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Given the growing size of patent databases and portfolios, scholars and practitioners alike need metrics to help them in weighting patent counts or in ranking patents to focus on the most important ones. The main objective of this paper is to help them in this task with a practical and replicable approach. The discriminating criterion chosen is the potential market for the patented invention and the approach uses five different patent features (forward citations, grant decisions, families, renewals, and oppositions) that (1) have been found positively correlated with the value of patents in the literature, (2) can be extracted from patent databases, and (3) could inform on the existence of a potential market for the invention. The paper therefore discusses the main methodological issues in measuring and interpreting these metrics over a large international dataset and proposes one approach to extract from the different measures a consistent score that can be used to weight or rank patents.

JEL Classifications: O31; O34; O50
Keywords: Patent value, Families, Renewals, Oppositions, Citations, Grant rate

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The puzzle of patent value indicators*

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Abstract

Given the growing size of patent databases and portfolios, scholars and practitioners alike need metrics to help them in weighting patent counts or in ranking patents to focus on the most important ones. The main objective of this paper is to help them in this task with a practical and replicable approach. The discriminating criterion chosen is the potential market for the patented invention and the approach uses five different patent features (forward citations, grant decisions, families, renewals, and oppositions) that (1) have been found positively correlated with the value of patents in the literature, (2) can be extracted from patent databases, and (3) could inform on the existence of a potential market for the invention. The paper therefore discusses the main methodological issues in measuring and interpreting these metrics over a large international dataset and proposes one approach to extract from the different measures a consistent score that can be used to weight or rank patents.

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1. Introduction

Anyone relying on patent data to measure the outputs of innovative activities is faced with the well-known skewness of the patent value distribution (Griliches 1990; Scherer and Harhoff 2000; Silverberg and Verspagen 2004), compromising the usefulness of raw patent counts in this perspective. Recent developments in the patent system have yet strengthened this issue: the boom in the number of patent applications (Kortum and Lerner 1999), the inflation in patent application sizes (Archontopoulos et al. 2007; van Zeebroeck et al. 2009), and the rise of new patenting strategies (Jaffe and Lerner 2004; Guellec and van Pottelsberghe 2007; van Zeebroeck and van Pottelsberghe 2008) have raised considerable challenges for patent offices to face, and may be changing the nature of patents and yet compromise the '1 patent = 1 invention' equation.

Overall, it results that some patents are important, and some are less, or not at all. Therefore, one should not count them in the same way or grant them the same attention. Unfortunately, the growing size of the patent databases exploited by scholarly researchers and of the patent portfolios managed by practitioners makes it impossible to manually screen patents in search for the more important ones and raises the need for affordable approaches to produce value-weighting schemes for patent counts or to automatically scan a large set of patents and select candidates for a more careful analysis.

The literature on patent value has proposed various features that have been found positively correlated with the value of patents and could be used to produce value-weighted counts (see e.g. Trajtenberg 1990; Hall et al. 2005). The objective of this paper is to review these different metrics and to analyze how they can be used in practice to weight or rank patents over a large international database. In this sense, the objective is therefore not to measure the value of patents or to come up with a financial appraisal of a given patent or even portfolio. Instead, it is to somehow separate the wheat from the chaff by pinpointing those patents or applications which stand out in terms of potential importance from a large portfolio.

To do so, one therefore needs some pieces of data that would inform on the potential value of a patent to weight each observation accordingly. Such measures considered in this paper include grant decisions, renewals, families, citations and legal challenges in the form of oppositions and their outcomes. Because some of these measures are associated with costs incurred by a patentee to obtain or maintain the patent (i.e. families and renewals), they have sometimes been used to produce value estimates based on the investments they represent and on the assumption that rational applicants would only incur these costs when they deem their patents of sufficient value to recoup them.

In this paper, the standpoint is different. The criterion proposed to rank or weight patents is not their economic value, but the confidence one may have on the existence of some market for the patented invention. The five measures considered in this paper do meet this criterion but raise different issues when applied to a large international, multi-sector database. In addition, we observe that they would not produce the same value-based rankings, probably due to the complexity of their interrelations and correlation with value. With other words, the different indicators do not "see" the same patents as more important.

Therefore, the paper proposes a practical approach to rank patents based on each of the different indicators, while taking into account the various factors that affect the comparability of the indicators across industries and time. This approach is based on the percentiles of each measure's distribution and therefore assigns a score between 1 and 100 to each patent for each measure. The different scores could then be aggregated into one composite score, which could then be used to rank or weight patents by importance.

The remainder of the paper is organised as follows: section 2 reviews the literature on patent value and discusses the rationale for selecting five measures in particular: forward citation counts, grant outcomes, families, renewals, and oppositions. Section 3 investigates different issues and choices to be made in computing and interpreting these five measures over large sets of patents. A practical implementation is proposed over the entire cohort of patent applications filed to the European Patent Office (EPO) over a 22 years period, enriched with data available for the first time at this comprehensive scale. Section 4 investigates the consistency of the five measures and assesses their ability to capture the same high-value patents. Section 5 proposes a new approach to address these issues in practice when seeking to rank patents by potential importance, and conclusions are drawn in section 6.

2. Value indicators: what are they and what do they tell us?

The literature on patent value[1] can be roughly organised into three broad categories: a first set of papers focus on the estimation of the economic value of patents based on different pieces of information within patent databases or through field surveys. The former approach includes patent families (Grefermann et al., 1974; Schmoch et al. 1988; Putnam 1996; Harhoff et al. 1999) and renewals (Pakes and Schankerman 1984), and the latter varies between inventor surveys (Harhoff et al. 2002; Brusoni et al. 2006; Gambardella et al. 2006) and expert surveys (Reitzig 2003). The main common observation of this strand of the literature is the severe skewness in patent value distributions, with a very long right tail and a majority of patents associated with no or very little value (Scherer, 1965; Griliches 1990; Lanjouw 1993; Schankerman 1998; Scherer and Harhoff 2000; Scherer et al. 2000; Silverberg and Verspagen 2004). This property is illustrated with citation counts in Figure A1 in appendix.

A second strand of the literature makes use of weighted patent counts to analyse the impact of innovation and IP rights on firm value or performance. To do so, scholars in this field have assessed the correlation of different features of patents with firm value (Griliches 1981; Griliches et al. 1986; Narin et al. 1987; Trajtenberg 1990; Lerner 1994; Lanjouw and Schankerman 2004; Hall et al. 2005),[2] new product introduction, new firm creation (Shane 2001) or surveyed monetary appraisal by inventors, in an attempt to validate the use of more accessible data in value-weighting schemes. Patent features considered in this respect include citations received from subsequent patent filings (Trajtenberg 1990), legal disputes such as patent oppositions (Harhoff et al. 2002; Graham et al. 2002) and litigation (Lanjouw and Schankerman 1997), and claim counts (Lanjouw and Schankerman 2004).

