to be material to patentability, which creates two potential biases. First is the possibility of overloading the reference section, so that the examiner might not be able to easily identify the most appropriate piece of prior art against which the novelty and inventiveness conditions should be checked. Second, some key technical references might not be listed by the applicant and, therefore, must be found by the examiner in its own investigation of the available prior art. The USPTO has been investigating the possibility of outsourcing searches since the early 2000s. The Office has started a proof-of-concept pilot project on the search reports prepared for international applications under the PCT. According to Kezenske (2003), contractors must demonstrate technical and legal competence, show that there is no conflict of interest between these and other searches they carry out, and agree to maintain strict confidentiality. Another parallel investigation concerns the role of search engine technology (with keywords) in the examination process. The study performed by Chin (2009) concludes that so far keyword search is unreliable as an exclusive method for locating patent prior art.

Japan has outsourced search reports to independent organisations in the private sector, for many years. About 225,000 search reports were outsourced in 2008, of which 80% (180,000) were "dialogue-type" outsourcing.[15] The expansion of the outsourcing of prior art searches is mainly due to the rise of new search organizations, the recruitment of searchers by those new organizations and the increase in their processing capacity. In 2009, about 1,840 people worked for search organizations, of which about 88% were employees of the Industrial Property Cooperation Centre, which includes a substantial number of former JPO examiners.

The EPO has adopted a strategy that is opposed to any type of outsourcing to the private sector, as it feels it is particularly important to have the search report performed by the examiner.[16] The implicit advantage of this practice is that it improves examiners' knowledge of the relevant prior art and, therefore, sharpens their ability to gauge the inventive step.

In summary, the USPTO and the JPO face potential drafting problems, as applicants can fail to list relevant prior art or hide it in a long list of irrelevant references. Furthermore, the JPO relies extensively on outsourcing, and the USPTO is planning to evolve in a similar direction. In addition to the many sources of potential information asymmetries (competencies, conflict of interests and

[15] According to the JPO's 2009 Annual Report, "dialogue-type outsourcing" means an outsourcing method in which the patent examiner receives the report on the search result from the searcher together with an oral presentation from the searcher. On the basis of this report, the patent examiner conducts a supplementary search when necessary. The officially registered search organizations include the Industrial Property Cooperation Center (all classes, 1,621 employees); Techno Search, Inc. (several classes, 94 employees); Japan Association for International Chemical Information (organic compounds, 22); Technology Transfer Service Corp. (amusement, 32); Advanced Intellectual Property Research Institute Co., Ltd. (opto devices, 21); Patent Online Search Corp. (amusement, 24); Pasona Group Inc. (automatic control, 14); and Protec Ltd. (semiconductor devices, 12).

[16] In the 1980s and early 1990s, search reports were handled by employees based in the branch of the EPO at The Hague, and the examinations were performed in the Munich branch. The late 1990s brought the implementation of the BEST programme (Bringing Examination and Search Together), which is believed to have improved the quality and speed of the whole examination process at the EPO.

confidentiality), outsourcing does not contribute to the examiners' knowledge of the prior art, as examiners receive the reference lists from third parties, from which they must assess the inventive step. The opposite is true at the EPO. For these reasons, the identification of relevant prior art might be more comprehensive at the EPO than at the USPTO or the JPO.[17]

OD2.4. Intermediate search report. The fact that search reports are not made publicly available (especially for domestic applications) indicates a lack of transparency on the part of the USPTO and the JPO, especially when compared with the EPO. The EPO's search reports include all relevant prior art and are published along with the patent application 18 months after the priority date. Any patent application following the PCT route (regardless of the selected search authority) automatically leads to the publication of the patent and its international search report. The lack of search reports for domestic applications in the US and Japan reduces the ability of other applicants (or third parties, like entrepreneurs) to properly assess the patentability of their inventions and, therefore, makes the self-selection process less effective. The EPO systematically adds a non-binding opinion on patentability to its search reports, which provides important information to applicants and serves to further increase the drop-out rate.

OD2.5. Languages of prior art(s). The novelty condition is essentially based on the formal identification of relevant prior art. Prior art is assessed within the scope of all published documents in the language(s) spoken by the examiners. For the US, this is essentially scientific and technical work published in English, and for Japan it is essentially scientific and technical work published in Japanese, although some English-language documents are probably considered as well. One great advantage of the EPO in this respect is that most examiners are fluent in the three official languages (German, French and English). As they have access to a wider knowledge base than US or Japanese examiners, EPO examiners can therefore provide a more comprehensive identification of prior art.

OD2.6. Opposition process. In areas with a post-grant opposition process, third parties may challenge the patentability of an invention by submitting additional prior art that would have not been identified by the examiners. The EPO has a low-cost, post-grant opposition system that allows any third party to challenge the patentability of an invention for a period of nine months from the decision to grant. This intrinsic self-correction mechanism improves the identification of prior art and may lead to the revocation of the patent. There is no post-grant opposition process at USPTO or JPO.[18] In the US, there are two features that may lead to the cancellation of a granted patent: interference proceedings and re-examination. The former is a priority contest between applicants/patentees seeking to protect the same invention, while the latter may be requested by third parties or by the patentee during the lifetime of a granted patent. Validity challenges are also possible in Japan and in all European countries, but they take place within the frame of regular litigation.

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[17] The fact that the merger of existing prior art documents does not preclude to satisfy the novelty condition is another indicator of the "softness" of the US identification of prior art. According to Barton (2000), prior publications in the US system would not bar issuance unless all features of the invention have been disclosed in a single prior publication, which is not the case in Europe.

[18] Due to the 2003 revision of relevant lawin the US, the system of opposition to the grant of a patent was integrated into the system of trial for the invalidation of a patent, and can therefore be viewed as a litigation proceeding.

OD2.7. Grace periods. The grace period is a period during which the inventor is allowed to publish an invention, generally through scientific working papers or conferences, and to submit a patent application on the same content at the end of the period, without being barred from receiving a patent for failure to respect the novelty condition. This flexibility is particularly welcomed by researchers and academic spin-offs, because the patenting process does not obstruct or delay their publication output. Grace periods allow the authors of the published material to "reserve" the invention for one year without the inconvenience or cost of filing a patent. It also delays the date at which the invention will fall into the public domain (see Franzoni and Scellato, 2010). For third parties, the grace period is therefore synonymous with a longer period of uncertainty. In addition, as a scientific article or a conference presentation is drastically different from a patent in terms of format and structure, the grace period can be seen as a time during which the applicant can substantially adapt an invention. In cases of litigation, the comparison of a patent with a scientific paper might prove to be an intellectually acrobatic exercise. The US's grace period is one year, while it is six months in Japan.[19] Europe has no grace period. Notably, the grace period does not particularly improve transparency and the selection process. However, it makes the system more affordable or accessible to scientists and technology-based start-ups, which was the prime motivation behind the introduction of the grace period. This component illustrates the balance between affordability (or accessibility) and quality.

OD2.8. Controlled adaptability. Applicants naturally try to obtain the widest protective scope in order to maximise the strength of their patent in case of litigation. They are also motivated by the fact that technology evolves – patent owners try to adapt their claims so that that they fit the latest design of their invention. The EPO and the USPTO have drastically different approaches regarding the degree of flexibility related to changes to the number and content of claims. The flexibility depends on the type of changes that are requested. Three types of change may be considered: adaptation of the claims and descriptions for a given invention; significant adaptation, including many more claims and subject matter through the filing of subsequent patents (continuation in parts, CIPs); and the split of a large patent into one or several smaller patents (divisional applications). The first adaptive mechanism is somewhat favoured by the EPO, while the last two are favoured by the USPTO.

