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A QUALITY INDEX FOR PATENT SYSTEMS

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ABSTRACT

A quality index for patent systems*

This paper presents a quality index for patent systems. The index is composed of nine operational design components that help shape the transparency of patent systems and affect the extent to which they comply with patentability conditions. Seven factors are related to rules and regulations (e.g., grace period, opposition process and continuation-inparts), while two factors measure patent offices' resource allocation (i.e., workload per examiner and incentives). The index is computed for 32 national patent systems, it displays a high heterogeneity across countries. Cross-sectional quantitative analyses suggest that the demand for patent rights—or the propensity to patent—is lower in patent systems with a higher quality index, controlling for research efforts, patent fees and the "strength" of enforcement mechanisms.

JEL Classification: O30, O31, O34, O38 and O57
Keywords: intellectual property, patent propensity, patent system and quality

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1. Introduction

Recent policy debates in the US have focused on the importance of the quality of patent examination processes (stringency of patent-selection mechanisms). In fact, the US Patent and Trademark Office (USPTO) is often criticized for its propensity to grant many patents of low quality.[2] In contrast, the European Patent Office (EPO) is perceived as being more stringent. Apart from these perceptions, no or little evidence is available on the stringency or transparency of selection mechanisms in patent systems. Furthermore, studies of how these differences might influence the behavior of innovating firms are lacking.

As a matter of fact, the quality of patent systems – defined here as the stringency and transparency of patent selection mechanisms – has received relatively little attention in the economic literature. From the early theoretical investigations onwards, the focus has been on the “strength” of patent systems, which is generally assumed to affect the rate of innovation. The “strength” terminology is not typically used to reflect the degree of quality in the selection process. Instead, a patent system is commonly classified as *stronger* when more domains are patentable (Gallini, 2002), when the period of patent protection is longer (Grossman and Lai, 2004), or when the geographical scope is enlarged (Scherer, 2002). The indices of “patent rights” produced by Ginarte and Park (1997), and the updated versions published by Park (2008) for 110 countries and by Lerner (2002) for 60 countries, crystallize this tendency to define “strong” patent systems as those that are essentially applicant friendly. *Applicant friendliness* is a more relevant term because the index rises when more technological areas are patentable, when patents have a longer duration or when patents provide the patent owners with greater legal power.

The most common approach to empirically gauging quality within or across patent systems relies on “selection rates”. Scholars compare grant rates (e.g., Guellec and van Pottelsberghe, 2000; Palangraya et al.,2011) or litigation rates (including opposition rates, see Graham et al., 2002). A patent that is granted or that resists litigation is assumed to be of high quality. This approach, while undoubtedly useful, is subject to a series of biases (see van Pottelsberghe, 2011), as applicants may adopt heterogeneous filing strategies across industries and countries, and as many “borderline” patents are never litigated.

Studies of patent litigation actually focus on only the top of the “patent iceberg” (the most valuable patents are subject to litigation). The focus is rarely on the quality of the selection mechanism. Some authors explicitly consider the filtering process in their theoretical models (e.g., O’Donoghue, 1998; Dewatripont and Legros, 2008; Farrell and Shapiro, 2008) and find that more stringent selection mechanisms induce more effective incentives to innovate. The quality of examination processes has also received increasing attention in recent years, especially among authors focusing on the US patent system. Jaffe and Lerner (2004), Maskus (2006), Quillen (2008), and Bessen and Meurer (2008) implicitly or explicitly raise the hypothesis of a vicious cycle in which a low-quality selection standard leads to the filing of more low-quality applications, which in turn reduces the examination quality because examiners become overloaded. Such authors frequently argue that the low patentability standard in the US is mainly driven by the Court of Appeals of the Federal Circuit (CAFC), because judges create jurisprudence with their decision, especially regarding patent invalidation proceedings. Although this argument is valid to some extent, it should not hide

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[2] See, for instance, “Patent reform: the spluttering invention machine – America’s patent system has problems; a new law would fix only a few” (*The Economist*, March 17, 2011).

the fact that many factors shape the quality and transparency of patent selection mechanisms. Scholars have rarely systemically investigated the processes put in place to check patentability. When they have done so, they have tended to explore only the US patent system (i.e., Quillen (2006) and Burk and Lemley (2003)).

To the best of our knowledge, van Pottelsberghe (2011) provides the first international systemic comparison of patent system quality. The author compares the operational designs of three major patent systems (Europe, Japan and the US) to investigate the extent to which the conditions of novelty and inventiveness are met in a transparent way. The international heterogeneity of operational designs may ultimately lead to different degrees of rigor and transparency in patent selection processes. The composite index built by the author confirms that there is substantial variation in quality across the three patent systems and graphical evidence suggests that the degree of quality is negatively correlated with the demand for patent rights. As a graphical representation of three points provides only partial evidence, there is an obvious need for further investigation into the impacts of the stringency and transparency of patent selection mechanisms on applicant behavior.

The objective of this paper, therefore, is to empirically test whether the degree of quality of patent systems – defined as the extent to which patentability standards are met in a transparent way – affects the behavior of applicants, especially in terms of their propensity to patent. This objective requires, first, the construction of a "quality" index and, second, the inclusion of this index in a quantitative model designed to explain variations in the demand for patent rights across countries.

The quality index presented in this paper is based on nine operational design components. The index is computed for the national patent systems of 32 countries. In each country, more than 1,800 patent applications were filed in 2008. The components include seven structural factors (e.g., grace period, opposition process, hidden applications) and two resource allocation factors (i.e., workload per examiner and incentives). The quantitative analysis aims to explain various alternative indicators of demand for patent rights on the basis of the quality index, controlling for research efforts, patent fees and the strength of enforcement mechanisms.

The paper is structured as follows. Section 2 presents the methodology used to compute the quality index from nine components of patent systems' operational designs. Section 3 presents and compares the indices computed with three alternative weighting schemes. Section 4 is devoted to the empirical model, which aims to evaluate the impact of the quality index on the demand for patent rights. Section 5 concludes and presents several policy implications. The results confirm that there is significant variation in quality across countries, and that these variations, together with research efforts, patent fees and enforcement mechanisms, help to explain important cross-country variations in the demand for patents.

2. The quality index and its nine components

In this paper, quality is defined as the extent to which patent systems comply in a transparent way with their legal patentability standards: the novelty and inventiveness conditions. The novelty condition requires that the codified invention is new to the world. In other words, the invention cannot be published or presented at a conference before the patent application is filed. The inventiveness condition requires that the invention contribute sufficiently to the state of the art; in other words, it must be non-obvious for a person skilled in the art. These two legal standards might be similarly codified in patent systems but their implementation, or the extent to which they are fulfilled, varies significantly across countries. The degree to which a legal standard is satisfied depends on the operational design of the patent system in general and resource allocation practices put in place by the patent office in particular. Significant divergences in operational designs may lead to different degrees of quality (or rigor). van Pottelsberghe (2011) relies on several operational design components to investigate the novelty and inventiveness conditions. The present paper includes nine components, which were chosen for their relevance and information availability.

The operational designs of the 32 patent systems investigated here include seven structural (or legal) components and two managerial components that reflect patent offices' resource allocation profiles. These nine components help shape the quality of patent selection mechanisms. They include: (1) the ownership of an invention, (2) the intermediate search report during the examination process, (3) the allotted period for an examination request, (4) post-grant opposition, (5) the grace period, (6) the option to hide patent applications, (7) the option to adapt patents through continuation-in-parts and other mechanisms, (8) resource allocation per examiner and (9) the examiners' workload per examiner.

Each of these components takes a value ranging from 0 to 1 for each patent system. The unweighted sum of these nine values gives the unweighted quality index (QUW). Two alternative weighting schemes could be used as well: the first is based on a relevance scale of 1 to 3 (QW13), while the second is based on a bilateral comparison of each component (QWB). Formally, if the metrics for the nine operational design components are designated as $\{x_1, x_2, \ldots, x_9\}$ and if $\{w_1, w_2, \ldots, w_9\}$ denote the nine weights assigned to each operational design component, the index for each country is computed as follows:

$$\sum_{i=1}^{9} w_i x_i \quad , \qquad (1)$$

where $\sum_{i=1}^{9} w_i = 1.$

In the unweighted index (QUW), each component is, in fact, equally weighted (w=0.11). Higher values of the index indicate better quality. Each operational design component is defined in the following subsections. In addition, the metric is presented and its potential impact on quality is explained. In-depth explanations and justification are available in van Pottelsberghe (2011). Appendix Table A1 summarizes the metrics and their potential impacts on quality. Appendix Table A2 displays the components' values for the 32 patent systems.