A third strand of literature draws on the previous by taking the proposed indicators and correlates for granted and exploiting them to investigate different determinants of or patterns in patent value (Guellec and van Pottelsberghe 2000 2002; Maurseth 2005; van Zeebroeck and van Pottelsberghe 2008).

[1] See Dixon and Greenhalgh (2002), Reitzig (2004a,b), Meyer and Tang (2005), Greenhalgh and Rogers (2007), and Sapsalis and van Pottelsberghe (2007) for recent literature surveys on patent value.
[2] Additional examples are provided with Cockburn and Griliches 1988; Shane and Klock 1997; Hall 1999; Bosworth et al. 2000; Bosworth and Rogers 2001; Bloom and van Reenen 2002; Czarnitzki et al. 2005; Griffiths et al. 2005; Greenhalgh and Rogers 2006; Hall and MacGarvie 2006.

All these works left anyone interested in analyzing or managing patents with various measures and correlates of patent value, of which only some can be extracted from patent databases in a systematic way. Given the recent surge in patenting observed throughout the world, scholars and practitioners now have to deal with ever larger sets of patents to analyze and manage. In this respect, the need for appropriate value-weighting schemes or ranking methods mounts dramatically.

Ample evidence suggests that a growing number of patents are filed over trivial inventions (see e.g. Jaffe and Lerner (2004) and Guellec and van Pottelsberghe (2007)). It is therefore essential, for scholars and practitioners alike, to be able to screen patents efficiently and to filter the gold out of the rubbish by selecting patents which would be worth being investigated or valued more precisely. Such filtering methods would consist in identifying patents that stand out of a given set or portfolio according to a given criterion. This criterion, in turn, need to be measurable through features that can be readily extracted from patent databases.

This paper takes as a criterion the existence of a market for the patented invention. The rationale behind this choice is that it looks to us as the most reasonable information one can hope to find in patent features, and the common denominator of most the value measures and correlates proposed in the literature. Our objective is therefore to extract all features that could be indicative of a potential market. As a prerequisite, we limit the choice to measures that have already been found positively correlated with patent value. Candidates should therefore be found in the literature briefly reviewed here above: citations, families, renewals, grant decisions, and legal challenges. Among legal challenges, one is however limited to patent oppositions since they are the only challenges systematically recorded within patent databases. All these features have in common that they all denote a potential market, as discussed here below and summarized in Table 1.[3]

*** TABLE 1 ABOUT HERE ***

<u>Citations</u>

The search reports produced as part of the grant procedure provide for each patent application or grant the list of references it makes to the existing prior art (backward citations) and the list of posterior patent publications making references to it (forward citations). Altogether, they allow for the construction of technological linkage indicators for individual patents, both upstream and downstream.[4] One main argument supports the validity of forward citations as indicators of a potential market: they reveal the existence of downstream research efforts, suggesting that money is being invested into the development of the technology at stake. In addition, the fact that a given patent has been cited by subsequent patent applications suggests that it has been used by patent examiners to reduce the scope of protection claimed by a

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[3] Different scholars considered in addition the number of claims (Tong and Frame 1994; Lanjouw and Schankerman 2004), but claims seem largely influenced by drafting styles and legal systems (see Archontopoulos et al. (2007) and van Zeebroeck et al. (2009)), and claim counts probably make less sense in the European and Japanese patent systems where a patent can only include one independent claim (or up to one per type of invention: product, process, apparatus or use). Therefore, each claim in excess of 4 is necessarily a dependent claim, which could reduce as well as expand the scope of protection claimed. Finally, even under the assumption that claim counts are indicative of patent scope, there is little reason to state that a larger patent scope should indicate the existence of a larger market for the invention.

[4] Some authors (e.g. Hall et al. 2001) even go further by looking at the technological areas in which the patented invention found its roots (i.e. the IPC classes which the cited patents belong to) or to which the patent further contributed (i.e. the IPC classes which further citing patents belong to), constructing indicators of ‘originality’ and ‘generality’.

subsequent patentee to the benefits of the society. In this sense, forward citations could signal the social value of inventions.[5]

Grant decisions

The fact that an application has resulted into a granted patent or not provides another helpful insight onto its potential value, as pointed out by Guellec and van Pottelsberghe (2000 2002).[6] Indeed, non granted patents have by nature limited private value to their owner as they can hardly be enforced, and the main costs for patent applicants (at least in the European patent system) are incurred once the application is granted and needs to be translated and validated in each designated Member State (see van Pottelsberghe and François (2009) and van Pottelsberghe and van Zeebroeck (2008)).

Family sizes

The size of patent families, represented by the number of countries in which protection is sought for the same invention as imagined by Grefermann et al. (1974) and revived by Putnam (1996), has been examined and found positively correlated with patent or firm value by many authors, in particular Schmoch et al. (1988), Lanjouw and Shankerman (2001), and Harhoff et al. (2002). Given the costs required to file and enforce patents in many countries, only those with sufficient expected value to their owners will be extended abroad, denoting an expected market for the patented technology.[7]

Renewals

As of its grant, a patent can only be enforced – at least in the European patent system – as long as renewal fees are duly paid by the patent holder for each jurisdiction where patent protection needs to be maintained. Failure to pay the required fee on time in one country would provoke the patent to irremediably lapse in this country. The costs these fees represent to the owner imply that few patents reach their maximum age of twenty years[8] and may suggest that rational applicants would only incur them when justified by the market perspectives for the patented invention. Hence, whether renewal fees for a specific patent were paid all along its life or whether a patent lapsed before its maturity provides yet another indication of its private value that is empirically supported (Pakes and Schankerman 1984).[9]

Oppositions

Finally, opposition cases provide a very interesting signal of a patent's value on the market as perceived by a third party, since they designate patents whose importance justified to the opponent or the owner the cost and risks associated with the dispute, clearly establishing the existence of a market for the patented invention (Lanjouw and Schankerman 1997 2001; Harhoff and Hall 2002; Harhoff et al. 2002; Graham et al. 2002).[10] One of the great

[5] The reading of Jaffe and Trajtenberg (2002)'s volume dedicated to the analysis of patent citations is highly recommended.

[6] See also Palangkaraya et al. (2005), Jensen et al. (2005), Schneider (2006), and Webster et al. (2007) for additional studies on grant outcomes.

[7] Note that his may induce a home advantage bias (nationals of a country own a larger share of the patents filed in their home country) or disadvantage bias (applications filed in a country may include many domestic patents of lower value that are not worth being extended abroad, resulting in a lower average value of domestic patents).

[8] Lanjouw and Schankerman (1999) observe that less than 50% of patents granted in Germany are maintained 10 years or more beyond their grant.

[9] See also Pakes 1986; Schankerman and Pakes 1986; Pakes and Simpson 1989; Lanjouw et al. 1998; Schankerman 1998; O'Donoghue et al. 1998; Cornelli and Schankerman 1999; Deng 2005; Bessen 2008.