At the EPO, applicants may adapt their claims and description (change, withdraw or add claims) up to the grant date under the supervision of the examiner, provided that the changes do not add new subject matter.[20] This flexibility has been reduced since April 2010, but it still exists to some extent.

[19] In Japan, a request for grace period should be made when filing a patent application, with a supporting certificate filed in due course. If a patent application is filed within the grace period of six months from the date of first disclosure, the invention shall be deemed to have not lost novelty.

[20] The extent to which a patent application can be amended (in terms of its description, claims or drawings) is governed by EPC Rule 137 "Amendment of the European patent application", which is allowed as follows: (1) Before receiving the European search report, the applicant may not amend the description, claims or drawings of a European patent application unless otherwise provided. (2) After receipt of the European search report, the applicant may, of his own volition, amend the description, claims and drawings. (3) After receipt of the first communication from the Examining Division, the applicant may, of his own volition, amend the description, claims and drawings once, provided that the amendment is filed at the same time as the reply to the communication. No further amendment may be made without the consent of the Examining Division. (4) Amended claims may not relate to unsearched subject matter that does not combine with the originally claimed invention or group of inventions to form a single, general inventive concept.

In Japan, applicants can amend the patent (i.e., add, modify or withdraw claims) until the first office action, which provides a modification period of just over three years from the application date. At the USPTO, such amendments are more difficult – claims cannot be redrafted and a maximum of two modifications are allowed – but it is easy to file subsequent patents through the "continuation" process.

Continuation application (CAPs) and continuation in parts (CIPs) are subsequent applications linked to a priority (first) filing, which share the same "priority date" (date of first filing). CIPs may add, change, or withdraw numerous claims to the original application. They are frequently used by applicants at the USPTO in order to maintain important claims under examination while enlarging the scope of protection. The possibility of adding claims in several CIPs provides an incentive to file further applications and adapt the scope of the intellectual property to the evolution of the technology. Companies increasingly use CIPs in the US, as illustrated by Quillen and Webster (2001), Quillen et al. (2002) and Hedge et al. (2009). This practice not only creates a substantial opportunity to adapt patents but it also artificially increases the number of patent applications at the USPTO. Hedge et al. (2009) show that about 30% of all US corporate-assigned patents included at least one continuation. CIPs are not allowed in Japan and Europe.

The third type of flexibility arrangement – divisional applications – are patent applications (generally including a large number of claims) that are split into one or several smaller applications in order to ensure unity of the inventions (at the request of the examiner), to delay the grant date (a strategic behaviour of the applicant), or to hide some of the claims (among several hundred). They can also be used when the applicant does not yet know which claim could be useful. There are two side effects to this process: later grant dates and longer uncertainty on the market.[21] In Europe, divisional applications are allowed, but abusive reliance on this option has been limited since April 2010, when the EPC decided to substantially reduce the period during which a divisional application can be filed (before April 2010, unlimited subsequent divisional applications of divisional applications were allowed, with the extreme case being that claims could be pending for nearly twenty years).[22] The US system allows for intensive use of divisional applications.

Overall, the US system is the most flexible with respect to the novelty condition, as it allows easy, numerous adaptations to the patent document while the priority date is maintained. The EPO and JPO are much less flexible. They therefore provide a higher degree of certainty and visibility to third parties. For small changes (under the scope of the invention described in the first patent), however, the EPO and the JPO are more flexible. They allow companies to adapt and fine-tune their patent under the supervision of examiners. One consequence of these heterogeneous practices is

[21] The filing of divisional applications at the EPO is associated with abnormally long pendency. van Zeebroeck (2009) shows that this type of application represents almost 50% of the applications for which examination lasted 10 years or more. The slowing of the process may be encouraged by the willingness to postpone the costs of maintaining a patent in force in several countries.

[22] See EPC Rule 36, which states that an applicant has a maximum of 24 months from the examining division's first communication in respect of the earliest application on which the divisional is to be based. This earliest application has to be pending at the time the divisional application is filed, and it cannot introduce new subject matter that extends beyond the content of the earlier application [Art. 76(1) of the EPC]. This rule will substantially reduce the filing of divisional applications per patent application, limiting therefore the possibility to "game" the system.

that examination pendency is generally irrelevant for comparisons of patent offices. At the EPO, the amendment of a patent induces communication and validation with the examining division, which naturally increase pendency: if the applicant wants a change, additional time is needed. In the US, flexibility is achieved through the filing of a CIP. In other words, a significant change in the targeted scope of protection actually takes the time needed to examine two or more subsequent patents.

OD2.9. Hidden applications. The possibility of hiding patents (or claims) introduces uncertainty in the system, especially for entrepreneurs who are active in the technological area covered by the hidden claims. In most countries, patent applications are kept secret (unpublished) for 18 months from the date of first filing, after which the patent application is automatically published. In contrast, the USPTO only automatically publishes patent applications for international markets (under the PCT route) after 18 months. Domestic applications targeting the US market alone can be kept secret during the entire examination process, and be published only if and when patents are granted.[23] This applicant-friendly specificity undermines the US patent system, as it encourages "submarine" strategies that consist of keeping a patent pending (and, hence, unpublished) until a patent is granted, and then enforcing it immediately. In Europe, (nearly) all applications are published 18 months after their priority date. It is only possible to hide an application if it is refused by an examiner or withdrawn by the applicant before the official publication date. In Japan, all applications are published 18 months after the application date.

A second way of hiding proprietary technology is to file "jumbo" applications, which include several hundred claims and pages. This method can be used even if the application is published. Finding the relevant claim, especially for a would-be entrepreneur who performs a freedom-to-operate analysis, is like finding a needle in a haystack. These applications generally lead to several subsequent divisional applications. Recently, large applications have become more expensive, as higher claim-based fees have been set by the USPTO and EPO. As discussed in OD.2.8, the use of divisional applications is much more limited at the EPO than at the USPTO.

In summary, the nine components of the operational design related to the novelty condition, taken as a whole or individually, suggest that the US has taken a softer approach to the implementation of the novelty condition than the EPO. This is true in terms of identification of prior art and transparency (see Table 3). Japan is in an intermediate position – it is closer to the US on some dimensions and closer to the European system on others. The softness of the USPTO is characterized by: many patentable subject matters for which the state of the art is not properly codified, a first-to-invent system, the applicant's identification of prior art, the lack of search reports, a single working language, the lack of an opposition process, a long grace period, the

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[23] The USPTO website states: "Publication of patent applications is required by the American Inventors Protection Act of 1999 for most plant and utility patent applications filed on or after November 29, 2000. ..., an applicant may request that the application not be published, but only if the invention has not been and will not be the subject of an application filed in a foreign country that requires publication 18 months after filing (or earlier claimed priority date) or under the Patent Cooperation Treaty. ... As a result of publication, an applicant may assert provisional rights. These rights provide a patentee with the opportunity to obtain a reasonable royalty from a third party that infringes a published application claim provided .... and a patent issues from the application with a substantially identical claim. Thus, damages for pre-patent grant infringement by another are now available" (emphasis added).

possibility of substantially adapting claims and content during the examination process, and the possibility of hiding applications.

LS3. Inventiveness

In Europe, the legal standard for the inventiveness condition is that the invention should be significantly different from the state of the art or involve an "inventive step". In the US, the condition is somewhat similar at first sight – "non-obviousness" is required to grant a patent. The operational design put in place to test the inventiveness condition can be analyzed on the basis of seven components.