2.1 Invention ownership

In the vast majority of countries, a patent is awarded to a person or firm that is the first to file a patent application for an invention, regardless of the identity of the first person or organization to really invent it. In opposition to this "first-to-file" rule, there is a "first-to-invent" principle, which is not based on the identity of the first person or institution to file a patent for that invention. This existence of two systems affects quality and transparency in two ways. First, the “first-to-file” principle has the advantage of stimulating early disclosure of inventions and, hence, makes new knowledge 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. Second, in case of litigation, patent disputes often start with the right of ownership, where the "true" first inventor must be identified. This identification can be complex and time consuming. As a result, the "first-to-file" rule improves the quality of patent systems through two mechanisms: the faster diffusion of knowledge and the lower uncertainty on the market for patents. This component is codified as a binary character, where a value of 1 indicates better quality of the patent system.[3]

$$x_1 = \begin{cases} 1 & \text{if the prevailing system is "first-to-file".} \\ 0 & \text{if the prevailing system is "first-to-invent".} \end{cases}$$

2.2 Publication of a search report

In virtually all patent systems, novelty is the first condition that must be met for the granting of a patent. This novelty condition is assessed with respect to the state of the art (i.e., everything that was accessible to the public prior to the filing date by means of a written or oral description, prior usage or any other means).

A search report aims to provide the applicant with a first assessment of the invention's patentability. It covers all relevant prior art and can be accompanied by a non-binding opinion on patentability (this is the case for patents that follow the international Patent Cooperation Treaty (PCT) route). Therefore, a search report provides the applicant with important information and helps to further increase the drop-out rate. Applicants will drop out of patent applications for which it is not deemed worthwhile to perform a substantive examination given the information that is brought to their attention in the search report. In other words, published search reports improve the self-selection process and, hence, reduce examiners' workloads. Moreover, the search report is generally published along with the patent application 18 months after the priority date, which allows third parties to indentify and assess the invention in a transparent way. This component is codified as a binary character:

$$x_2 = \begin{cases} 1 & \text{if the patent office provides and publishes a search report.} \\ 0 & \text{if it does not.} \end{cases}$$

2.3 Examination request and term to request an examination

A majority of patent offices perform substantive examinations in order to assess whether a patent application complies with the legal inventiveness standard (referred to as "non-obviousness" in the US) and, hence, whether the patent should be granted. Some patent offices only provide registration services and do not undertake substantive examinations or searches for prior art.

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[3] Scotchmer and Green (1990) argue that, in a 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 Scotchmer and Green's 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.

Even when a patent office carries out substantive examinations, the filing of a patent application does not necessarily automatically lead to an examination. Some patent offices require the applicant to request an examination before a pre-determined deadline. This requirement to submit a request for an examination gives the applicant more time to assess the financial value of the patent. This self-assessment can rely on a search report (if available) and/or on the valuation strategy of the patent, including its commercial value. This self-selection process reduces the workload of patent offices, as only the most promising patents will be examined. For instance, Lazaridis and van Pottelsberghe (2007) show that, for the EPO, 35% to 40% of all withdrawals take place before a request for examination is made. The majority of these withdrawals occur just after the search report is provided. For the Japan Patent Office (JPO), Yamauchi and Nagaoka (2009) show that the 2001 shortening of the request for examination period (from seven years to three years after the application date) 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. Therefore, the presence of a request for examination requirement has a positive influence on the patent systems, as it allows for a self-selection process and reduces the number of examinations that are performed for patents that will not be used.

The drawback of this system is that it extends the overall time to process the examination. The unexamined applications may block other firms' innovative projects for a longer time. In brief, a request for examination requirement positively influences the quality of the patent system. However, if the period in which an applicant can submit an examination request is lengthy, quality will be negatively affected, as this creates a lack of transparency (and more uncertainty on the market). The codification of this operational design component takes this dual influence into account by relying on the following formula if a substantive examination must be requested:

$$x_3 = 1 - \frac{\text{term to request examination}}{\max\{\text{term to request examination}\}},$$

where the *term to request examination* is computed in years from the filing date and the *max {term to request examination}* is seven years, which corresponds to the longest allotted term to request an examination of all patent offices in the sample. For example, if a patent office has a term to request an examination of two years from filing, its score is: $1 - \frac{2}{7} = 0.7$. The longer the duration of the term to request an examination, the lower the quality of the patent system because third parties and would-be competitors must wait longer to identify proprietary technologies. If the patent office does not have a requirement for a request of examination or merely does not undertake any substantive examination, $x_3 = 0$.

2.4 Post-grant opposition

The post-grant opposition process allows third parties to raise objections to the granting of a patent. The opposition can be filed during a limited period of time after a decision to grant a patent is made by a patent office. The process is associated with much lower costs than “regular” litigation (litigation generally starts with a patent validity challenge). In this process, third parties may challenge the patentability of an invention by submitting prior art that could have not been identified by the examiners or by submitting additional arguments against the inventiveness of the innovation. This correction mechanism improves the identification of prior art and frequently leads to revocation (in about one-third of all patents that are opposed) or amendments (in about one-third of cases) of granted patents.

The period during which third parties can file an opposition varies across countries included in the sample from three to twelve months after the final publication of the granted patent. Accordingly, the coding scheme of this component is constructed as follows:

- If there is no possibility to file a post-grant opposition; $x_4 = 0$.
- If there is a possibility to file opposition the following function is used:

$$x_4 = \frac{\text{term to file a post grant opposition}}{12},$$

where the *term to file a post grant opposition* is expressed in months after the decision to grant the patent by the patent office. This function indicates that the longer the post-grant opposition period, the higher the quality of the system.

2.5 Grace period

A grace period is a period during which the inventor is allowed to file a patent after the publication of the invention, which generally occurs in scientific working papers or at conferences. In the absence of a grace period, a published invention cannot be granted a patent because it fails to meet 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 published material to “reserve” their inventions for a certain period of time without the inconvenience or cost of filing a patent. It also delays the date at which the invention will “truly” fall into the public domain (see Franzoni and Scellato, 2010).

For third parties, therefore, the grace period is 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. As a result, although the grace period makes the system more accessible to scientists and technology-based start-ups, it decreases the system’s quality, as there is more uncertainty on the market due to the lack of transparency. This component illustrates that accessibility and quality in patent systems are not always compatible.

Grace periods last six or twelve months, and are codified as follows:

$$x_5 = 1 - \frac{\text{Grace period}}{12},$$

where the term *Grace period* is expressed in months. A system with no grace period has a value of one.

2.6 Hidden applications

Patent applications are generally kept secret (unpublished) for 18 months from the date of the first filing, after which the patent application is automatically published. Consequently, it is possible to hide an application if it is refused by an examiner or withdrawn by the applicant before the official publication date. However, some patent offices, especially the USPTO, allow an applicant to hide a domestic application throughout the entire examination process. This practice introduces uncertainty on the market, especially for entrepreneurs who are active in the technological area covered by hidden claims. Furthermore, this possibility hampers other patent offices from identifying the patent application as part of prior art. It also encourages "submarine" strategies of keeping a patent pending (and, hence, unpublished) until it is granted and then enforcing it immediately. As a result, the possibility of hiding patent applications decreases the quality of a patent system, especially in terms of transparency.

This component is codified as a binary character:

$$x_6 = \begin{cases} 1 & \text{if the applications are published after a period of maximum 18 months from the} \\ & \text{filing date and there is no possibility to hide the application.} \\ 0 & \text{otherwise.} \end{cases}$$

2.7 Adaptability

Applicants naturally try to obtain the widest scope of patent protection in order to maximize the strength of their patent in case of litigation. Furthermore, as technology evolves, patent owners try to adapt their claims to fit the latest design of their invention. This can be achieved through a continuation-in-part application (CIP), which can be defined as "an application filed during the lifetime of an earlier application, repeating some substantial portion or all of the earlier application and adding matter not disclosed in the earlier application" (AIPPI, 2007, p. 1). CIPs are therefore linked to an original prior application and share its priority date. CIPs may add, change or withdraw numerous claims to the original application. They can be used by the applicant to maintain important claims under examination, thereby delaying the examination process while enlarging the scope of protection. The possibility of adding claims using CIPs provides an incentive to file further applications and adapt the scope of the intellectual property to the evolution of the technology. This practice not only creates a substantial opportunity to adapt patents but it also artificially increases the number of patent applications.[4]

Another way for patent owners to adapt their patent to the latest design of their invention is to file a "patent of addition". Patents of addition can be defined as "patents filed during the lifetime of an earlier application and which relate to an improvement or modification of the invention of the earlier application not having been disclosed in the earlier application" (AIPPI, 2007, p. 1). A patent of addition is an accessory of an earlier patent and expires at the same time as the original patent (i.e., the two have the same priority date). This process enables a patent holder to protect any change or development that has been made to the invention, even if that change or development is devoid of inventiveness, provided the subject matter is included in the same inventive concept.