[10] Additional examples are found in Allison and Lemley 1998; Allison et al. 2003; Hall et al. 2003; Harhoff and Reitzig 2004; Jerak & Wagner 2003; Cremers 2004; Reitzig 2004a; Wagner 2004; Cincera and Prokopieva 2005; Blind et al. 2007; Cincera 2007.

advantages with oppositions is that they need to be filed within nine months from the publication of the mention of the grant of the European patent (Article 99 EPC) and, once filed, are recorded within the patent office's systems and subsequently appear in patent databases.

Given their potential to reveal the existence of a market, these five measures can be seen as informative on the economic importance of each patented invention. For the simplicity of the exposure, they will be referred to as 'value indicators' in the remainder of this paper. It should however be recalled that not all these measures could be used to infer the economic value of patents.[11]

3. Value indicators: how to compute and interpret them?

This section presents an attempt to formalize the different choices to be made in the raw measurement of each indicator over a large international and multi-sector database and emphasizes the main issues in their interpretation. In doing so, we distinguish between pure measurement issues, potential biases in the raw measure, and difficulties in interpretation.

*** TABLE 2 ABOUT HERE ***

The different indicators are computed over a unique dataset, made of different pieces of data gathered from PATSTAT (EPO 2006), OECD (2006) and different EPO databases. This dataset includes all patent applications filed or transferred to the EPO between 1980 and 2002 (i.e. excluding PCT applications designating the EPO which had not entered the regional phase by the end of 2002), which represents about 1.4 million patent filings. Different specifications of the indicators have been implemented and descriptive statistics for each computed measure are reported in Table 2. The evolution of these raw measures is depicted in Figure 1. Beside these value indicators, the dataset is completed with country, sector and time dummies.[12]

*** FIGURE 1 ABOUT HERE ***

Figure 2 exhibits high-level patterns in the average value of patents across different industries,[13] with industrial chemistry as a reference.[14]

*** FIGURE 2 ABOUT HERE ***

3.1 Citations

One of the main difficulties with patent citations is that they can come at any point in time, long after the cited patent was filed, granted, or even reached full term. Therefore, the effect of time increases the probability for any patent to have been cited by subsequent patents. The easiest remedy to this censoring issue consists of counting citations received by patent

[11] Lanjouw and Schankerman (2004) preferred the term 'quality' for their composite measure, because they "found it difficult to think of any other characteristic that would be common to all four indicators". We prefer however to avoid this term given the complexity of the debates on patent quality.
[12] The counting method is based on countries of residence of the applicants and on year of filing at EPO. See Dernis et al. (2001) for a review of the different possibilities in this respect and their impact on patent statistics.
[13] Defined here by EPO Joint Clusters (Archontopoulos et al. 2007).
[14] Statistics for all industries are provided in Table A1 in appendix.

applications within a given period of time (e.g. within the first 5 years from their publication). This approach to produce raw counts of forward citations is formalized in Equation 1:

$$CIT_{i,T} = \sum_{t=P_i}^{P_i+T} \sum_{j \in J(t)} C_{j,i} \qquad (1)$$

In this equation, $CIT_{i,T}$ is the number of forward citations received by patent application i published in year P_i within T years from its publication. $C_{j,i}$ is a dummy variable which is equal to 1 if application j is citing application i, and 0 otherwise. $J(t)$ is the set of all applications published in year t. Table 2 indicates that the average number of citations received by EPO filings from subsequent filings within the five first years following their publication is 1. Some 50% of applications were never cited in 5 years.

For the most recent patents, the number of citations cannot be observed and is therefore right-censored. Hall et al. (2005) propose a statistical approach to deal with this censoring issue by inferring the number of forward citations.

A second major difficulty with patent citations relates to the number of publications associated with each single patent. When a patent is filed or extended in various countries, it results into several publications in different languages. At later stages, any of the corresponding publications may be referred to in the search reports issued by the patent office. For instance, it is common practice at the EPO to cite patent publications at the USPTO rather than their European counterparts. As a result, many European patents appear with fewer citations than they actually deserve since citations are pointing to the corresponding US document. Consequently, raw counts of citations at the patent level could underestimate the actual number of citations received by the entire family. The only way to address this issue is to rely on an international database such as the Patent Statistical Database (PatStat) distributed by the European Patent Office (EPO 2006) which contains patent publications and citations from over 50 different countries. Prior to counting citations, one first needs to regroup equivalent patents into families (typically based on priority numbers) and then to compute citations at the family level. Choices need however be made on how similar the sets of priority numbers must be for patents to be considered equivalent. The definition of priority-based families proposed by Graham and Harhoff (2006) consists in considering them as groups of patent publications sharing the exact same set of priority numbers. This definition has made its way in the field and Dietmar Harhoff's website provides a very convenient dataset to plug into PatStat to obtain citations at the family level under this definition (Harhoff 2008).

Looking at Figure 1, it appears that the raw number of five-year citations, measured at the patent level according to Equation 1, is marked by a very sharp increase (about 70% total growth) in 15 years. A similar observation has been made by Hall et al. (2001) with US citations. At first sight, this sharp increase might denote an increasing importance of patent filings on average, but four institutional factors may artificially drive this surge in forward citations to a large extent: the surge in patent applications filed to patent offices worldwide, which *ipso facto* expands the cohort of citing documents; the parallel increase in the average number of backward citations (a 30% growth between 1985 and 1995), suggesting that recent applications increasingly rely on the existing patent literature and might be more incremental in nature; the boom in claims embedded into applications (as observed by van Zeebroeck et al. 2009), which serve as the unit of analysis in the search process at the EPO; and the effect of improved bibliographic resources and search tools available to patent examiners.[15] These factors dictate to consider the evolution in forward citations with much care as it may reveal changes in scale rather than an increasing value of patents over time.

Hall et al. (2001) propose two different ways to address the potential bias in the raw measure due to this change in scale over time. Their first approach consists in dividing citation counts by the average count for a group of similar patents, thereby scaling patent counts according to some standard or benchmark. Their second approach consists in isolating the different artificial 'inflationary' effects impacting citation counts to correct them according to the intensity of the different influential factors.

More generally, citation counts are difficult to interpret by nature, due to their lack of natural scale. As Hall et al. (2001) have it, "intrinsically, information on patent citations is meaningful only when used comparatively [...] and the evaluation of the patent intensity [...] can only be made with reference to some 'benchmark' citation intensity." This makes citation counts difficult to compare across time and industries, where different scales in citation intensity have been observed as well and clearly appear in Figure 2.