OD3.1. Novelty condition. According to the UK Trade Marks, Patents and Design Federation (TMPDF), a timely, high-quality search is central to the quality of the EPO's examination capability.[24] Therefore, less rigour in the identification of prior art, or a soft novelty condition, is a first element that might hamper the quality of the examination process. The relevance of an appropriate search report for the examination is also coined by several patent offices which act as international search authorities in the PCT process.[25] The subsection on the novelty legal standards (LS2) provides evidence that suggests that the novelty condition is softer, or assessed with less rigour, in the US than in Europe, while Japan is in an intermediate position.

OD3.2. Request for examination. A filing at the USPTO automatically leads to a search and examination, whereas an applicant must make a specific request for examination at the EPO and the JPO (otherwise, the patent falls into the public domain). At the EPO, the applicant benefits from a search report after 18 months, as it provides preliminary clues on patentability and, therefore, affects the drop-out rate (Lazaridis and van Pottelsberghe, 2007, show that 35% to 40% of all withdrawals take place before the request for examination, the majority being withdrawn just after the search report is provided, which attests to the usefulness of this "request"). At the JPO, a request for examination can be made for up to three years after the filing date. Prior to October 2001, this period was seven years. In Japan, the applicant's decision process relies essentially on a self-assessment of commercial value, because no search report is made available. Yamauchi and Nagaoka (2009) show that the shortening of the request for examination period has led to a sharp increase in the number of patents to be examined, an increase that is logically associated with a fall in average quality.

A "request" system reduces the number of examinations that are performed for patents that will not be used and, therefore, reduces the number of pending applications. With the new three-year lag for examination requests, nearly 70% of all applications are now examined in Japan, compared to about 55% ten years ago. At the EPO, about 80% of all applications are subject to an examination request.

[24] "A high quality search underpins everything, for without it, the rest of the examination process can be a waste of time. Moreover, reliably good early searches can lead applicants to abandon applications that would otherwise clog the system" (TMPDF, 2008, p. 2).

[25] For instance, both the USPTO and EPO have declared that in the PCT route they would act as an International Preliminary Examination Authority (IPEA) only if they were also the International Search Authority (ISA) in the first phase. This practice clearly underlines the importance of the search report in the examination process.

The weakness of the "request" system is that it could prolong the period during which the unexamined applications may block other firms' activities. This situation does not occur at the EPO, because the request for examination must be made just after the publication of the patent and the search report, or 18 month after the priority date. Furthermore, the search report is associated with a non-binding opinion on the patentability of the invention, which improves the self-selection process, as a decision to continue with a patent application can then be based on both the economic potential of the invention and the technical opinion of the examiner.

How do these three processes affect the quality of the examination process? The combination of an 18-month period with a search report and a non-binding opinion allows for a reduction in the number of examination requests and also reduces uncertainty for third parties. In Japan, the examination request lag is longer (which further reduces the number of requests for examination) but is only based on the potential market value of the invention and not on its potential patentability (no search report is available). The USPTO favours speed but at a cost – more examinations to perform on patents with a lower average quality.

OD3.3. Definition. At the USPTO, the patentability condition that is assessed during examination is "non-obviousness", which is perceived to be more lax than the criterion used by the EPO or JPO, which consists of an "inventive step". The two concepts are somewhat similar but the practices used to assess them differ. At the EPO, the evaluation of the inventive step is based on the problem-solution approach and the "could-would" concept. In the US, the concepts that prevail in courts are the "teaching-suggestion-motivation" test and the "Graham" factors.

The EPO's inventive step is considered to be achieved if, when compared to the state of the art, the claimed invention is not obvious to a person "skilled in the art" (European Patent Convention, EPC, Art. 56). In the early 1980s, the EPO adopted the "problem/solution" approach (Guidelines Part C, chap. IV, section 9; explained in Guellec, 2007), which requires the establishment of the objective technical problem to be solved (which corresponds to the difference between the invention and the closest prior art) and then considering whether the claimed invention (or "solution" to the technical problem) would have been obvious to the person skilled in the art. Such a "person" is defined as an ordinary practitioner aware of what was general knowledge at the time of invention.[26]

In the US, the critical question is whether there is something in the prior art to suggest the obvious nature of the combination of previously known elements. This requirement is generally referred to as the "teaching-suggestion-motivation" (TSM) test. In order to prove obviousness, this test requires a demonstration that some suggestion or motivation exists to combine known elements to form a claimed invention. The TSM test has been the subject of much criticism, as illustrated by the US Supreme Court decision in *KSR v. Teleflex* (2006), which held that the true test of non-obviousness is the Graham analysis.[27]

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[26] The "could-would" concept consists of investigating whether the skilled person would have been prompted to modify the closest prior art in such a way as to arrive at something falling within the terms of the claims. In such a case, the invention does not involve an inventive step and the patent is, therefore, not granted.

[27] According to the "Graham factors", obviousness should be determined by: 1) the scope and content of the prior art; 2) the level of ordinary skill in the art; 3) the differences between the claimed invention and the prior art; and 4) objective

Some scholars argue that the non-obviousness rule has been relaxed in the US for at least some subject matters (e.g., Gallini, 2002; Jaffe, 2000; Barton, 2000). Comparisons of patent offices' inventiveness from the definition of "inventive step" or "non-obviousness" is far from straightforward. Notably, the rules in Europe (i.e., the "problem-solution" approach and the "could-would" concept) were created by the EPO to ensure a homogeneous approach for examiners from different countries and examination cultures. The TSM test and the "Graham factors" were created and used by courts in the US (Federal Circuit Court and the Supreme Court), which indicates a more pronounced application of rules in the courtroom than in the patent office.

Important elements related to the patentability condition may, however, contribute to pushing the EPO upward on the quality ladder: the notion of clarity and support by the description section (Art. 84 EPC), the notion of sufficiency of disclosure (Art. 83 EPC) and the notion of unity of invention (Art. 82 EPC). These provisions can be found in most patent systems, but it seems that the extent to which they are ignored varies across patent offices, which is probably related to the time allocated for a proper examination.

In general, the arguments in this "definition of inventiveness" section are not sufficient to conclude that the USPTO has a higher degree of inventiveness than the EPO or JPO. However, the EPO's approach seems to be slightly more "defined" than the USPTO's.

OD3.4. Incentives (wages and social recognition)- The incentive to stay at the office and perform a high-quality examination is related to employment conditions. USPTO examiners are civil servants with wages that are not particularly competitive. The position is often used as a stepping stone to higher-wage jobs in the private sector, jobs that require experts who know how to get a patent granted (NAPA, 2005, p. 82). One direct consequence is a high employee turnover at the USPTO – approximately 33% per annum (the average employee stays three years). In Japan the patent office is a branch of the Ministry of External Trade and Industry (METI). METI employees have a fairly good wage and a high social recognition, which translate into low turnover. The EPO also has low turnover in its workforce (less than 5%) and very high wages, as examiners have the status of international civil servants and enjoy many additional advantages (such as holidays and educational support for children). The social recognition of EPO examiners falls into an intermediate position. The EPO is located outside the policy making arenas (it is mainly based in Munich and The Hague), and it is independent from European institutions.