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[4] Companies are increasingly using CIPs in the US, as illustrated by Quillen and Webster (2001), Quillen et al. (2002) and Hedge et al. (2009). Hedge et al. (2009) show that about 30 percent of all yearly US corporate-assigned patents include at least one continuation.

In short, these two types of flexibility or adaptability arrangements allow applicants to adapt their patents by modifying or enlarging the scope of protection, and therefore increase the degree of uncertainty in the system. This is especially true for third parties, as such possibilities lessen their ability to have a realistic overview of the rights that may have an impact on their freedom to operate. As a result, the possibility to file continuation-in-part applications or patents of addition decreases the quality of patent systems. This component is codified as follows:

$$x_7 = \begin{cases} 1 & \text{if CIPs } \textbf{and} \text{ patents of addition are not allowed.} \\ 0 & \text{if CIPs } \textbf{or} \text{ patents of addition are allowed.} \end{cases}$$

Note that other types of flexibility arrangements, such as divisional applications, could also be considered. These applications generally include a large number of claims, and they 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 behavior of the applicant) or to hide some of the claims (among several hundred). This type of arrangement is not considered in this paper because almost all patent offices allow this practice in order to overcome unity objections raised by the examiner and still retain the original priority date.[5]

2.8 Incentives

The literature on agency theory (e.g., Friebel et al., 2006) in relation to patent offices emphasizes that explicit incentive mechanisms can be powerful tools in cases of information asymmetries between an organization's management and its employees. The incentive to perform a high-quality examination is clearly related to employment conditions, including benefit packages and examiners' salaries. High benefits packages could act as a performance incentive and may also reduce employee turnover, which would, in turn, translate into more experienced examiners. In contrast, weak benefit packages may ultimately lead to higher turnover among examiners. It can fairly be assumed that high benefit packages for examiners should improve the quality of the overall patent system, through the recruitment of highly skilled examiners for permanent positions, implicitly retaining experienced ones.[6]

Unfortunately, salary scales are rarely public information and, when they are, "only" data on the gross remuneration package is generally available. In addition, many other dimensions (e.g., holidays, taxation, allowances for children, allowances for home leave, allowances for education costs, retirement schemes, health insurance coverage) must be taken into account, which makes international comparisons of compensation packages difficult. An alternative method is used by Picard and van Pottelsberghe (2011), who rely on total personal expenses per employee or per examiner. In the present paper, total personnel expenses divided by total staff is used as a proxy for the benefit packages of a patent office's employees. This measure is expressed in US PPPs (US purchasing power parities) to take stock of differences in price

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[5] In Europe, divisional applications are allowed. However, abusive reliance on this option has been limited since April 2010, when the EPC (European Patent Convention) decided to substantially reduce the period during which a divisional application can be filed (prior to April 2010, unlimited subsequent divisional applications were allowed with the extreme case being that claims could be pending for nearly twenty years). The US system allows for intense use of divisional applications.

[6] Some authors, like Lemley (2001), argue that no or little resources (in terms of budget or examiners' time) should be allocated to the examination of patent filings because only a few of them will reach the market and be associated with financial returns. The minority of high-value patents should then be assessed only in case of litigation.

levels across countries. The following formula is used to compare patent offices' incentive mechanisms:

$$x_8 = \frac{personnel\ expenses\ per\ total\ staff}{\max\{personnel\ expenses\ per\ total\ staff\}}.$$

x_8 varies between zero and one. The higher the ratio, the more an office devotes financial resources to examiners' compensation packages. It is assumed that a higher ratio (a higher budget per employee) translates into better incentives and, hence, into more motivated and experienced examiners, and lower turnover (cf. van Pottelsberghe, 2011). The higher the ratio, the higher the quality of the selection process.

2.9 Workload

If the workload per examiner is too high, it could have a negative impact on the quality of the examination process, as examiners would be forced to perform their task faster. They would, therefore, undertake a less thorough investigation of novelty and inventiveness. However, a comparison of examiners' workloads across patent offices is far from straightforward.

The first challenge arises from the fact that patent applications across countries have not the same size in terms of the number of pages or the number of claims per patent (van Zeebroeck et al. (2009) and de Rassenfosse and van Pottelsberghe (2011)). As a measure, therefore, the number of patent applications per examiner would provide a biased picture of relative workloads across countries. An alternative, less biased indicator is the total number of claims filed – measured as the average number of claims per patent multiplied by the number of patent applications – per examiner. A second challenge stems from the fact that patent offices do not have the same examination standards. For instance, not all patent offices perform substantive examinations. Therefore, computing examiners' workload for a "registration-only" office is logically meaningless.[7]

In brief, the workload is assessed as the total claims filed per examiner. A high workload is assumed to have a negative effect on quality, given that examiners must execute their work faster, which should translate into less thorough examinations. The index component related to workload is computed for each patent office as follows (all values fall between zero and one):

$$x_9 = 1 - \frac{claims\ per\ examiner}{\max\{claims\ per\ examiner\}}\ \textbf{and}$$

$$x_9 = 0 \quad \text{if there is no substantive examination,}$$

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[7] A third challenge originates from the fact that the examination process can be partially outsourced by the patent office. For instance, the Japan Patent Office (JPO) outsources search reports to independent organizations. Therefore, the apparent workload could be overestimated (an examiner who does not perform search reports can treat nearly twice as many patents; cf. Picard and van Pottelsberghe, 2011). However, this outsourcing effect is not taken into account for several reasons. First, this practice is believed to reduce the quality of the patent systems because it does not contribute to the examiners' knowledge of the prior art, as examiners receive the reference lists from third parties and must assess the inventive step on the basis of these reference lists. Second, this practice involves many sources of potential information asymmetries regarding the competencies of private companies and potential conflict of interests.

where *max{claims per examiner}* designates the highest workload in the sample. The higher the workload, the lower the ratio will be and, thus, the lower will be the quality index. If a patent office does not perform any substantive examinations, the component is set to 0.

3. Three weighting schemes and the index values

The nine quality index components of equation (1), which are presented in the previous subsection, all have values that range from 0 to 1. They capture aspects of operational designs that are expected to affect the broad quality of a patent system: the stringency of its selection process and its transparency. The quality index is computed for the most important patent offices worldwide in terms of yearly patent applications. All patent offices with more than 1,800 patent applications in 2008 are considered, which leads to a sample of 40 countries. However, as it was difficult to access reliable information for eight countries, the final sample includes 32 countries.[8] The index is computed using the latest available data for the years 2008 or 2009. Appendix Table A1 summarizes the metrics and formulae used to measure the nine index components and briefly explains how they could affect quality. Appendix Table A2 displays the values for each of the nine operational design components for the 32 patent systems.

Equation (1) can be computed with or without weights. A computation without weights would mean relying on the same weight for all components. However, the use of a specific weighting scheme would suggest that some components are more important than others in terms of ensuring a transparent and thorough selection process. Two alternative weighting schemes are considered. The first (W13) is constructed by allocating each component a relevance score on a 1 to 3 Likert scale. A value of 1 reflects low relevance for the quality of patent systems, while a value of 3 reflects high relevance. The second weighting scheme (WB) is constructed using a bilateral comparison of all components. Appendix B (cf. Tables B1 and B2) describes these two weighting schemes and presents their values. These values are mainly driven by a self-assessment based on logical considerations (cf. van Pottelsberghe, 2011). Table 1 provides the Spearman's rank correlations[9] (r_s) among the three indices. These correlations are higher than 0.85, which suggests that the rank sensitivity is generally low. The quality ranking of patent systems is not significantly affected by the chosen weighting scheme.

Table 1. Spearman's rank correlation of the quality indices (QUW, QW13, QWB)

	QUW	QWB	QW1-3
QUW	1.00		
QWB	0.88	1.00	
QW1-3	0.95	0.96	1.00

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[8] As a result of a lack of information, the index could not be computed for the patent offices of the following countries or regions: Italy, Israel, the Ukraine, Indonesia, Philippines, the Eurasian Patent Organization, Vietnam and Egypt.