3.2 Grant decisions

At the EPO, patent applications are published no later than 18 months after their filing and appear in patent databases along with granted patent. Many authors have disregarded patent applications for long, partly under the influence of the US patent system in which patent filings were not published before grant until 1999, and partly by convenience or under the assumption that only granted patents matter. We argue that this assumption no longer holds for three main reasons. First, the inflation in examination delays (from 3 years on average in the early eighties to over 5 years in the early 2000's) implies that a larger chunk of a patent life is now made of pendency, and these first years after publication may turn out to be the most critical on the market (particularly given the acceleration in product life cycles). Second, Article 67 of the European Patent Convention (EPC) specifically provides that pending applications produce the same legal effects during the entire examination period than if a valid patent had been granted, so that they could theoretically be enforced and may at least be sufficient to keep away competition or force competitors to concede a license over their own technology. There is ample evidence that some patentees may deliberately behave in ways that defers the patent office's decision on their filings (see Hegde et al. 2007; van Zeebroeck and van Pottelsberghe 2008; and van Zeebroeck 2007; 2008). And third, a large number of patents receiving many citations have actually not been granted.[16]

If patent applications do matter, then their grant status is however very important in assessing their potential significance on the market. Granted patents are easier to enforce and their validation is costly, suggesting that their expected market outcomes would justify these expenses. This however implies one particular measurement issue with European data: should we consider patents as granted as soon as the patent office communicates its decision to grant a patent or only once the applicant has validated his patent in at least one EPC member state, which he is only offered one year to do?

[15] Figure A2 in the appendix exhibits the evolution of the number of searchable patent and non patent documents available at the EPO. This is the first driver advanced by Hall et al. (2001).
[16] See Nagaoka (2004), who shows that almost 60% of cited patents in Japan have not been granted.

In this paper, we prefer the second option as it imposes a double test that is more informative: the grant decision by the office indicates whether the application meets the patentability requirements in terms of novelty and inventive step in particular, whereas the validation by the applicant reveals the confidence the applicant has in the market potential of his invention.

The grant outcome index is therefore expressed in Equation 2:

$$GRANT_i = G_i . V_i \qquad (2)$$

where G_i is equal to 1 if the application *i* has been granted by the EPO and 0 otherwise, and V_i is equal to 1 if the granted application *i* has been validated by the applicant in at least one EPC Contracting State and 0 otherwise.

Overall, about 60% of all applications filed at the EPO between 1980 and 2002 with a known outcome were granted by the EPO and validated by their owner in at least one EPC Contracting State, about 3% have been refused, 31% were withdrawn and about 6% were granted but not yet validated. There are over 200,000 applications filed in 2002 or before which were still in the EPO backlog in early 2006.[17]

The interpretation of the grant and validation of a patent is clearly more straightforward than with citation counts, especially since it is a binary outcome. However, grant rates are marked by significant differences across time and industries. In view of the surge in patenting activity and in the absence of observed changes in patentability requirements or examination standards, the drop in average grant rate over the past decades depicted in Figure 1 is indicative of a drop in the average quality of patents over time,[18] suggesting an increasing propensity to file patents on smaller inventive steps or on less patentable subject matter. This is what is argued by Jaffe and Lerner (2004) in the US and Guellec and van Pottelsberghe (2007) in Europe.

Figure 2 however betrays substantial differences in average grant rates across industries. These differences should probably be looked at more carefully as they may result from different examination practices, or from the fact that in some sectors (e.g. in the biotech and software industries) inventions are more frequently on the borderline of patentable subject matter, or the level of inventive step is more difficult to assess. Similarly, in recent fields of technology, the patentability standards of the office may be less predictable, resulting in more patents being filed. It is therefore difficult to compare aggregate grant rates across industries. Nonetheless, there is no reason to believe that the validity check conferred by the office's decision to grant a patent or the costs of a validating it would vary from one industry to the other, so that a single valid grant decision should have the same meaning in any industry.

3.3 Family sizes

More complex issues are to be addressed in the measurement of family sizes. In particular, families can be observed at different geographical scales and at different points in time, leading to very different values.

[17] Note that the dataset comprises grant decisions taken up to January 2006 included.
[18] We may speak here of quality as this tends to indicate patents that increasingly fail to comply with the patentability requirements.

In terms of geography, one first needs to make a choice in terms of the area to look at. We may for instance consider the number of jurisdictions around the world in which an application was filed no matter the outcome in each country. Table 2 reveals that the international family size of EPO patent applications ranges from 1 to 50 countries with a mean size of about 5 countries. But not all jurisdictions should be regarded evenly as they may vary widely in the size of their market. One may therefore prefer considering whether a patent is triadic. Triadic Patent Families (TPF) are made of applications filed in the three largest patent offices in the world, namely the USPTO, the Japanese Patent Office, and the EPO (Dernis et al. 2001; OECD 2006).[19]

Table 2 shows that about 50% of EPO applications are triadic. This relatively high share may be partly explained by the international nature of the EPO. Even to European patentees, once they are ready to expose the costs of a European extension, they are more likely to be ready to expose those of an international extension to the largest overseas markets. In this respect, EPO patents are less sensitive to the home advantage bias for they present an intrinsic international nature (van Zeebroeck et al. 2006), and triadic families are made of particularly high value patents (e.g. Guellec and van Pottelsberghe 2004 and Sapsalis and van Pottelsberghe 2007), which suffer even less from home advantage effects than USPTO or EPO patent data (Criscuolo 2005).

When focusing on Europe, the size of a European patent family strongly depends on the grant of the patent. As the EPO offers a centralised processing of European applications, patents could be extended (validated) in different European jurisdiction only if and once granted by the EPO (in up to 31 member states as of 2006).[20] If an EP application is pending, refused or withdrawn, its family size is limited to one (EP first filings) or two (EP second filings) offices in Europe. Therefore, the family size of a European application may be considered as the number of EPC Member States in which a patent was effectively validated once granted.[21] This number represents the scope of validation or initial European family size of patent *i* granted by the EPO. As reported in Table 2, the average validation scope of granted patents covers about 5 countries.[22]

The size of the EPC family can naturally reduce over time as patents are abandoned in different countries, hence the possibility to observe the geographical scope at different points in time as proposed in Equation 3.

[19] Note however that because non-granted applications have only been published for a few years in the US, triadic patent families include by definition patents filed to the EPO and the JPO and granted by the USPTO.

[20] Recall that the number of Member States to the EPC has evolved from 10 in 1977 to 35 in 2009.

[21] To compute this number using EPO renewals databases, validation records with a lapse within the first year from the date of grant needs to be discarded as they denote lapses '*ab initio*'. Lapses *ab initio* concern countries which were designated by the applicant at the time of grant but in which the applicant did not pay the required validation fees or failed to provide a valid translation. In such a case, there has in fact not been any validation of the patent, but EPO databases assume that granted patents are necessarily validated in all countries designated by the applicant, and record a lapse ab initio ex-post, should it appear that the validation has actually not been effective at the end of year 1 after grant.