In addition to these structural differences in wages or social recognition, other incentive mechanisms have been put in place. The USPTO has a more pronounced orientation towards "explicit" incentive mechanisms, whereby the quantity (and speed) of work performed by an examiner partly determine the wage, regardless of the quality of the examination.[28] The EPO and

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evidence of non-obviousness. In addition, three factors might be used to provide evidence of "non-obviousness": 1) commercial success; 2) long-felt but unsolved needs; and 3) failure of others.

[28] Regarding the USPTO, M. Lemley reports that "There are strong structural and psychological pressures on examiners to issue patents rather than rejecting applications, no matter how weak the alleged invention seems" Lemley (2001, footnote 5).

JPO rely more on an "implicit" incentive scheme based on peer review mechanisms (several dimensions of the day-to-day tasks, including training, social interaction, improvement of patent classification and assistance to colleagues). The literature on agency theory (e.g., Friebel et al., 2006) emphasizes that explicit incentive mechanisms can be a powerful tool in cases of information asymmetries between the management of an organization and its members. However, they can lead to behaviour that is detrimental to the goal of an organisation, especially when the work is complex and subject to uncertainty. For the patent examination process, explicit incentives exclusively based on quantity and speed are likely to negatively affect the quality of work.

OD3.5. Examination skills and expertise (education, experience and feedback). The very low employee turnover (less than 5%) at the EPO and JPO is evidently correlated with longer average experience of the typical examiner, especially when compared to the USPTO. An examiner at the EPO is recognised as fully operational after five years of training and experience. Since the examination process is complex, technical and legally binding, examiners with longer experience should deliver higher-quality service on average.[29] At the USPTO, almost 80% of patent examiners had less than three years of examining experience in 2009, while the share of examiners with more than 10 years fell from 20% in 2004 to 7% in 2009. This decline is the result of the aggressive recruitment of new examiners by the USPTO and a significant reduction in the number of experienced examiners (from about 750 five years ago to about 400 today).[30] Lemley and Sampat (2008) find that examiners' characteristics, including their experience, significantly influence the outcome of the examination process, which is an unexpected, socially suboptimal effect.

The extent to which examiners interact is one aspect of the examination that implicitly affects an examiner's ability to assess the degree of inventiveness of a patent. The survey presented in Friebel et al. (2006) shows that examiners perceive their work as highly interdependent. In other words, poor quality work undertaken by one examiner increases the workload of that examiner's colleagues. In this respect, the EPO has a well-defined, unique practice that consists of having a Division that makes the decision to grant a patent. A Division involves three colleagues in the examination process: the first examiner, the second examiner, and the chairman. This organisational routine constitutes a key quality check in the EPO process and institutionalizes substantial interactions between examiners.[31] At the USPTO, the examination is generally performed on the individual level. Cockburn et al. (2002) provide evidence of heterogeneity across examiners in their examination processes. This heterogeneity is related to experience, tenure and other characteristics.

[29] This positive correlation between an examiner's experience and the quality of work is documented by the British Trade Mark, Patents & Design Federation: "A number of our members have experienced poor quality search and examination, which some attribute to the work of new recruits who have had less training and supervision than used to be provided" (TMPDF, 2008, p. 3).

[30] Cf. http://www.patentlyo.com/patent/2010/02/patent-examiner-experience-levels.html.

[31] The first examiner analyses the application, writes communications to the applicant and analyses their replies and amendments, and recommends granting or refusal. The second examiner checks the recommendation to grant (votum) or refuse, checks the form of the final text of a granted patent, and agrees to grant or refuse or sends the application back to the first examiner with comments. The chairman checks the legal and technical reasoning of the first examiner's votum or refusal, carries out a detailed check of the text of the final application documents, and agrees to grant or refuse or sends the application back to the first examiner with comments.

OD3.6. Workload and pendency. Various measures of workload per examiner are presented in Table 2 for the year 2008. The ratio of incoming applications per examiner is presented in columns [4] and [5]. Column [4] shows the total number of applications for which a search of prior art must be performed – 74 at the USPTO compared to 59 at the EPO. In Japan, the "search for prior art" workload is less relevant, as it is outsourced. The higher workload for US examiners is exacerbated when examination duties are taken into consideration. Column [5] displays the number of patents for which a substantive examination must be performed. The two columns show a significantly higher workload in the US, especially for substantive examinations. The JPO seems to have a substantial workload, but this is due to the fact that patents in Japan are much smaller. This "claim-number" effect is taken into account in columns [6] and [7], which present the total number of claims filed per examiner (for search reports) and claims under examination per examiner, respectively. For prior art searches, an examiner at the USPTO must tackle more claims than an examiner at the EPO. For substantive examinations, the average examiner at the EPO receives about 540 claims per year, about one-third of the 1,776 claims per examiner in the US and the 1,403 claims per examiner in Japan.

Column [8] in Table 2 shows that the actual amount of work performed per examiner is also nearly twice as high in the US as it is in Europe. European examiners grant, on average, 15 patents per year, against 26 in the US and the much higher figure in Japan (which reflects smaller patents). These figures suggest that the incoming workload for examiners and their actual output are two to three times higher at the USPTO than at the EPO, while the JPO is in an intermediate position.

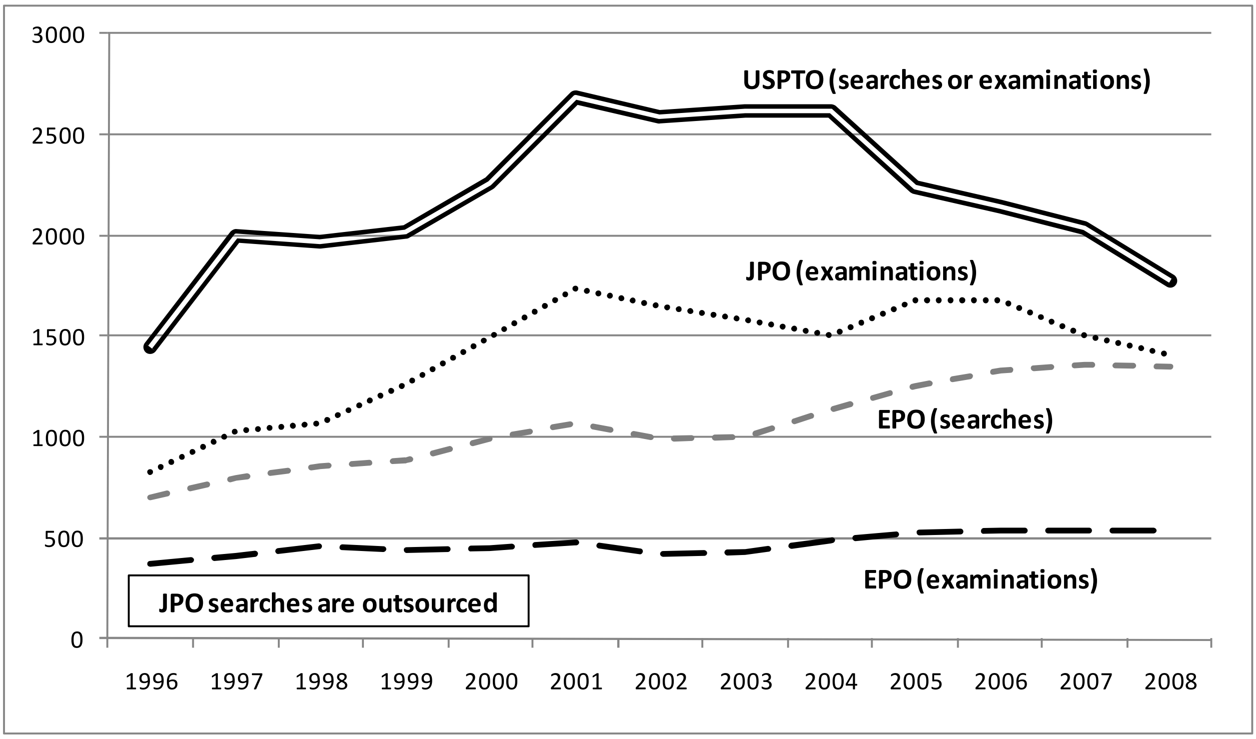
Table 2. Rigour in the patent production process, 2008