[9] Spearman's rank correlations (or Spearman's rho) indicate how the ranks of objects in one sample differ from the ranks in another sample. Values range from -1 to 1. A value of 1 indicates that the ranks are identical, while a value of -1 indicates that they are exactly inverted (Ginarte and Park, 1997).

Another approach to testing the sensitivity of the index to the chosen weighting scheme is proposed by Ginarte and Park (1997). The idea of Ginarte and Park's test is to substantially change the weights assigned to the nine components of the index, one at a time. In the unweighted index, each component is given the same weight (11.11 percent). As alternatives, eighteen new versions of the index are created. In each version, one of the components is assigned a weight of 22.22% (double the original weight of 11.11%) and then a second weight of 33.33% (three times the 11.11%), while assigning the other eight components equal weights. For instance, the component "search report" is once assigned a weight of 22.22%, while the other components are each given a weight of 9.72%, which results in a new version of the index. Then, the same component (search report) is assigned a weight of 33.33% and the others a weight of 8.33%, which results in a second new version of the index. The same approach is adopted for each component, which leads to 18 new indices. These new indices can then be compared to the unweighted index using Spearman's rank correlations.

Table 2. QUW: robustness to significant changes in a single component's weight

Operational design components	r_S with the UW index when the weight of the component is 22.22%	r_S with the UW index when the weight of the component is 33.33%
Ownership	1.00	1.00
Search report	0.90	0.78
Exam request and term to request an examination	0.91	0.72
Post-grant opposition	0.97	0.89
Grace period	0.95	0.90
Hidden application	1.00	1.00
Adaptability	0.93	0.89
Incentives	0.99	0.95
Workload	0.93	0.84

Note: The table presents Spearman's rank correlations with the quality index (QUW).

Table 2 shows that the rank sensitivity is rather low – the ordering of patent systems' quality indexes across the alternative weighting schemes is generally the same. The Spearman's rank correlation between the unweighted index and the alternative versions of the index when a weight of 22.22% is used is always higher than 0.90. When a weight of 33.33% is used, the rank correlation is higher than 0.84 for all components but two. In all cases, the Spearman's rank correlation is higher than 0.70, which confirms that the rank sensitivity to alternative weighting schemes is generally low. It can, therefore, be concluded that the quality ranking of patent systems is not particularly sensitive to the chosen weighting scheme.

Table 3 presents the normalized quality indices (QUW, QW13 and QWB) using the European Patent Office as a base (EPO = 100) for the three alternative weighting schemes. The EPO systematically has the highest-quality index, while the USPTO has the lowest. A typology of four groups of countries can be identified: high-quality indices that are above 70 with the three alternative indices (includes the EPO, the UK and the Nordic countries), medium-high-quality indices that range from 50 to 70 (including Japan, China, France, Turkey and South Korea), medium-low-quality indices that range from 40 to 50 (including Australia, Germany, Brazil, Mexico and Thailand), and low-quality indices that are below 40 (including the US, Canada, India, New Zealand and South Africa). Section 4 investigates whether this quality metric affects the propensity to file patents across countries.

Table 3. Quality indices for patent systems, 2008

	QUW	QW1-3	QWB
High			
EPO	100.00	100.00	100.00
UK	80.97	72.97	69.29
Sweden	72.28	74.36	72.19
Norway	72.08	74.08	71.90
Denmark	71.90	73.83	71.55
Finland	71.79	73.68	71.19
Medium high			
Austria	67.84	62.40	58.11
Poland	67.37	61.74	55.65
China	67.16	60.63	58.90
The Netherlands	65.23	58.71	52.74
France	63.88	56.78	50.04
Japan	62.21	59.26	60.12
Switzerland	61.88	59.60	54.25
Chile	61.56	59.95	61.95
Russia	61.16	57.77	57.24
Colombia	59.77	59.83	61.96
South Korea	59.65	58.86	58.05
Turkey	56.32	48.88	46.05
Malaysia	56.06	54.56	55.05
Medium low			
Australia	53.55	46.16	44.84
Greece	53.05	41.40	34.37
Germany	52.42	46.16	43.41
Singapore	51.55	50.58	46.29
Spain	51.15	38.71	30.58
Brazil	47.89	44.58	47.15
Thailand	47.84	47.74	46.86
Mexico	47.16	50.00	50.39
Low			
India	41.53	37.16	30.53
New Zealand	40.55	34.96	31.25
South Africa	39.53	27.85	22.27
Canada	39.45	35.83	36.09
US	17.60	24.99	32.99
The US reform (2011)			
US11[a] *(medium low)*	*38.51*	*43.37*	*44.18*
US11+25%[a] *(medium low)*	*40.74*	*46.55*	*48.65*

Note: QUW stands for the quality index computed using the unweighted sum of the nine components. QW1-3 stands for the quality index computed with a "1 to 3" relevance score for each component. QWB stands for the quality index computed with a weighting scheme of the nine components compared to each other (cf. appendix Table B2).

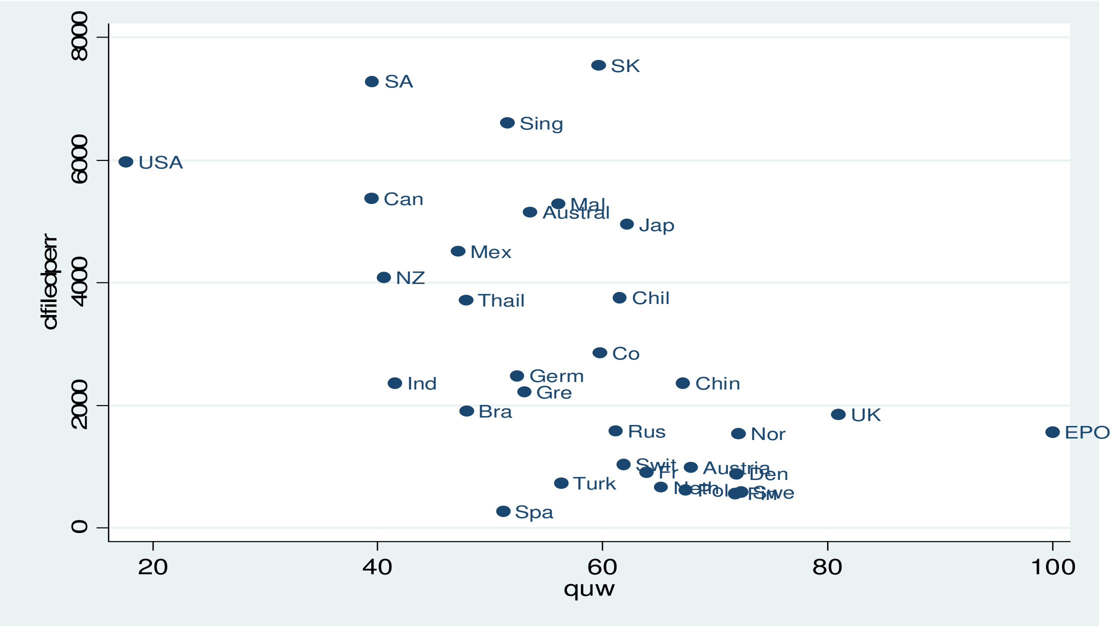
[a.] US11 gives the values of the indices for the US taking into account the recent proposed reform of the US patent law, the America Invents Act (S. 23). This proposal was introduced during the 112th United States Congress on January 25, 2011, and was passed by the United States Senate on March 8, 2011. The proposal still needs to go through a number of legislative steps before coming into force. Nevertheless, if enacted, it will impact the quality index in two ways. First, it will switch the country's patent system from "first-to-invent" to "first-to-file". Second, it will introduce a post-grant opposition period within nine months from the date of the decision to grant a patent. US11+25% means that an increase of 25% of resources per examiner is made thanks to a better control of fee income.

The impact of the patent reform currently being debated in the US (as of April 2011, see note *a* in Table 3) is illustrated by the US11 index and the US11+25% index. The former reflects the facts that the reform may result in the creation of an opposition process and the adoption of a first-to-file system. The latter index takes into account the fact that the office would allocate more resources per examiner (an increase of 25%) as a result of gaining control of its own fee revenues. The bottom rows of Table 3 show that the US's quality index would improve to the extent that the United States would join the medium-low-quality group.

4. Empirical implementation

The consequences of these heterogeneous degrees of quality across patent systems are gauged in Figure 1, which presents the relationship between the degree of quality in a patent system, measured using an unweighted index (QUW), and the claims filed per thousand researchers in that country (a measure of the relative attractiveness of a country's patent system). The figure highlights a negative relationship between the quality of the patent system and the relative demand for patent rights. The correlation coefficient of QUW with the claims filed per thousand researchers is -0.54 (and is significantly different from zero at the 1% probability threshold).