[22] The absolute mode of the distribution of initial EPC family sizes is 3, which corresponds in most cases to the three largest countries (France, Germany and the UK) and also to the threshold from which the EPO option is said to become economically justified in comparison with individual national procedures (see e.g. van Pottelsberghe and François, (2009); van Pottelsberghe and van Zeebroeck (2008) showed that France, Germany and the UK are targeted in priority, i.e. by some 70% of granted patents).

$$SCOPE_{i,t} = \sum_{c=1}^{C} A_{i,c,t} \tag{3}$$

In this equation, $SCOPE_{i,t}$ is patent i's geographical scope, t years after its date of filing. C is the total number of countries considered and $A_{i,c,t}$ is a dummy variable equal to 1 if patent i was active in country c after t years from its date of filing and 0 otherwise. It may be observed in Table 2 that the family size after 10 years (i.e. with t=10) is significantly smaller than its initial size (about one country smaller on average).

Such indicators based on numbers of countries of validation or maintenance present a major downside: given the institutional expansion of the EPC (from 10 countries in 1977 to 32 in 2007), a comparison of raw family sizes over time would be significantly biased (see van Pottelsberghe and van Zeebroeck 2008). One approach to solve this issue would consist either in defining C in equation 3 as the set of countries which were accessible throughout the entire period considered. Another option would be to standardize the size of each family according to a certain benchmark. This could be achieved by dividing the number of countries in the family by the total number of countries accessible to patents from the same cohort.

However, Figure 2 also reveals significant differences in average scope across industries. Although this would probably lead to different estimates of patent value by sector if one was interested in modelling it, the reality lies probably more in market structures and competitive processes than in sheer differences in economic value. For instance, in industries marked by important economies of scale, obtaining exclusive rights on the largest markets may be sufficient to prevent competitors from reaching the same economies of scale and hence excluding them from any smaller market. Such industry specificities will render family sizes less comparable across sectors and suggests a more appropriate standardization procedure: one could for instance divide the scope of each patent by the average scope of patents in the group it belongs to (in terms of application dates and sectors for instance).

This issue is reinforced by Figure 1, which shows that the average raw number of countries of coverage per patent at the EPO has declined over the eighties and the nineties, despite the institutional expansion of the EPC area. This might suggest as first sight a drop in the expected value of patents by their owners since they seem to seek protection in increasingly smaller areas. Van Pottelsberghe and van Zeebroeck (2008) however showed that this contraction in average scope corresponds in fact to a growing focus on the largest European markets (particularly France, Germany, and the UK) and is balanced by longer maintenance rates on average. From Figure 1, it appears also that the share of triadic applications at EPO has considerably increased in the past decades. Most of this increase has however occurred in the early eighties, that is, in the early years of the EPO. Since the mid eighties, once the EPO option became well established in the European patent system, this share has in fact remained remarkably stable. The evolution in family sizes might therefore be strongly affected by institutional and structural factors that make them difficult to compare over time without the standardization proposed here above.[23]

2.4 Renewals

[23] In addition to this 'fixed-effect' correction, counts of countries could also be weighted by some measure of the size of each market, such as GDP or number of inhabitants.

Given that patents are filed, granted and validated in different countries, they may experience different hazards in each jurisdiction. Depending on each country's maintenance requirements, a patent may lapse at different points in time across jurisdictions and hence may have as many life durations as countries in which it has been validated. Consequently, it is impossible to measure the age reached by European patent rights without making any choice on the geographical scope on which one would like this age to be measured.

In addition, the age reached is censored for applications filed less than 20 years ago. Given that the EPO has been active for less than 30 years now, there is a very limited window of EP applications on which maintenance to full term could possibly be observed. To use such renewal information on reasonably recent applications, one therefore could define a maximum threshold and draw a line between patents which survived this long and patents which did not. In this respect, van Pottelsberghe and van Zeebroeck (2008) proposed a 10-years term from the date of filing as a good balance between relevance and timeliness of the indicator. Given the latest data on renewals in our dataset is available for the year 2005 this indicator is only applicable to applications filed up to 1995.[24]

Here again, this may be observed at different geographical scales. The single renewal approach (*SRA*) consists in determining whether the patent of interest has been renewed for a certain number of years from its filing date in at least one country. This is equivalent to computing the oldest age of renewal attained by the patent of interest over a chosen set of countries (*A*), as proposed in Equation 4, where $AGE_{i,c}$ is the age reached by patent *i* in country *c*.

$$SRA_{i,A} = \max_{c \in A}(AGE_{i,c}) \tag{4}$$

One can then use a certain threshold in time to deal with censoring as suggested here above. From our data, 70% of all patents granted by the EPO that were filed between 1980 and 1995 have been renewed for 10 years or more in at least one EPC Contracting State. By comparison less than 40% of granted patents filed in or before 1990 survived 15 years or more.

The complete renewal approach (*CRA*) consists in looking at the period in which patents were maintained in the entire set of countries. This would correspond to the minimum age reached by a given patent over the entire area, as expressed in Equation 5.

$$CRA_{i,A} = \min_{c \in A}(AGE_{i,c}) \tag{5}$$

Looking for instance at the three largest and most frequently targeted countries in Europe (i.e. *A*={France, Germany, UK}), Table 2 shows that the share of EPO grants maintained 10 years in these three countries simultaneously falls to about 50%. And if one considers patents that survived 10 years in the three big countries and two others, as few as 25% remain.

The intertwining of the term of renewal and geographic dimensions (the geographical scope may vary over time as patents may lapse in some countries each year) motivated the Scope-Year Index (SYI) proposed by van Pottelsberghe and van Zeebroeck (2008). This indicator counts the number of country-years of activity for each patent. Considering a given set of 10

[24] Building on Hall et al. (2005), another option to deal with right-censoring could be to infer the renewal of each patent based on their characteristics.

countries and a period of maintenance of 10 years, the SYI attributes a score between 1 and 100 to each patent.

Apart from the censoring issue, renewals are affected by industry patterns as the previous indicators (see Figure 2). These patterns may be enrooted here again in differences in product or development life cycles. In addition, in certain industries (e.g. pharmaceuticals), the cost of maintaining a patent may be marginal as compared with the R&D efforts undertaken and the potential returns, so that some firms may choose to renew most of their patents up to the statutory term no matter their expected value or exploitation. Figure 1, exhibiting a positive trend in average renewal rates at the EPO, reinforces the need for a standardization procedure such as the one proposed for family sizes.

2.5 Oppositions

Finally, oppositions filed against EPO patent grants are easier to measure. Indeed, nine months after its grant by the Office, it is definitively known whether a patent has been opposed or not. The opposition indicator could therefore simply consist in a binary variable indicating whether a given patent has been opposed or not, a piece of information that does however only make sense for granted patents. Table 2 indicates for instance that only 6% of all granted European patents that were filed between 1980 and 2002 have been opposed, a declining figure as depicted in Figure 2.