	Examiners (EX) [1]	**Filings (IN)** [2]	**Grant (OUT)** [3]	**IN/EX (search) [2]/[1]=** [4]	**IN/EX (exam)** [5]	**INC/EX (search)** [6]	**INC/EX (exam)** [7]	**OUT/EX [3]/[1]=** [8]	**Pendency in months** [9]
USPTO	6,055	448,000	159,961	74	74	1,776	1,776	26.4	32
JPO (1)	1,680	391,002	154,699	n.r.	156	n.r.	1,403	92.0	(36)+32
EPO	3,868	226,813	59,819	59	36	1,349	540	15.5	(18)+45

Data source: Own calculations based on data provided in annual reports of the three patent offices, the Trilateral Statistical Report, 2008, and the WIPO Annual Report, 2008. (1) In Japan the search process is outsourced to external organisations, which makes "per-examiner" comparisons irrelevant for searches. [5] and [7]: The share of patent applications for which a request for examination is filed is 100% at the USPTO, 94% at the EPO and 67% at the JPO. The share is smaller in Japan because the applicants can wait up to three years before requesting an examination. [6] and [7]: INC stands for the total number of claims included in patent applications, which are computed from the average number of claims per patent filed – 24 at the USPTO, 23 for total applications filed at the EPO (PCT international + EU Direct), 15 for patent applications at the EPO for which examination is required (including PCT regional), and 9 at the JPO.

The trends in workloads per examiner over the past 12 years are depicted in Figure 3. Comparing workloads is not straightforward: the JPO does not perform searches in-house, while one must clearly distinguish between the workload for searches and the workload for substantive examinations at the EPO. At the USPTO, searches and examinations must be performed for all applications. Three observations can be made from Figure 3. First, the USPTO has always had the highest workload per examiner and the EPO has always had the lowest, while the JPO has been in an intermediate position. Second, a strong convergence between the EPO and the USPTO has occurred for search workloads. The USPTO sharply reduced the average workload through the recruitment of nearly 2,000 new examiners between 2002 and 2007, whereas the EPO constantly increased the "search" workload of its staff. Third, despite the USPTO recruitment efforts, there are still striking divergences in the "examination" workload. The average EPO examiner has addressed approximately 500 claims per year over the past 12 years, compared to more than 1,700 for the average USPTO examiner and 1,500 for the average examiner at the JPO.

Figure 3. Trend in annual number of claims under search or examination per examiner, 1996-2008



Source: Own computation from USPTO, EPO and JPO information on patent filings and average number of claims, and from the Trilateral Statistical Report for data on examination rates for the JPO and the EPO.

One explanation for this considerable difference in workloads is the average time spent by examiners on each patent. Smaller workloads allow for longer pendency.[32] The EPO has the longest average pendency (63 months, 18 of which are for the search report and 45 are for the substantive examination), which is similar to the average pendency at the JPO (68 months, of which three years

[32] Informal contacts suggest that a search for prior art is performed in less than two hours at the USPTO, compared to about eight hours at the EPO (see Lemley, 2001, for detailed data on the USPTO processes). For the examination process, a US examiner spends about 13 hours per patent, compared to about 30 hours at the EPO. This is confirmed by the Federal Trade Commission (2003, chap. 5, p. 5): an average application gets only about 15-20 hours of patent examiner time.

are allowed for the request for examination and 33 months for examination), but much higher than the examination duration at the USPTO (35 months, all inclusive).

The relatively long pendency rate in Europe is not due to backlogs, but rather is endogenous and structural for five reasons. First, the slower process in Europe – longer examination pendency – means that examiners spend more time on each patent application than the time spent by examiners at the USPTO (35 months) or the JPO (33 months). Assuming that all examiners possess similar analytical skills, it can be inferred that EPO examiners' decisions are based on a more in-depth analysis of applications. This would, in turn, lead to a higher-quality patent (i.e., higher rates of withdrawal or refusal) or a higher degree of rigour in the selection process.[33] Second, the fact that a patent is validated by three examiners (the Division described in the examination skills component, see OD3.5), including a senior "chairman", requires more time than a patent granted by a single examiner. Third, as explained earlier (see OD2.8), modifications of the legal scope of protection associated with a technology are achieved through the adaptation of the priority filing in Europe and through the submission of a new (CIP) filing in the US. The adaptive process at the EPO generates interactions and communications with the examiners, which logically generates delays. Fourth, applicants in Europe can easily request "oral proceedings", which is particularly common when the examiner intends to refuse the patent or request significant amendments to the patent.[34] This results in more exchanges between the examiner and the applicant. Conversely, at the USPTO and JPO, examiners routinely issue refusals whenever the applicant's reply to the first examination report is unsatisfactory. Fifth, applicants rely on various tools to delay the grant date, which is synonymous with high costs (translations, national validation fees and national renewal fees must be covered once the patent is granted).[35]

OD3.7. Post-grant opposition process. At the EPO, the post-grant opposition process allows third parties to challenge the validity of a patent for up to nine months after the decision to grant. This process improves the quality of the European patent system, as it is much less expensive than patent litigation in court, and it allows third parties to produce new prior art or useful information regarding the validity of a patent. About 5% of granted patents are currently opposed at the EPO, while the US and Japanese systems do not have an opposition process, which means that challengers bear the burden of very high litigation costs (see Graham et al., 2002; Graham and Harhoff, 2006; and Maskus, 2006, for qualitative and quantitative arguments in favour of the introduction of a reasonably priced, post-grant opposition process at the USPTO).[36]

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[33] Lazaridis and van Pottelsberghe (2007) show that nearly half of the withdrawals can be considered as being induced by the work of EPO examiners because they occur just after a communication from the EPO.

[34] This is the "right to oral proceeding" defined in Article 116(1) of the EPC and the "right to be heard" defined in Article 113(1).

[35] The tools used to delay the grant date are listed in Stevnsborg and van Pottelsberghe (2007). For instance, Lazaridis and van Pottelsberghe (2007) show that one communication between the examiner and the applicant induces a one-year delay in the examination process, regardless of its outcome (withdrawal or grant). Mejer and van Pottelsberghe (2010) provide evidence on the sharp increase in costs that follows the granting of a patent in Europe.

[36] Graham and Harhoff's (2006) welfare calculations suggest that the benefit of a post-grant review mechanism could be nearly USD 25 billion. The main parameter affecting this estimate is not savings on the cost of litigation but the social costs of currently un-litigated patents that bestow excessive market power on some applicants. This market power either allows the patentee to extort licensing fees or forces competitors to invent around the respective patent.