Figure 1. Unweighted quality index (QUW) and the relative demand for patent rights, 2008



Note: The horizontal axis measures the quality level (QUW) and the vertical axis measures the claims filed per thousand researchers in a country.

In other words, the graphical representation confirms that the degree of quality in a patent system is negatively correlated with the demand for patent rights expressed in relative terms (claims filed per thousand researchers). In order to derive a more precise approximation of the extent to which the degree of quality in a patent system affects the propensity to use it, a quantitative model must be used. Therefore, this negative relationship is investigated in the remainder of this section through a simple multivariate econometric analysis of the demand for patent rights across countries.

The objective is to estimate the parameters of a patent demand function on the macroeconomic level. In the model, the number of employees (*L*) devoted to the "idea-production sector" is assumed to be the main driver of patent applications for two reasons. First, researchers are at the root of the innovation process and generate ideas that might be patentable (the number of researchers is taken as a raw measure of research efforts), as in de Rassenfosse and van Pottelsberghe (2009). Second, patent applications might be filed from abroad. The higher the inventive activity of a country, the more likely non-residents are to file applications for domestic patent rights. In other words, the number of researchers not only captures the innovation potential of a country but also indicates the attractiveness of that country for foreign technologies.[10] This relationship is represented in equation (2).

$$P_i = c + \lambda \mathbf{L_i} + \sum_n \delta_n \mathbf{X}_{n_i} + \varepsilon_i \,, \qquad (2)$$

where *P* is the observed demand for patent rights at the national patent office of country *i* (*i* =1, ..., 32), λ captures the impact of the number of researchers on the demand for patent rights, c is the intercept and ε is the error term. Several factors (X) potentially affect the propensity to rely on the patent system. These factors are the quality of the selection mechanism (the more transparent and stringent a system is, the lower the demand for patent rights); the "strength" of the patent system (the more applicant friendly a system is, the higher the demand for patent rights); and relative fees (the higher the fees, the lower the demand for patent rights). Cross-country evidence of the impact of fees and "strength" indicators on the demand for patent rights is provided by de Rassenfosse and van Pottelsberghe (2007, 2009), and by Danguy et al. (2010).

The remainder of this section aims to test whether quality, as measured using the three indices presented in the previous section, affects the demand for patent rights. The next subsection shows the results of the basic model, with a focus on the number of researchers and quality as the main factors influencing the propensity to patent. The second batch of estimates includes several additional explanatory variables (relative fees and patent "strength" indicators). The third subsection tests the robustness of the results to alternative measures of demand for patent rights (patent numbers instead of claim numbers, domestic and non-resident patent applications).

4.1 Quality and the demand for patent rights

Equation (2) is first estimated with the quality indices used as factors that could influence the propensity to rely on a patent office. The demand for patent rights is measured as the total number of claims filed at the patent office (the product of the total number of patent applications in 2008 and the average number of claims per patent in the same office).[11] Note that the number of claims is used instead of the number of patent applications because the "typical" patent size (in terms of page numbers or claim numbers) varies substantially across

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[10] The distinction between resident and non-resident applicants is made at a later stage. An alternative indicator of 'attractiveness' for foreign patents could be the GDP level (see, for instance, Harhoff et al., 2009) for empirical evidence). However, this variable is correlated with the number of researchers, as it also captures the innovation potential of a country to some extent.

[11] All variables and data sources are presented in Appendix Table C1.

countries and is influenced by claim (or page)-based fees (cf. van Zeebroeck et al. (2009) and Archontopoulos et al. (2007)). The three alternative quality indices are successively included in the model. The estimated parameters for the full sample and for the restricted samples are presented in Table 4.

Table 4. Researchers and quality as determinants of the demand for patent rights

		Quality index			**Outliers**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Researchers	3.76***	3.79***	3.87***	3.95***	2.59***	2.74***	3.97***
(000s)	(3.27)	(6.03)	(4.64)	(4.11)	(5.84)	(3.31)	(4.07)
QUW		-38.5***			-12.7**	-13.7*	-4.9*
		(-3.01)			(-2.29)	(-2.05)	(-1.75)
QW1-3			-29.6**				
			(-2.17)				
QWB				-24.4*			
				(-1.77)			
Constant	-100. 7	2129.9***	1497.9**	1139.1	759.3**	805.3**	189.2
	(-0.83)	(2.97)	(2.13)	(1.70)	(2.28)	(2.09)	(0.99)
R-squared	0.73	0.85	0.81	0.79	0.76	0.67	0.77
Nobs	32	32	32	32	31	30	29
Dropped countries					US	US, China	US, China, EPO

The dependant variable is the number of claims filed (in thousands). The econometric method is ordinary least squares, robust estimates; *t*-statistics are in parentheses; *, ** and *** denote significance at the 10%, 5% and 1% probability thresholds, respectively.

Column (1) reports the results when quality is not taken into account. The number of researchers is associated with a positive and significant parameter of 3.8. Columns (2) to (4) display the results when the three indices of quality are successively included in the model. All indices are significant at a 10% probability threshold. The unweighted index (QUW) is the most significantly different from zero, with a probability threshold of 1%. These results support the observation made in the previous section that the quality index of patent systems is weakly sensitive to the adopted weighting scheme. This robustness and the high significance of QUW lead us to rely on the unweighted index for the subsequent estimates.

Columns (5) to (7) assess the robustness of the model by dropping outliers from the sample. Figure D1 in the Appendix suggests that the US, China and Europe might have a substantial impact on the estimated parameters. Column (5) presents the estimated parameters for the sample without the US, column (6) shows the estimated parameters for the sample without the US and China, and column (7) presents the estimated parameters without the US, China and the EPO. In all cases, the quality index remains significant at the 10% probability threshold, although the amplitude of the parameter is reduced when the US is dropped from the sample (column (5)), and even further when the US, China and the EPO are dropped (column (7)).[12]

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[12] Note that in a logarithmic form, the quality index is also significant at a 1% probability threshold. The estimated parameters of a "log-log" model have the following values for an R-squared of 0.79:

In summary, the econometric analysis confirms that there is a negative relation between the quality of a patent system and the demand for patent rights – the higher the quality, the lower the demand for patents. In other words, several components of the operational design of patent systems, which affect the stringency of the selection process and its transparency, substantially affect applicant behavior. The tougher it is to get a patent granted, the less applicants are willing to apply for a patent. The next subsection tests whether this observation holds when other factors are included in the model.

4.2. Additional factors affecting the propensity to use a patent system

In addition to the legal and operational design factors that affect the quality of patent systems' selection process, fees and the strength of a patent system might also affect the propensity of applicants to file for patent rights. However, a comparison of patent fees across countries is far from straightforward (cf. van Pottelsberghe and Mejer, 2010), as fee structures differ from one country to another. In this empirical investigation, the cumulated fee indicator developed by de Rassenfosse and van Pottelsberghe (2010) is used. It consists of the cumulated administrative patenting fees up to the grant (i.e., from the filing to the fourth year) for the "average" patent, and includes filing, search, examination and granting fees. The fees per claim are then computed and divided by GDP per capita to obtain the fees per claim per thousand GDP per capita (FCGDPC). This indicator represents an affordability index, which measures the extent to which an inventor may be able to handle the cost of patenting in his or her country.

The term "patent strength" is not typically used to indicate the degree of quality of a patent system but rather to reflect its enforcement potential or "leading breadth". 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 obtain more power through lawsuits.

Ginarte and Park (1997) compute an index of patent strength ranging from 0 to 5 (called the IPI index, or intellectual property index). Higher values of this index indicate higher levels of protection.[13] This index is composed of five categories, each having a maximum score of 1: coverage of subject matters that can be patented; membership in international patent treaties (IPTRE); duration of protection; enforcement mechanisms; and restrictions (IPRES; reflects protection against the loss of rights, including compulsory licensing or working requirements for inventions).

In addition to the aggregate IPI index, the impacts of the categories "restrictions", "IPTRE" and share of patentable subject matters are analyzed separately. The remaining categories display little variance across patent systems and are therefore not included in the econometric analysis. Logically, fewer restrictions on patentable subject matters should lead to more applications. Therefore, a new indicator (SUBM), corresponding to the proportion of the following subject matters that are patentable, is used: computer programs, methods of doing business, and plant and animal varieties. SUBM takes the value of one if all of these subject matters are patentable. These subject matters are used because they are frequently considered

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$$\ln(clfiled) = 6.61^{***} + 0.99^{***} \ln(researchers) - 1.45^{***} \ln(quality\ UW) + \varepsilon\ .$$

[13] "Strong" is probably the wrong qualifier for such policies, which should be referred to as "applicant friendly" because more domains are patentable, for longer, with a wider geographical scope and with greater legal power.

as being less appropriate for patent protection. Indeed, some of them can be protected through other intellectual property rights, like copyrights (e.g., software) or plant variety protection. In addition, it is difficult to identify the state of the art for these subject matters due to the imperfect codification of knowledge in these fields, which reduces the relevancy of the search report and, hence, the quality of the inventiveness assessment.