This binary indicator would however ignore the different possible outcomes of an opposition case, which are determined within two years on average (potential appeal proceedings included).[25] Following an opposition case, a patent can be maintained as such, amended or irremediably revoked in the entire EPC area. These three potential outcomes statistically occur with a similar frequency.[26] The outcome of such actions may therefore not only inform on a patent's legal strength but more importantly it may considerably affect its value. If revoked, a patent would become unenforceable and lose most the private value it could carry. The impact of amendments is more difficult to assess since they might either affect a very limited portion of the claims and have hence a limited impact on their value, or compromise the essence of the scope of protection in which case the patent would be worth very little once amended. In this case, the maintenance of a patent beyond opposition may nevertheless suggest that some value has survived the opposition justifying to the patentee the costs of maintaining its rights as amended.

Table 2 shows that out of all opposition cases in the dataset 50% of the patents concerned have been renewed after the decision was rendered. Excluding cases which were not yet decided in 2003,[27] this number rises to a more relevant 65%. Table 3 presents some statistics on the renewal rates and term of maintenance of opposed and unopposed patents filed in the period 1980-1995 by a decision rendered in the opposition. On average, opposed patents which survived the opposition were maintained about 2 years longer than undisputed patents. The table also reveals that about 8% of patents that survived an opposition as granted (i.e.

[25] Given an average granting procedure of 5 years, opposition-based indicators are therefore measurable with a 7-years lag on average.
[26] Note however that some 20% of opposition cases concerning patents filed up to 2002 were still pending at the time the data was extracted, that is in January 2006.
[27] This threshold allows two years beyond the end of the opposition procedure to observe whether the patent was renewed or not.

without amendment) were not renewed two years after the end of the procedure.[28] Surprisingly, the same proportion applies to patents amended, suggesting that amendments do not lead to patents being abandoned, at least not more than rejected oppositions do. Nonetheless, the table shows that patents amended tend to be maintained for slightly less long than patents which survived their opposition unamended (6.38 years vs. 6.85 years).[29]

*** TABLE 3 ABOUT HERE ***

Since opposition indicators are binary in nature, they are safer to interpret. The apparent decline in opposition cases in the eighties and nineties is however subject to caution. On the one hand, the easiest explanation would be found in a decreasing interest to challenge third-party patents, which could be interpreted as a sign of a lower threatening power (or value) of patents on average. On the other hand, one might sustain a reverse argument, in which it is precisely because patents are stronger nowadays that the chances to obtain their revocation are lower, which could discourage third-parties to challenge them. The stability in the frequency of the different outcomes does however not support this latter line of reasoning. In this case, we would indeed have expected rejections of oppositions to become relatively more frequent, which is not the case. Nonetheless, another factor pleads for a careful interpretation of the observed trend: we know nothing of the inter-partes settlements negotiated outside of the EPO. Such settlements might ultimately have the same effect as an opposition (e.g. leading to the non-renewal of a patent by an applicant), which would then appear as a simple lapse in the database, or give rise to a financial compensation between parties that can hardly be observed.

As a consequence, it is also advisable to account for industrial properties and potential changes in market conditions over time when comparing opposition incidences or rates across industries or time.

4. Puzzling value indicators

As all the indicators discussed here above may look relevant with respect to our objective, which one should we choose, and beforehand, should we choose one? The truth is that little attention has been paid so far to the consistency or substitutability of the different indicators proposed in the literature in view of assessing their relative importance.[30] Therefore the question one may wonder is to what extent they 'see' the same patents as more important?

A first element of answer to this question is provided by Table 4, which reports Spearman rank correlations between value indicators. Overall, most indicators appear weakly correlated with each other. One striking exception concerns the triplet made of grant status, scope and age reached, which are deeply intertwined and strongly depend on each other for institutional reasons: only granted patents can be extended across the EPC area and can survive for long. We may therefore clearly conclude that the grant status is largely reflected within the scope and age indicators. Apart from this triplet, all correlation coefficients score in the range 0.02

[28] This is in line with Calderini and Scellato (2004) who find that 14% of patents which survived an opposition in the telecom industry were not renewed in the first four years after the end of the opposition procedure.

[29] The fact that their total lifespan looks slightly longer on average (15.03 years vs. 14.28) simply betrays the fact that the opposition procedure lasts longer on average (over 1 more year) when the patent is amended than when it is simply maintained as such. This issue is more thoroughly investigated in van Zeebroeck (2007). This therefore does not preclude the possibility that amended patents lost a large share of their value in the amendment. Consequently, a conservative approach would consider oppositions rejected as the only cases in which one can be certain that the patent and its value remained unaffected by the opposition procedure.

[30] Except a small number of papers examining the issue at an aggregate firm, sector or national level, e.g. Kleinknecht et al. (2000; 2002), Hagedoorn and Cloodt (2003), Jensen and Webster (2004).

to 0.34. They are nonetheless all significant at the 1% probability level. These relatively low levels of correlation between the indicators considered are in the order of the ones found by Lanjouw and Schankerman (2004).[31]

*** TABLE 4 ABOUT HERE ***

A factor analysis, reported in Table 5, sheds additional light on the relationships between the different indicators. The analysis produces 3 different factors. The first one is very strongly related with the grant variable and its two main correlates (scope and age), suggesting that it essentially captures the grant status of each application. The second factor is mostly associated with the number of citations, the triadic variable and the age, which means with almost every indicator (citations, families and renewals) apart from the grant status (summarized by the first factor) and opposition. This second factor might be the closest to the remaining value that can be captured together by our indicators once the effect of grant decisions has been removed.

Interestingly, the opposition indicator has virtually no load on this factor but it almost the only one (apart from the citations to a smaller extent) that is loaded on the third factor, suggesting that the opposition indicator is quite orthogonal to the others. Nonetheless, most indicators (except for the grant variable and its correlates), keep a very high degree of uniqueness (over 80 percent), confirming the observation made by Hall et al. (2005) as well as Bessen (2008) that there must be many unexplained factors affecting the relationships between these features of patents, and probably a lot of noise in their relationship with their economic value.

These complex relations between indicators can be illustrated graphically, for instance by mapping all patents on two axes, each representing a given indicator. If the indicators looked into the same direction, the most important patents would score high on both dimensions, and the less important ones would be concentrated in the lower left area of the graph. With other words, most patents should be concentrated around the diagonal and we would expect no patents to appear in the upper left and lower right quadrants.

This is what is proposed in Figures 3 and 4. The first figure maps all patents filed to the EPO in 1990 and 1991. The two indicators chosen as axes are the number of citations received within 5 years (*CIT[5]*) on the horizontal axis, and the age (*SRA[EPC]*) reached on the vertical axis. The numbers in the graph indicate how many patents obtain the corresponding score on each axis. In addition, the figure highlights patents which have been opposed (the grey area indicates patents that were revoked or amended in the opposition and therefore arguably lost most of their value). It is very striking to observe that the biggest numbers are far from nearing the diagonal axis. There are large sets of patents in the lower right quadrant (scoring high on citations but not even granted) and in the upper left quadrant (scoring low on citations but high on renewals). If we assume that outstanding patents should be remarkable on all indicators simultaneously, then only 26 patents out of 125,000 can be considered as most important (having 10 citations or more and still active after 15 years and a successful opposition).