LS4. Fee policies

Low fee policies across the three patent offices seem to have contributed to the trend towards a higher number of patent applications. Although they are rarely considered to be effective policy leverage, patent fees do matter. Recent quantitative evidence confirms that applicants' behaviour is influenced by the fee structure.[37] In Japan, entry fees (i.e., filing and search fees) have always been very low at virtually zero (see de Rassenfosse and van Pottelsberghe, 2008). In the US, these fees have fluctuated between USD 500 and USD 700 PPPs, whereas Europe is slightly more expensive. Up to the granting of a patent (i.e., filing, search and examination fees), Japan and the US have cumulated fees of about USD 2,000 PPPs compared to approximately USD 5,000 PPPs in Europe. Over the past 15 years, a downward trend in entry and total fees up to the grant has probably encouraged the increase in patent filings at the EPO. The relatively low fees in Japan and the US partly explain the large number of patent filings observed in these two countries (see van Pottelsberghe and François, 2009).

An affordability index (fees divided by GDP per capita), which reflects the extent to which an inventor may be able to support the cost of patenting in his or her own country, is computed by de Rassenfosse and van Pottelsberghe (2010). It shows that the US is, by far, the most affordable patent system, while the EPO is the least affordable. Japan is in an intermediate position. The authors also show that the US is the only country in the world where yearly renewal fees are lower than yearly application fees. Yearly renewal fees in the US actually decrease over time.

The fee schedule should be sufficiently high to hinder low-quality applications. At the same time, it should not prevent young, innovative companies and universities from entering the system. For this reason, the USPTO and the JPO have had an SME-specific fee schedule for many years, in which these entities pay only 50% of the fees. The EPO does not have a similar schedule that favours small entities. This aspect is more related to affordability than to quality.

Summary

The qualitative analysis presented in this section is summarized in Table 3. In order to assess the relative levels of quality for the novelty and inventiveness legal standards, the three patent offices were assessed for each of the operational design components on a 1 to 3 scale, from a low to a high stringency and transparency. The quality scale of the three patent offices for each component is motivated by the arguments provided in this section. For instance, the EPO scores 3 for the "Opposition Process" (OD2.6), compared to a score of 1 for the JPO and USPTO.

[37] It could be argued that fees should not play an important role because they constitute only a fraction of total patenting costs (which include services provided by attorneys, drafting support and searches for prior art). These costs are difficult to approximate (see van Pottelsberghe and Mejer, 2008) and are indeed substantial. See de Rassenfosse and van Pottelsberghe (2010) for a survey of studies that estimate the fee elasticity of patent demand. On average, the fee elasticity of demand for patents fluctuates around -0.3: an increase of 10% in fees induces a decline in the demand for patents of about 3%.

Since the components of a given operational design do not have the same relevance, they were positioned on a "relevance scale" reflecting the extent to which they matter in terms of satisfying the legal standard in a transparent way. Two relevance scales were created (see Table 1 and Section 4). The first (W1-3) goes from 1 to 3, while the second (weights based on bilateral comparisons, WB) was created by comparing each component with all other components (see Table 1 for a description of each component, and Appendix 1, Tables A.1 and A.2, for the bilateral comparisons of all components). The "weight" columns (W1-3 and WB) in Table 3 provide the relevance level for each component.

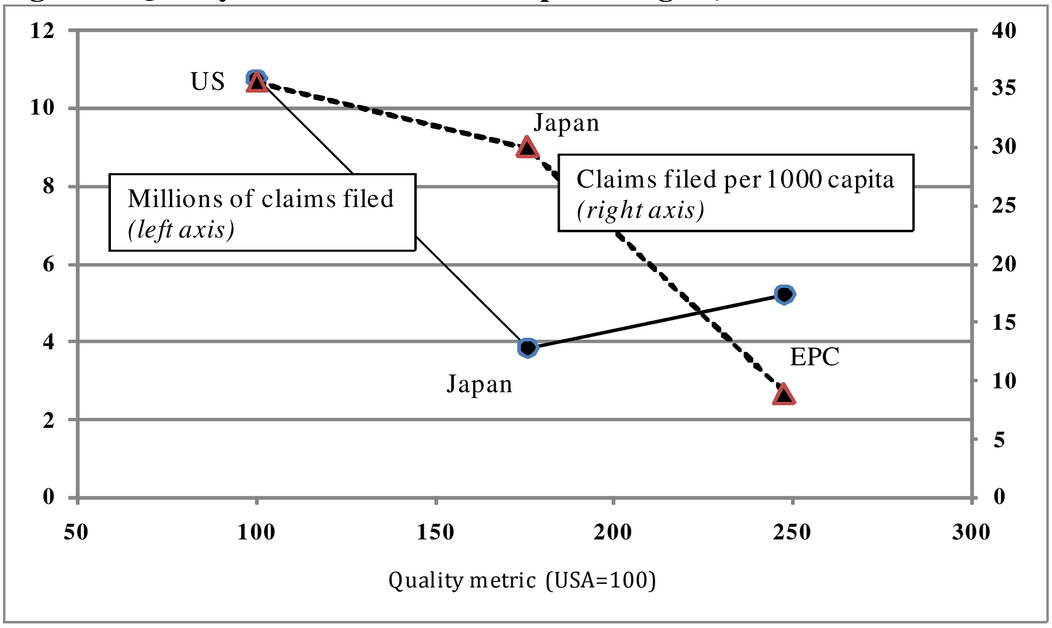
Table 3. Quality assessment of the two-layer patent system

		W1-3[1]	WB[1]	US	Japan	Europe
LS1. Patentable subject matters				*Many*	*Medium*	*Medium*
LS2. Search for prior art						
-	OD2.1. Subject matters	2	3	1	2	2
-	OD2.2. Ownership (F2F vs. F2I)	1	2	1	2	2
-	OD2.3. Identification of prior art	2	3	2	2	3
-	OD2.4. Search report	1	2	1	1	2
-	OD2.5. Language(s)	2	5	1	1	3
-	OD2.6. Opposition process	3	7	1	1	3
-	OD2.7. Grace period	1	0	1	2	3
-	OD2.8. Controlled adaptability	3	8	1	3	3
-	OD2.9. No hidden patents	2	6	1	3	3
Weighted sum of OD2.x (W1-3; USPTO=100)				***100***	***174***	***247***
Weighted sum of OD2.x (WB; USPTO=100)				***100***	***185***	***259***
Thoroughness of prior art identification				***Low***	***Medium***	***High***
LS3. Inventiveness						
-	OD3.1. Novelty test	3	4	1	2	3
-	OD3.2. Request of examination	2	2	2	2	3
-	OD3.3. Definition of inventiveness	1	0	1	1	2
-	OD3.4. Incentives	2	3	1	2	2
-	OD3.5. Skills, expertise	3	6	1	3	3
-	OD3.6. Low workload	3	4	1	2	3
-	OD3.7. Opposition process	2	2	1	1	3
Weighted sum of OD3.x (W1-3; USPTO=100)				***100***	***178***	***250***
Weighted sum of OD.3.x (WB; USPTO=100)				***100***	***200***	***261***
Rigour in inventiveness check				***Low***	***Medium***	***High***
LS4. Fees (pre and post-grant)				***Low***	***Medium***	***High***
Broad selectivity (four legal standards)				***Low***	***Medium***	***High***

(1) See Table 1 and Appendix 1 for a description of the legal standards, the components of their operational design and the relevance of these components for quality assessment.

For instance, in terms of the operational design of the novelty condition, the “ownership” and “grace period” components have a weight of 1 because they are not the most relevant factors affecting quality in patent systems (the “first-to-file” system should stimulate applicants to display their invention faster and reduces uncertainty in case of litigation; the grace period adds some uncertainty for third parties). The opposition process and controlled adaptability have a weight of 3 because they play a key role in the examination process. With the former component, third parties can submit new prior art, while the latter limits the possibility of adapting patents to existing technologies. For the operational design related to the inventiveness legal standard, the novelty condition, workload and education/experience of examiners all have a weight of 3 because they are supposed to play a key role in the patent selection process.