Table 5 presents the estimated parameters of equation (2) when the additional explanatory factors are added. The first column displays the results given the addition of fees per claim per GDP per capita (FCGDPC, or relative fees). Fees have a negative, significant impact on the number of claims filed, which confirms the results obtained by de Rassenfosse and van Pottelsberghe (2007, 2009). A quadratic model for the impact of fees seems to be more suitable, as evidenced in column (2). These results suggest that the impact of fees is non-linear and follows a traditional demand curve. The higher the relative fees, the lower the negative impact of a marginal increase in fees on the demand for patent rights.

The role of the strength of patent systems is investigated in columns (3) to (6). Column (3) presents the impact of the aggregated index of IP protection (IPI) created by Ginarte and Park (1997). IP protection has a positive and significant impact on the number of claims filed: the "stronger" a patent system, the more common patents applications are. This result illustrates, to some extent, the duality between the quality and the strength of patent systems. While an increase in quality results in a decline in patent filings, an increase in the system's strength (applicant friendliness) leads to an increase in patent filings.

The three subsequent columns (4 to 6) report the impact of three of the five individual categories of the IPI index: restriction (IPRES), membership in international treaties (IPTRE), and the new indicator of "sensitive" patentable subject matters (SUBM). The category of restrictions on patent rights – i.e., a working requirement for the invention, compulsory licensing and revocation of patents – has a large, positive and significant impact on patent filings. Notably, it is the absence of restrictions that has a positive impact on patent filings, as this category of the IPI index measures protection against losses of rights (i.e., the higher the IPRES, the lower the number of restrictions). In other words, the lower the number of restriction on patent rights, the higher the demand for patent rights. In contrast, membership in international treaties (IPTRE) is associated with a positive parameter, which is, however, not significantly different from zero. Column (6) displays the results when the coverage of patentable subject matters (SUBM) is taken into account. The estimated parameter associated with this variable is positive but not significant (except at a 15% probability threshold). A more significant parameter was expected, as one would logically expect a higher demand for patent rights when more subject matters are patentable.

Finally, column (7) presents the results for the model that simultaneously includes all of the significant explanatory variables: the number of researchers, the quality index (QUW), the fees per claim per thousand GDP per capita (FCGDPC) in a quadratic format and the restrictions on patent rights (IPRES). The number of researchers is logically the most significant determinant of the demand for patent rights. In addition to research efforts, the quality of a patent system, its relative fees and the degree of patent friendliness (strength) simultaneously affect the demand for patent rights. Whereas higher quality and higher fees have a negative impact on demand for patents, patent friendliness has a positive, significant impact.

Table 5. Determinants of the demand for patent rights, additional factors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Researchers	3.99***	4.34***	3.57***	3.52***	3.73***	3.62***	4.00***
(000s)	(7.46)	(8.21)	(7.25)	(8.83)	5.94	(5.36)	(10.04)
QUW	-40.3***	-36.7***	-43.1***	-42.4***	-39.7***	-32.8**	-40.2***
	(-3.57)	(-3.67)	(-3.64)	(-4.35)	(-3.06)	(-2.34)	(-4.46)
FCGDPC	-26.1**	-100.3***					-72.9**
	(-2.15)	(-2.81)					(-2.57)
FCGDPC^2		1.37**					0.98**
		(2.42)					(2.15)
IPI			646.9**				
			(2.28)				
IPRES				1629.4***			1197.8***
				(2.86)			(3.00)
IPTRE					517.7		
					(1.43)		
SUBM						503.8	
						(1.65)	
Constant	2359.0***	2330.7***	-279.5	1609.0***	1753.6**	1697.1**	1902.7***
	(3.50)	(3.71)	(-0.28)	(3.42)	(2.60)	(2.12)	(3.86)
R-squared	0.88	0.90	0.88	0.90	0.86	0.87	0.92
Nobs	32	32	32	32	32	32	32

The dependant variable is the number of claims filed (in thousands). The econometric method is ordinary least squares, robust estimates; *t*-statistics are in parentheses; *, ** and *** denote significance at the 10%, 5% and 1% probability thresholds, respectively.

4.3. Alternative metrics for the demand for patent rights

The dependent variable could be measured using alternative metrics, such as the number of patent filings, or the number of claims filed by resident and non-resident applicants. The effects of using such metrics on the results are presented in Table 6. The first two columns present the results when the demand for patent rights is measured in terms of claims filed by residents, whereas columns (3) and (4) present the results for the demand for patent rights when measured in terms of claims filed by non-residents. The estimated parameters in terms of sign and significance are similar to those obtained with the total (aggregated) demand for patent rights. However, differences in amplitude and significance occur between residents and non-residents. When resident demand is considered, the number of researchers plays a more important role than it does for foreign applicants, which was expected, as researchers generate innovations that might be patentable. On the other hand, the three variables affecting the propensity to rely on a patent system have higher, more significant impacts on the demand for patent rights by non-residents than by residents. In other words, foreign applicants are more sensitive than domestic applicants to fees (negative), quality (negative) and patent strength (positive).

The final test uses the number of patents rather than the number of claims as the dependent variable. The results presented in columns (5) and (6) indicate that, using this measure, fees and quality have a negative impact on the demand for patents, whereas patent friendliness has no significant impact.

Table 6. Alternative metrics for the demand for patent rights

	Claims filed by residents (000s)		Claims filed by non-residents (000s)		Patents filed (000s)	
	(1)	(2)	(3)	(4)	(5)	(6)
Researchers	2.43***	2.26***	1.89***	1.70***	0.29***	0.29***
(000s)	(7.69)	(7.48)	(6.40)	(8.64)	(7.25)	(6.82)
QUW	-16.99**	-18.79**	-21.77***	-23.76***	-1.59**	-1.66**
	(-2.41)	(-2.69)	(-4.46)	(-5.76)	(-2.25)	(-2.25)
FCGDPC	-42.53**	-29.18	-59.68***	-44.96***	-0.45**	-0.42*
	(-2.58)	(-1.62)	(-2.85)	(-2.97)	(-2.26)	(-1.90)
FCGDPC^2	0.52*	0.33	0.87**	0.66**	0.0006*	0.0006*
	(1.87)	(1.09)	(2.67)	(2.75)	(1.98)	(1.71)
IPRES		588.20*		649.00***		27.46
		(2.02)		(3.12)		(0.91)
Constant	1072.9**	870.1**	1417.1***	1193.4***	107.3**	97.2**
	(2.46)	(2.26)	(4.43)	(5.05)	(2.47)	(2.23)
R-squared	0.83	0.84	0.88	0.91	0.81	0.81
Nobs	31	31	31	31	32	32

The econometric method is ordinary least squares, robust estimates; *t*-statistics are in parentheses; *, ** and *** denote significance at the 10%, 5% and 1% probability thresholds, respectively.

5. Concluding remarks

The objective of this paper is to create a quality index for the patent selection mechanisms of 32 countries and test whether quality affects the behavior of applicants. The first part of the paper is devoted to the methodology used to compute the index (formulae, components and alternative weighting schemes). Heterogeneity is observed across countries. The EPO and the patent offices of the UK and several Nordic countries have the highest-quality metrics. At the other extreme is the US and several Commonwealth countries, which have the lowest indicators of quality. The medium-high group includes many European countries (e.g., Austria, Poland, France), the major Asian economies (e.g., Japan, China, South Korea, Malaysia) and several other countries (e.g., Russia, Switzerland). The medium-low group includes, among others, Germany, Brazil, Mexico, Spain and Singapore. The patent reform currently being debated in the United States (as of April 2011) would improve the country's quality index slightly, allowing the US to move from the low-quality group to the medium-low quality group.

The second part of the paper aims to investigate whether the quality of patent systems affects applicants' filing behavior. Several quantitative models are used to test whether patent offices with a high quality index receive fewer patent applications. The results show that the higher the quality index, the lower the demand for patent rights (measured using three alternative indicators, including the number of claims filed, by domestic organizations and from abroad, and the number of patents filed). In other words, applicants gauge the quality of patent offices and adapt their filing behavior accordingly. This negative relationship between quality and the demand for patent rights is still observed when the roles of relative fees, the number of researchers and the strength of enforcement mechanisms are taken into account. Interestingly, non-resident applicants are more sensitive to quality and relative fees than resident applicants.