*** FIGURE 3 ABOUT HERE ***

[31] This does however not contradict Hagedoorn and Cloodt (2003) who found very high correlations between patent count, citation-weighted patent counts, R&D expenditures and new product announcements at the firm level in different sectors.

A similar exercise is displayed in Figure 4, comparing forward citations (still on the horizontal axis) with triadic, grant and opposition indicators for all EPO patents filed between 1990 and 1995. Here again, under the assumption that these indicators are able to capture the same outstanding patents, we should expect to see the boxes matching each other (for instance expecting most triadic patents to be granted and vice-versa), which is far from being the case. On the contrary, a significant share of patent filings has a low value on one dimension but a high value on the other dimension, and very few patents reach the maximum value simultaneously on several dimensions. For example, one third of patents which survived an opposition were never cited and one fifth of the most cited applications have never been granted (hence opposed). Conversely, only 77 patents out of more than 370,000 applications have been simultaneously granted, triadic, opposed, maintained after opposition and cited 10 times or more.

*** FIGURE 4 ABOUT HERE ***

The main message from the statistics and figures reported in this section is threefold. First, it appears that the different value indicators are weakly correlated with each other, probably because there is much noise in their relationship with the actual economic value of patents. Second, a factor analysis would mainly capture the grant status of each application and then leave us with at least two factors, which are difficult to interpret and leave a very large amount of uniqueness in each measure. With other words, a factor analysis would essentially capture the common direction the different indicators look at, and hence reinforce the selection of outstanding patents that they would identify in common, but ignore the largest part of their discriminatory power. Third, when looking at indicators to signal patents that might be of more importance than their counterparts, it appears that the different indicators would mostly point out different patents as outstanding and produce different rankings.

As a consequence, anyone – scholar or practitioner – seeking features to help in filtering or ranking patents by potential importance, should not only deal with several issues hampering their comparability across industries and over time, but would be left with different patent rankings depending on the indicator used. In the next section, we develop one possible approach to provide a single ranking of patents that would be fairly consistent across industries and time.

5. Toward a composite ranking of patent value

The preceding section leaves us with a puzzling picture. All value indicators are affected by significant systemic or structural factors that make them hard to compare across sectors and over time. For instance, oppositions may be more frequent in fields where patents play a more important role in competitive processes; technology life cycles may be longer in certain fields leading to higher renewal rates; geographical scopes may be more concentrated in traditional industries with high barriers to entry and broader in some high-tech industries; etc.

As a result, all indicators exhibit large cross-industry discrepancies. Biotechnology patents are cited twice as often as civil engineering patents, but they are less likely to be granted. Patents in the industrial chemistry sector are 3 to 4 times more frequently opposed than in the Audio, Video and Media sector. From Table A1 in the appendix, it appears in particular that average grant rates vary between 50% (in the telecommunications sector) and 72% (in the automotive industry), opposition rates between 2% (for telecoms and audio, video and media patents) and 8% (in chemical sectors), triadic rates range from about 37% (in civil engineering) to 77% (audio, video and media), the SY Index between 23 (in computers) and 42 (in organic chemistry and biotechnologies), and 5 years forward citations vary between about .95 (civil engineering, handling and processing) and 2.84 (telecommunications). But one could hardly conclude that these patterns are anyhow indicative of any difference in actual economic value of patents across sectors.

Nonetheless, the empirically robust correlation of each of these indicators with the value of patents suggests that they carry some information that may signal patents of a potentially higher value, and in this quest, any piece of information that could help localize the needle in the haystack should be exploited. In this sense, if one's objective is simply to highlight potentially more valuable patents in a huge set of applications rather than to quantify the monetary value of each filing on a given scale, one could look at the indicators as 'probabilistic markers' signalling a potential above average value. No matter the scale of each indicator, what we would be interested in would be a measure of the extent to which each patent stands out on each indicator as a measure of the intensity of the value signal it carries.

To achieve this, the approach we propose consists in looking at the position of the patent of interest in the distribution of each indicator, for instance by computing the percentile to which each patent belongs according to each indicator. This consists in creating a variable that categorizes the chosen indicator by its percentiles, resulting in a discrete score between 1 (bottom 1 percent) and 100 (top 1 percent). In order to deal with the systemic and industrial effects discussed here above, the distributions should be looked at industry by industry, and year of filing by year of filing. This approach is formalized in Equation 6:

$$P(V)_i = x : V_i \in \left(P_{x-1}\{V(k,t)\}; P_x\{V(k,t)\}\right] \qquad (6)$$

Where V is the chosen value indicator, V_i is patent i's score on the indicator V, $P(V)_i$ is the percentile score of patent i on the indicator V, and $P_x\{V(k,t)\}$ is the x^{th} percentile of V for the subset of patents belonging to industry or sector k and filed in year t. The percentile score of a patent on one indicator, $P(V)_i$, gives a relative measure of the extent to which this particular patent stands out in its industry-year cluster. This score should therefore be relatively insensitive to the institutional, systemic or industrial factors discussed above (as confirmed by Figure A3 in appendix where most differences between sectors have disappeared) and reflects the probability that the patent of interest might be more important than its counterparts according to one indicator in particular.

This methodology has been applied to the entire dataset presented in section 3 over 7 different specifications of our value indicators: 5-year forward citations (*CIT[5]*), grant statuses (*GRANT*), triadic filings (*TRIADIC*), EPC families at grant (*SCOPE[at grant, EPC]*), maximum age reached in EPC area, bounded to 10 years (*SRA[EPC,10]*), opposition cases (*OPPOSED*) and survivals to opposition challenges (*SURVIVAL*). The industrial taxonomy we used to cluster patents in the procedure corresponds to the taxonomy in use at the EPO.[32] Other industrial taxonomies could of course be used, provided their level of granularity is broad enough to leave a sufficient number of observations in each sector-year cluster. Summary statistics for the respective percentile scores are reported in Table 5 and their evolution is depicted in Figure 5.

*** TABLE 5 ABOUT HERE ***

[32] This taxonomy is described by Archontopoulos et al. (2007), who also provide a correspondence table to IPC4 classes.

Altogether, these 7 different percentile scores – now comparable in scales – provide an amount of probabilistic signal about the potential value of each patent. Pursuing the objective of providing a ranking of patents to screen those which are potentially the most valuable, we could easily aggregate these different variables into one composite measure. Different aggregation functions could be imagined in this perspective, which are reported at the end of Table 5, such as taking the minimum, maximum, mean or median percentile scores for each patent.