Figure 2. Quality level and demand for patent rights, 2008

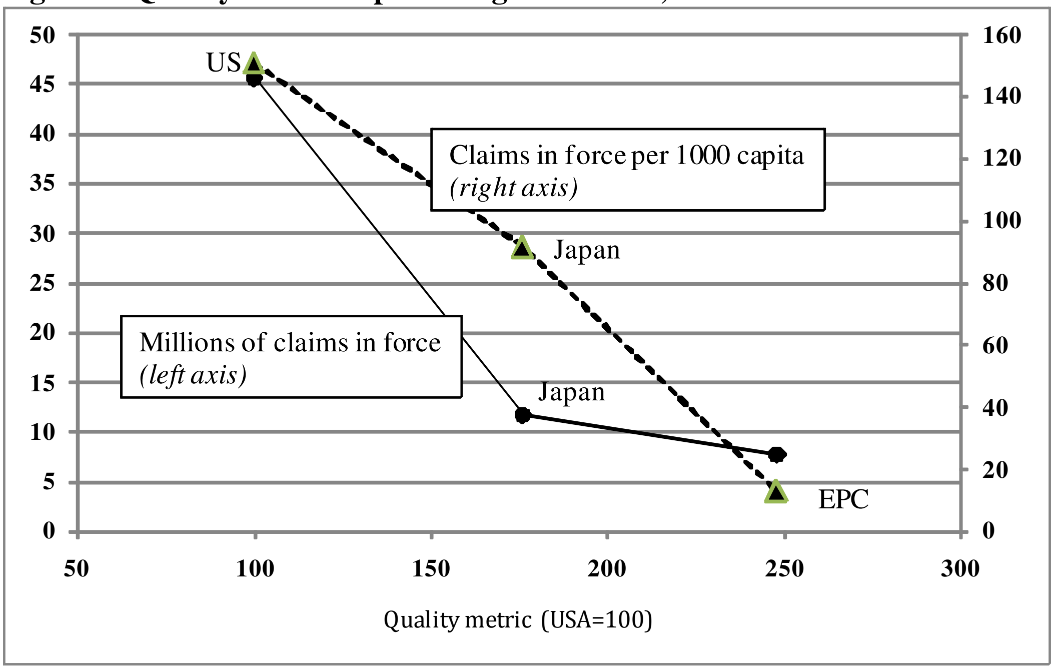


Source: see Table 3. The quality metric on the horizontal axis shows the average position for the two quality metrics (the operational designs of novelty and inventiveness) presented in Table 3 (USPTO=100; JPO=176; EPO=248). The vertical axes show the number of claims filed per 1,000 capita on the left side and the total number (millions) of claims filed on the right side (the number of claims per patent is estimated to be 24 at the USPTO, 9 at the JPO and 23 at the EPO).

In order to arrive at a broad approximation of the degree of quality of the novelty and inventiveness legal standards, the weighted sum of the ranks for the components of their operational design was computed. The results are indexed using the USPTO as a base (USPTO=100). There might be a degree of subjectivity (self-assessment by the author) in allocating the weights. However, the fact that the un-weighted sums would lead to similar results lessens this potential source of bias. Similarly, the logical elements used to rank the offices on a quality scale might be disputable and should be validated through more in-depth empirical research. However, it seems that the arguments put forward in this section provide a fair assessment of the situation. Table 3 indicates that the quality of the examination process is substantially higher in Europe than in the US, while the quality of the process in Japan falls somewhere in the middle. Using the metric developed in this paper, if the USPTO scores 100, then the JPO would score above 170 and the EPO would be at around 250.

In the US, the relatively low quality or rigor of the examination process (due to the high turnover of examiners, the heavy workload per examiner, the soft identification of prior art and the lack of an opposition process) that is associated with low fees and the fewest number of restrictions on patentable subject matter have probably led to a very high propensity to patent, as it is easy and inexpensive to get a patent granted. Even if this indicator is subject to some measurement errors, the USPTO's corrected grant rate of 87% to 97% makes it the most "applicant friendly". This high propensity to patent probably has given rise to enlarged backlogs. At the opposite end of the spectrum is Europe, where a thorough identification of prior art, associated with high rigour in the examination process and high fees, has led to relatively low demand for patents and a much less worrying backlog. Japan is in an intermediate position. For some components of its operational designs, it is closer to the US, while it is closer to Europe for others.

Figure 3. Quality level and patent rights in force, 2008



Source: see Table 3. The quality metric on the horizontal axis shows the average position for the two quality metrics (operational designs of novelty and inventiveness) presented in Table 3 (USPTO=100; JPO=176; EPO=248). The vertical axes show the number of granted rights in force, with the number of patents on the left side and the number of claims on the right side (the number of claims per patent is estimated to be 24 at the USPTO, 9 at the JPO and 15 at the EPO). As the patent system in Europe is fragmented, counting all patents enforced would lead to a large amount of double or triple counts. The figure represents the number of patents enforced in Germany (as a proxy for Europe), where 95% of EPO patents are validated after they are granted.

The ultimate consequence of these heterogeneous degrees of quality across patent systems can be gauged through the demand for patent rights, or through the number of patents or claims in force in the three geographical areas. Figure 2 presents the relationship between the degree of quality in a patent system, and the number of claims filed in absolute and relative terms. About 35 claims per 1,000 capita are filed at the USPTO per year (more than 10 million claims were filed in 2008), compared to 8 in Europe (more than 5 million claims were filed in 2008). In Japan, 27 claims were filed per 1,000 capita (nearly 4 million claims). The two curves indicate a logical negative relationship between quality and the demand for patent rights.

Figure 3 depicts the relationship between the degree of quality in a patent system and the number of patent rights (or claims) in force in absolute and relative terms. About 46 million claims are in force in the US, compared to 8 and 12 million in Europe and Japan, respectively. A similar relationship is evident in terms of the number of claims per 1,000 capita. In other words, the lower the degree of quality in a patent office, the higher the number of patents – of questionable legitimacy – in force in the system.

6. Conclusions and policy implications

The main objective of this paper is to test whether the quality of the examination services performed by a patent office can affect the demand for patent rights. This broad objective requires a methodology for assessing the degree of quality in patent systems and measuring the extent to which quality varies across countries. The paper claims that a systemic approach must be adopted in order to compare quality across patent systems. Economic analyses of quality in patent systems to date have frequently relied on ill-defined concepts of "strength" or "breadth". Whereas these two concepts are useful for theoretical modelling, they have limited concrete implications for policy. In addition, output rates, such as grant rates or litigation rates, can be biased by the strategic behaviour adopted by applicants and are hardly comparable across countries because of their systemic differences.

This paper, therefore, offers a new methodological framework that takes the systemic dimension of patent systems into account. The concept of quality is defined as the extent to which patent offices comply in a transparent way with the main legal standards that rule patentability conditions in their jurisdiction. The methodology consists of a two-layer analytical framework composed of "legal standards" (first layer) and their "operational design" (second layer). Four legal standards are taken into account: subject matter, novelty, inventiveness and the fee schedule. Patent offices have similar codified rulings related to the novelty and the inventiveness requirements. Therefore, an in-depth analysis of the operational designs put in place to comply with these requirements must be performed in order to assess quality. Several components of the operational designs of the novelty and inventiveness requirements are identified. These components vary in relevance (two relevance metrics are used) and allow to compare patent offices on a Likert scale (from 1 for a low contribution to the selection mechanism and weak transparency to 3 for a high contribution and strong transparency). This methodological approach leads to two main conclusions and one policy implication.