These results have important implications for policy makers, patent count methodologies and further research opportunities. The policy implications are threefold. First, as several facets of patent systems and their operational design influence applicant behavior, policy makers have a clear opportunity to fine-tune the design of their patent systems to a greater extent than is commonly believed. This is especially true for non-resident applicants, which are more sensitive to these policies than resident applicants.

Second, recent years have been marked by more intense collaboration among the largest patent offices in the world. This is evidenced by the increasing number of national patent offices being recognized as International Search Authorities (ISA) for PCT filings at WIPO, by the creation of Patent Prosecution Highways (PPHs), and by the creation of the IP5 network (which includes the EPO, and the patent offices of China, Japan, South Korea and the US). These projects could be perceived as preliminary steps towards a global mutual recognition process. Along a similar vein, several national patent offices in Europe have proposed a mutual recognition process, whereby a patent granted in Greece, for instance, would automatically be enforceable in Finland. The significant variations in the quality index across countries, worldwide and within the EU, suggest that a mutual recognition process would lead to a smaller common quality denominator effect in that applicants would file their patents in the least stringent, most opaque office. However, should such a legitimate attempt to evolve towards a global patent system receive further political support, the index presented in this paper – and especially its nine components – would serve as a useful basis for considering convergence mechanisms.

Third, the results presented in this paper suggest that patent count metrics based on priority applications in several national patent offices are subject to a potential bias. Indeed, patent office A might receive more applications than patent office B because the former has a lower quality index. In such situations, count differences would not automatically reflect differences in innovation performance.

Finally, the quality index shows an opposite effect than the patent strength index (also called patent rights) of Ginarte and Park (1997), which is essentially a patent friendliness index. The latter index has been used extensively in the literature to assess the economic impact of patent systems. One might, therefore, wonder whether a patent system with a higher quality index is more favorable to innovation and economic growth. Clearly, an extremely stringent system that would lead to the granting of, for example, only ten patents per year is unlikely to stimulate more innovation. However, the reverse is also true – the automatic granting of all patent applications would lead to a massive hold-up phenomenon, in which companies would allocate more resource to filing patents than to innovation. This is undoubtedly an interesting question for future research.

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Appendix Table A1. The nine components of the quality index: justifications and formulae

Components	Impact on quality	Measurement
Ownership	The "first-to-file" rule improves transparency about patent ownership	$\begin{cases} 1 & \text{if the prevailing system is "first-to-file"} \\ 0 & \text{if it is not} \end{cases}$
Search report	Publishing a search report has a positive impact on transparency and self-selection mechanisms	$x_2 = \begin{cases} 1 & \text{if a patent office publishes a separate search report} \\ 0 & \text{if it does not} \end{cases}$
Exam request and term to request an examination	A request for examination requirement improves self-selection processes but an extended period in which to request an examination reduces transparency for third parties	• If a substantive examination must be requested, the following function is applied: $x_3 = 1 - \frac{term\ to\ request\ examination}{\max\{term\ to\ request\ examination\}}$ • If a substantive examination does not have to be requested or if there is no substantive examination: $x_3 = 0$
Post-grant opposition	The possibility for third parties to file post-grant opposition has a positive impact on quality	• If there is a possibility to file post-grant opposition the following function is used: $x_4 = \frac{term\ to\ file\ post\ grant\ opposition}{12}$ • If there is no possibility to file a post-grant opposition: $x_4 = 0$
Grace period	The grace period has a negative impact on transparency	$x_5 = 1 - \frac{Grace\ period}{12}$
Hidden applications	The possibility to hide patent applications has a negative impact on transparency	$x_6 = \begin{cases} 1 & \text{if the applications of a patent office are published after a period of a maximum 18 months from the filing date and there is no possibility to hide applications} \\ 0 & \text{if the above are not applicable} \end{cases}$

Table A1 (cont.). The nine components of the quality index: justifications and formulae

Adaptability	The possibility to file continuation-in-part applications or patents of addition has a negative impact on quality	$x_7 = \begin{cases} 1 & \text{if CIPs } \textbf{and} \text{ patents of addition are not allowed} \\ 0 & \text{if CIPs } \textbf{or} \text{ patents of addition are allowed} \end{cases}$
Incentives	A high benefits package for patent office employees (including examiners) has a positive impact on quality	$x_8 = \frac{personnel\ expenses\ per\ all\ staff}{\max\{personnel\ expenses\ per\ all\ staff\}}$
Workload	A high workload has a negative impact on quality	- If the office undertakes substantive examinations, the following ratio is employed: $x_9 = 1 \mid \frac{claims\ per\ examiner}{\max\{claims\ per\ examiner\}}$ - If the office does not: $x_9 = 0$

Table A2. The nine components of the quality index: values by country, 2008

	A	B	C	D	E	F	G	H	I
Australia	1	0	0.64[1]	0.25	0.5	1	0	0.37	0.72
Austria	1	1	0.00	0.33	1	1	0	0.40	0.95
Brazil	1	0	0.57	0.00	0	1	0	0.60	0.83
Canada	1	0	0.29	0.00	0	1	0	0.41	0.61
Chile	1	0	0.93[2]	0.00	0	1	1	0.34	0.90
China	1	0	0.57	0.00	1	1	1	0.25[3]	0.80
Colombia	1	0	0.71	0.00	0	1	1	0.32	0.97[4]
Denmark	1	0	0.00	0.75	1	1	1	0.36	0.91
EPO	1	1	0.71	0.75	1	1	1	1.00	0.90
Finland	1	0	0.00	0.75	1	1	1	0.30	0.96
France	1	1	0.00	0.00	1	1	1	0.35	0.00
Germany	1	0	0.00	0.25	1	1	0	0.34	0.80
Greece	1	1	0.00	0.00	1	1	0	0.44	0.00
India	1	0	0.43	1.00	0	1	0	0.05[5]	0.00
Japan	1	0	0.57	0.00	0.5	1	1	0.56	0.58
Malaysia	1	0	0.71	0.00	0	1	1	0.18	0.80
Mexico	1	0	0.00	0.00	0	1	1	0.26	0.68[6]
Netherlands	1	1	0.00	0.00	1	1	1	0.46	0.00
New Zealand	1	0	0.00	0.25	0.5	1	0	0.22	0.43
Norway	1	0	0.00	0.75	1	1	1	0.37	0.91
Poland	1	1	0.00	0.50	1	1	0	0.18	0.96
Russia	1	0	0.57	0.00	0.5	1	1	0.21	0.84[7]
Singapore	1	1	0.00[8]	0.00	0	1	1	0.31	0.00
South Africa	1	0	0.00	0.00	1	1	0	0.31	0.00
South Korea	1	0	0.29	0.25	0.5	1	1	0.43	0.52
Spain	1	1	0.00[9]	0.00	1	1	0	0.28	0.00
Sweden	1	0	0.00	0.75	1	1	1	0.35	0.95
Switzerland	1	0	0.00	0.75	1	1	1	0.43	0.00
Thailand	1	0	0.29[10]	0.00	0	1	1	0.11	0.61
Turkey	1	1	0.75[11]	0.00	0	1	0	0.19	0.78
UK	1	1	0.71	0.00	1	1	1	0.36	0.70
US	0	0	0.00	0.00	0	0	0	0.75	0.72
US11	1	0	0.00	0.75	0	0	0	0.75	072
US11+25%	1	0	0.00	0.75	0	0	0	0.94	0.72

A stands for ownership; B for search report; C for exam request and term to request an examination; D for post-grant opposition; E for grace period; F for hidden applications; G for adaptability; H for incentives; and I for workload.

US11 gives the components of the quality index for the US taking into account the recently proposed reform of US patent law, the America Invents Act (S. 23) (cf. Table 3, note *a*). Data sources: The data in the table are based on information compiled from various sources, including: national laws and international conventions; annual reports of patent offices; direct enquires at patent offices; information publicly available on patent office websites; AIPPI (2007); WIPO (2008); and London Economics (2010).

Notes:

[1] Applicants can request an examination within five years of filing, although the patent office can direct the applicant to request examination at an earlier date. The latter generally occurs one to two years after filing

(according to the IP Australia website and London Economics (2010) p. 121). After being directed to request an examination, applicants have six months in which to do so. A term of 2.5 years to request an examination was thus used for the purpose of the ranking.