First, a country's legal standards and the components of their operational design interact with each other and form a coherent system. For instance, the soft identification of prior art (or incomplete search reports for the novelty legal standard) may undermine the inventiveness legal standard. Similarly, the patentability of controversial subject matters (e.g., business methods) affects the quality of search reports because prior art for these subject matters is not accessible or imperfectly codified. Further research should aim at validating the list of components that should be taken into account when characterizing operational designs, their level of relevancy and the ratings of patent offices. However, I believe that the selected components and their assessment provide a fair preliminary approximation of quality in patent systems.

Second, the analysis of three major economic areas (Europe, the US and Japan) highlights significant international differences in the extent to which patent systems fulfil their objectives. The patent selection process at the USPTO is less rigorous and transparent than at the EPO, as evidenced by the soft, flexible identification of prior art and the lesser degree of inventiveness. This lower rigour and transparency, coupled with low fees, has led to an unmatched, unprecedented number of yearly applications and patents of dubious quality being put into force (nearly 50 million claims) in the US market. There appear to be fewer divergences in terms of the legal standards that set the patentability conditions than in terms of operational design, which include the education and experience of examiners, their incentives, their workloads, and operational routines, such as requests for examination, the opposition process, publication of search reports, or the ease of adapting the scope of protection through claim changes or the filing of continuation in parts. In Europe, more restrictions on patentable subject matters, higher rigour in the identification of prior art, stricter evaluations of inventiveness and high fees translate into a significantly lower number of patent applications than at the USPTO and fewer patents being in force in the market (approximately 8 million claims are in force in Europe). Japan is in an intermediate position.

Gallini (2002) attributes the decline in patent standards largely to "the sharp rise in [patent] applications on products and processes in new subject areas for which the U.S. Patent and Trademark Office has limited expertise or access to prior art". This idea is firmly grounded, but the reverse causality is probably even stronger: lower standards induce more applications, because it is easier to get a patent granted. A vicious cycle therefore arises in which lax patent standards induce more applications, which in turn further reduces quality standards, as examiners become overloaded. This is the main hypothesis put forward by Jaffe and Lerner (2004) to explain the "broken" patent system in the US. Policy makers at large (politicians, patent offices, judges) would have designed the patent system in such a way that its current plight was inevitable. The present paper provides further empirical evidence in support of their hypothesis.

One important policy implication concerns ongoing attempts to converge towards a global patent system, whereby the largest patent offices would enter into work sharing and eventually a mutual recognition process in which a patent granted by office Y would be automatically granted by office Z. This desire for cooperation is evidenced by the growing number of bilateral Patent Prosecution Highway (PPHs) pilot projects signed and operated by the USPTO, the JPO, the EPO and several other national patent offices in Europe or Asia. Under the PPHs, a patent office Z that receives a search report or examination report made by another patent office Y must perform its own search and examination reports much faster than would be required for a regular application. However, this work-sharing process (embedded with some sort of mutual recognition) can harm the patent system of country Z if the degree of quality in patent office Y is manifestly lower. This issue is particularly relevant for EPO examiners, who bear the legal duty to perform a relevant search report themselves.

As long as the quality of the examination process is not harmonised among major patent offices and as long as their operational designs diverge, moves towards several bilateral work sharing and mutual recognition agreements might actually drive global patent quality down towards the lowest quality level possible. Prior to entering into mutual recognition processes, patent offices should converge in terms of their operational designs, a process that requires them to tackle painful questions related to examiners' incentives, education, training and workloads. In addition, post-grant opposition processes, intermediate requests for examination and the degree to which patent applications can be adapted during the examination through continuation in parts or divisional applications (i.e., controlled adaptability) must also be similar. In this respect, the components of the operational designs presented in this paper can act as a useful "checklist" for a potential convergence process. Furthermore, one must keep in mind that although Europe performs better in terms of quality, it does little in terms of accessibility or affordability for young, innovative companies, universities and scientists. Several components of a patent system's operational design exist to provide easier access to the system, including sharp fee reductions for SMEs and a grace period. These details do not improve the degree of quality in a patent system but they might ensure that those for whom the patent system was originally created can make use of it.

Thomas Jefferson (1794) penned perhaps one of the most well-known mottos: "Patents should draw a line between the things which are worth to the public the embarrassment of an exclusive patent, and those which are not. Patents are, after all, government-enforced monopolies and so there should be some 'embarrassment' (and hesitation) in granting them".[38] This illustrates the importance, in the eyes of a former president of the United States, of deploying a rigorous examination process to ensure a sound patent policy. An opposing view was advocated by Mark Lemley (2001) in his "rational ignorance" argument, whereby patent offices should not devote too many resources to examination because only a few patents are worthy of those resources, and these can be properly assessed in litigation proceedings. The economic literature provides little insight about the optimal degree of quality or rigour that should prevail in a patent system. In fact, the two extreme levels of quality could actually be detrimental to innovation. This paper, therefore, aims to contribute to the debate by developing a methodological framework that allows for assessments and comparisons of quality across patent offices. Our findings suggest that the EPO is closer to Jefferson's perspective, whereas the USPTO is closer to the "rational ignorance" pathway. However, it is still unclear whether Europe is already too low on the quality ladder or whether the US is still too high.

[38] Quoted in the signature of Michael Murer, Examiner on Sporting Goods, European Patent Office, in an email received on March 31, 2010.

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Appendix 1. Relevance of operational design components

Tables A.1 and A.2 present a pair-wise comparison of all of the components of an operational design. A "1" means that the row component is more important (or relevant) for quality than the column component. The simple sum (last column) provides a weighting scheme for the relevance of each component.

For the novelty legal standard, the most important components of operational design are controlled adaptability (8), the opposition process (7) and the difficulty of hiding patents (6). The components with low relevance are the grace period (0), the ownership rule (2) and the publication of a search report (2).

Table A.1. Relevance scale for the operational design of the novelty legal standard

	OD1	OD2	OD3	OD4	OD5	OD6	OD7	OD8	OD9	SUM
OD2.1. Subject matters		1		1			1			**3**
OD2.2. Ownership				1			1			**2**
OD2.3. Identification of prior art	1	1					1			**3**
OD2.4. Search report			1				1			**2**
OD2.5. Language(s)	1	1	1	1			1			**5**
OD2.6. Opposition process	1	1	1	1	1		1		1	**7**
OD2.7. Grace period										**0**
OD2.8. Controlled adaptability	1	1	1	1	1		1	1	1	**8**
OD2.9. No hidden patents	1	1	1	1	1		1			**6**

For the inventiveness legal standard, the most important components of operational design are skills (6), the novelty test (4) and the low-workload patents (4). The components with low relevance are definition of inventiveness (0), the request for examination (2) and the opposition process (2).

Table A.2. Relevance scale for the operational design of the inventiveness legal standard

	OD1	OD2	OD3	OD4	OD5	OD6	OD7	SUM
OD3.1. Novelty test		1	1	1			1	**4**
OD3.2. Request of examination			1			1		**2**
OD3.3. Def. of inventiveness								**0**
OD3.4. Incentives		1	1			1		**3**
OD3.5. Skills	1	1	1	1		1	1	**6**
OD3.6. Low workload	1		1	1			1	**4**
OD3.7. Opposition process		1	1					**2**