[2] After the filing of a patent application, the patent office of Chile (INAPI) conducts a preliminary examination to verify that all documents have been filed and that the application satisfies the formal minimum requirements for continued processing. The time to process this preliminary examination is unknown and depends on whether there are items lacking in the application that the applicant has to correct. If there are no observations or if any issues are handled in a timely manner, the application is accepted for processing. The applicant must then require publication of the application within 60 working days from the date of acceptance for processing. Within 45 days of the publication, any party may submit a (pre-)opposition to the patent application. Finally, within 60 days of the deadline for filing opposition, the applicant must request examination by paying the required fee to INAPI. As the time needed to process preliminary examination is unknown and variable, a term of 0.5 years (roughly 60 days for publication plus 45 days for the opposition plus 60 days for examination) was used as an approximation of the term to request an examination from the filing date.

[3] An approximation has been made in order to compute the ratio of personnel expenses per staff due to a lack of data. First, it is assumed that 32% of all employees of China's patent office (SIPO) are patent examiners, which corresponds to the average proportion of patent examiners among all patent office staff in the entire sample. Second, it is assumed that SIPO has a ratio of total expenditure per claim of 0.23 in thousand USPPP (approximation based on the median in the sample). Finally, it is supposed that 58% of the total expenditures are personnel expenses, which also corresponds to the median in the total sample.

[4] It is assumed that 32% of all patent office employees are patent examiners. 32% corresponds to the average proportion of patent examiners among all patent office staff in the entire sample.

[5] It is assumed that 58% of total expenditures are personnel expenses. This proportion corresponds to the median for the entire sample.

[6] It is assumed that 63% of all employees of the patent division of the Mexican patent office are examiners. This proportion is based on a comparison with other patent offices.

[7] It is assumed that 32% of all patent office employees are patent examiners. 32% corresponds to the average proportion of patent examiners among all patent office staff in the entire sample.

[8] In Singapore, applicants may request a search and an examination report at the same time, or they may request a search report and then an examination report within a certain period of time. The examination report is, in fact, non-binding. These reports are considered together here as a search report with a non-binding opinion, even though they might be undertaken separately. Therefore, the possible term to request a separate "examination report" is not taken into account.

[9] In Spain, applicants have two possible routes after receiving a search report. They can either choose to proceed under the General Award Procedure without a substantive examination of the application, or they can choose the route encompassing a substantive examination. Given that the substantive examination is not compulsory, the quality index includes only the route without substantive examination.

[10] The term to request an examination is exceptionally computed from the publication date because the applications are published immediately when they comply with the formal requirements.

[11] The applicant has three months after being notified of the search report to request an examination. Given that the applicant also has 15 months from filling to request a search report, it is assumed that the term to request examination is 1.75 years (21 months) from filing.

Annex B: Weighting schemes

Two alternative weighting schemes are proposed. The first is based on relevance levels on a 1 to 3 scale. The higher the relevance level, the more important that factor is for the quality of the patent system. Table B1 presents the relevance levels and the resulting weights for each component.

Table B1. Weighting scheme of the quality index components, based on a 1-3 Likert scale

Component	Relevance level	Weight
Ownership	1	5.3%
Search report	2	10.5%
Exam request and term to request an examination	1	5.3%
Post-grant opposition	3	15.8%
Grace period	1	5.3%
Hidden application	2	10.5%
Adaptability	3	15.8%
Incentives	3	15.8%
Workload	3	15.8%

The second weighting scheme is based on a bilateral comparison of all components. Table B2 provides the comparison matrix. If component A is considered to be more important for the quality of patent systems than component B, the former receives one point. It follows that a "1" in the table below means that the row component is more important for quality than the column component. The sum of the points received by each component creates a relevance scale, from which the weight is derived.

Table B2. Weighting scheme of the quality index components, based on bilateral comparisons.

		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**Sum**	**Weight**
A	Ownership (F2F)	0	0	0	0	0	0	0	0	0	0	0.0%
B	Search report	1	0	1	0	1	0	0	0	0	3	8.3%
C	Exam request and term to request an examination	1	0	0	0	1	0	0	0	0	2	5.6%
D	Post-grant opposition	1	1	1	0	1	1	0	0	0	5	13.9%
E	Grace period	1	0	0	0	0	0	0	0	0	1	2.8%
F	Hidden application	1	1	1	0	1	0	0	0	0	4	11.1%
G	Adaptability	1	1	1	1	1	1	0	0	0	6	16.7%
H	Incentives	1	1	1	1	1	1	1	0	1	8	22.2%
I	Workload	1	1	1	1	1	1	1	0	0	7	19.4%

Table C1. Variable descriptions and information sources

Variable	Description	Information source
Claims filed	Total claims filed at a patent office, measured as the product of the total patent applications at a patent office in the years 2008-2009 and the average number of claims associated with a patent at that office.	• For the patent applications: WIPO Statistics Database, September 2010; completed using data provided in the annual reports of the patent offices • For the average number of claims: van Zeebroeck et al. (2008) and publicly available information on the patent offices' websites for the claims-based fee threshold
Researchers	Number of researchers in R&D in 2006	UNESCO Institute for Statistics
QUW	Quality index of patent systems based on the unweighted weighting scheme	
QW1-3	Quality index of patent systems based on the 1 to 3 relevance scale weighting scheme	
QWB	Quality index of patent systems based on the bilateral comparison weighting scheme	
FEES (FCGDPC)	Fees per claim per thousand GDP per capita are the cumulated administrative patenting fees up to the grant (i.e., from the filing to the fourth year) in 2010 for the "average" patent, including filing, search, examination and granting fees, divided by the average number of claims and by GDP per capita (in current USD, data from 2008)	• For the cumulated administrative fees: de Rassenfosse and van Pottelsberghe (2010) and data available on patent office websites • For the average number of claims: see supra • For GDP per capita: World Development Indicators (WDI)
IPI	Ginarte and Park's IP Index of patent rights in 2005; the index ranges from 0 to 5, with the latter representing the highest level of protection of IP rights; the index is composed of five categories, each having a maximum score of 1; these categories include the number of subject matters that can be patented (coverage), the length of protection, the mechanisms for enforcing patents rights, memberships	Ginarte and Park (1997) and subsequent update in Park (2008)

	in international patent treaties and restrictions on the use of patents rights	
IPRES	One category of the IP Index; measures protection against losses arising from three sources: working requirements, compulsory licensing and revocation of patents; a value of 1 indicates that the country protects against all losses	Ginarte and Park (1997) and subsequent update in Park (2008)
IPTRE	One category of the IP Index; measures a country's participation in the international patent treaties	Ginarte and Park (1997) and subsequent update in Park (2008)
SUBM	Proportion of the following subject matters that can be patented: computer programs, methods for doing business, and plant and animal varieties; takes the value of one if all of these subject matters are patentable	Own ratio based on laws and regulations, and on WIPO (2008)
USPPP	Purchasing Power parities in USD in 2005	2005 ICP Global Results: Summary Table

Note: It is important to note that there is no "European patent" that automatically protects a patented invention in all EPO member states. The patents granted by the EPO need to be validated in each member state and such validation occurs only at the request of applicants. After this validation, the patent is protected in accordance with national laws. Moreover, the granted patents must be translated into the relevant languages and the applicants have to pay the associated fees. As a consequence, patents granted by the EPO are rarely validated in all EPO member states; instead, they tend to focus on a certain number of countries. For this reason, the EPO's total number of researchers does not correspond to the simple sum of the number of researchers in each member state. Instead, it corresponds to the number of researchers in the geographical area primarily targeted by 65% of applicants through their designation of desired states for protection. This geographical area encompasses the following countries: Austria, Belgium, Switzerland, Germany, Denmark, Spain, Finland, France, the United Kingdom, Ireland, Italy, Lichtenstein, the Netherlands and Sweden.

The IPI index is not computed for the EPO. Accordingly, the median of the IPI indices of countries for which the rate of designation as a contracting state is superior to 65% is used as a proxy for the EPO Region's IPI.

Annex D: Outliers

The leverage versus residual squared plot below provides a graphical way of indentifying the influential observations and outliers. The two reference lines are the means for leverage (horizontal) and for the normalized residual squared (vertical). It is worth mentioning that in linear regressions, an outlier is an observation with a large residual, while an observation with an extreme value on a predictor variable is called a point with high leverage (Chen et al., 2003).

The US has the largest residual squared and the highest leverage. China has a high residual squared, while the EPO has high leverage. These three observations give cause for concern. It is therefore useful to test the regression without these points (cf. main text).