These aggregate measures – we will focus on the mean aggregate indicator in the remainder of the section – may not be linearly correlated with the economic value of patents (although this would deserve further investigation in the future), but they indicate how confident one could be that the patent of interest is more valuable than average.

*** FIGURE 5 ABOUT HERE ***

In Figure 5, most indicators exhibit a slight declining trend throughout the eighties and the nineties, except the *TRIADIC* indicator that remained stable, the *GRANT* indicator which increased from about 20 in 1980 to about 25 in 1997, and the citations score, which increased in the same proportion. Similarly, Figure 6 exhibits the evolution in the mean percentile score, and reveals a drop by about 2 percentiles over the same period, although most of this drop happened in the early nineties. These trends may look at first sight as indicative of a slow decline in the average value of patents. However, two major nuances must be brought to this observation.

*** FIGURE 6 ABOUT HERE ***

First, given the distributional nature of these new scores, a drop in their averages does not reflect a drop in average value of the underlying indicator, but a reduction in its skewness. On the contrary, the increase in the percentile citation score does not reflect the growth in the average number of citations received observed in Figure 1, but rather the fact that the skewness in the citation counts distribution is larger for more recent patents than for older ones. In this sense, it reflects changes in the discriminatory power of the indicators rather than in sheer economic value, suggesting that recent patents tend to be more difficult to distinguish from each other using our indicators.

The second comment has to do with the censoring issues discussed in section 3. With the application of the correction mechanisms to renewals and citations in the form of a fixed term horizon of measurement (10 years for renewals and 5 years for citations), the horizon of measurability of the percentile scores reported here is limited to 1997. Going beyond this limit would require extrapolating or inferring the value of the different indicators for more recent patents, based on the other indicators or on different patent features, or both.

Notwithstanding these two comments, the declining evolution of the average composite value index in the early nineties, following 10 years of overall stability, raises question. This result is in line with previous findings on families and renewals (van Pottelsberghe and van Zeebroeck 2008), but is in apparent contradiction with Lanjouw and Schankerman (2004), whose quality index – based on forward citations, families, claims and backward citations – has increased in the period 1975-1991, possibly partly due to the observed inflation in patent size observed in Archontopoulos et al. (2007). Similarly, Schankerman and Pakes (1986) found that patent quality has increased in France, Germany and the UK in the period 1955-75.

Figure 6 also depicts the average national propensity to patent, measured as the ratio of EPO filings originating from one country each year over the total R&D expenditures of that country in the same year. Although highly anecdotal, the figure suggests an anti-symmetrical evolution. The increasing propensity to patent has given rise to different interpretations. Kortum and Lerner (1999), analysing this phenomenon in the US, concluded that the "*jump in patenting reflects an increase in US innovation spurred by changes in the management of research*." But in their book published 5 years later, Jaffe and Lerner (2004) share their concern of a sharp decline in average patent quality, endangering innovation and progress, relayed by Guellec and van Pottelsberghe (2007) in Europe.

At first sight, the trends depicted in Figure 6 may appear as supporting the more pessimistic view defended by Jaffe and Lerner. However, the interpretation of this trend is not clear-cut and it is probably not sufficient to definitely rule out which view is right. Because our composite index is not an approximation of patent value, but rather reflects the intensity of the signal provided by each constituting indicator on the potential value of each patent, its apparent decline should not too quickly be interpreted as a drop in average patent value, but rather first as a rarefaction of this signal. Two factors could explain this phenomenon. One obvious possibility is that the average value or quality of patents has really decreased in the period 1985-1995. Another possibility, however, is that the indicators provided by the literature are increasingly unable to capture the value of patents or discriminate on it, and hence that their decline may not be indicative of an erosion of the average patent value. The only confidence one may have at this point is that the empirical evidence produced in this paper does not bring much support to the optimistic view once defended by Kortum and Lerner (1999).

6. Concluding remarks

The objective of the present paper was threefold. First, it was to propose a state of the art on the patent features available within patent databases and correlated with patent value, which can inform on the existence of a market for a patented invention. Second, it was to emphasize and address the main methodological issues faced in their measurement over a large database. And third, it aimed at proposing a new practical approach to rank or weight patents according to the amount of signal provided by the different correlates on their potential value.

Patent value has been assessed in the economic literature with many different indicators, which differ in rationale, form and availability in a patent's life. The recent PatVal survey, conducted by Gambardella et al. (2006), has confirmed that most of the indicators considered here are indeed correlated with the monetary value of patents as perceived by their inventors. The main teaching from this paper is that despite their common correlation with patent value and shared distributional properties (e.g. a severe skewness), these indicators are in fact weakly correlated with each other, exhibit opposite evolutions and different industrial patterns, and would produce different rankings of patents.

The approach proposed in this paper to deal with these issues consists in replacing the score of patents on each indicator by a rank corresponding to the percentile it belongs to, in the set of similar patents. The percentile scores obtained can then be seen as the probability that the patent of interest is more valuable than average according to each indicator. These scores can then be used to rank or weight patents by probability of being valuable.

In addition, this approach has the advantage of being fairly robust to different structural or systemic factors that affect the underlying indicators and limits their comparability across industries or time. What is more, it reduces each indicator to a single scale between 1 and 100, which makes them easier to combine. Aggregating these percentile scores into one single measure has the advantage of allowing a ranking of patents based on all the exploitable information. Different aggregation functions could however be proposed. The resulting composite percentile-based measure should however not be seen as a proxy for the economic value of each patent, but rather as a degree of probability for each patent to be of more value than the others.[33] We believe this indicator is nonetheless valuable in the richness of the information it carries (citations, grants, oppositions, families and renewals), in its applicability to patent filings and not only to patent grants, and in its easiness of computation, compared to existing composite measures proposed in the literature.

In line with the Scope-Year Index proposed by van Pottelsberghe and van Zeebroeck (2008), the evolution of the percentile-based composite exhibits a small decline between the mid-eighties and the mid-nineties. This observation can give rise to two interpretations: either the indicators proposed by the literature have become less reliable in capturing the value of patents (possibly due to remaining structural or systemic factors), or there has really been a decline in the average value of patents. In the latter case, the boom in patenting observed over the past two decades could be carrying many applications of dubious value.

This trend bring some (although limited) empirical echo to the concerns about a decreasing quality of patents shared by Jaffe and Lerner (2004) and Guellec and van Pottelsberghe (2007), and may be related to the snowball effect characterizing today's patent world in which inventors patent in advance any potential improvement to their inventions in order to avoid being invented – or patented – around.

[33] Nonethteless, the validation of our composite index against more direct measures of value such as firm profits, stock market quotations, or inventors' survey would be a valuable exercise, worth some research in the future. Schettino et al. (2008) provide a validation of the like of a previous version of our composite index on a small sample of patents belonging to Italian SMEs and find it strongly correlated with the value index proposed in Lanjouw and Schankerman (2004) and Hall et al. (2007).

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Appendices

Figure A1 – Frequency distribution of 5-years forward citations

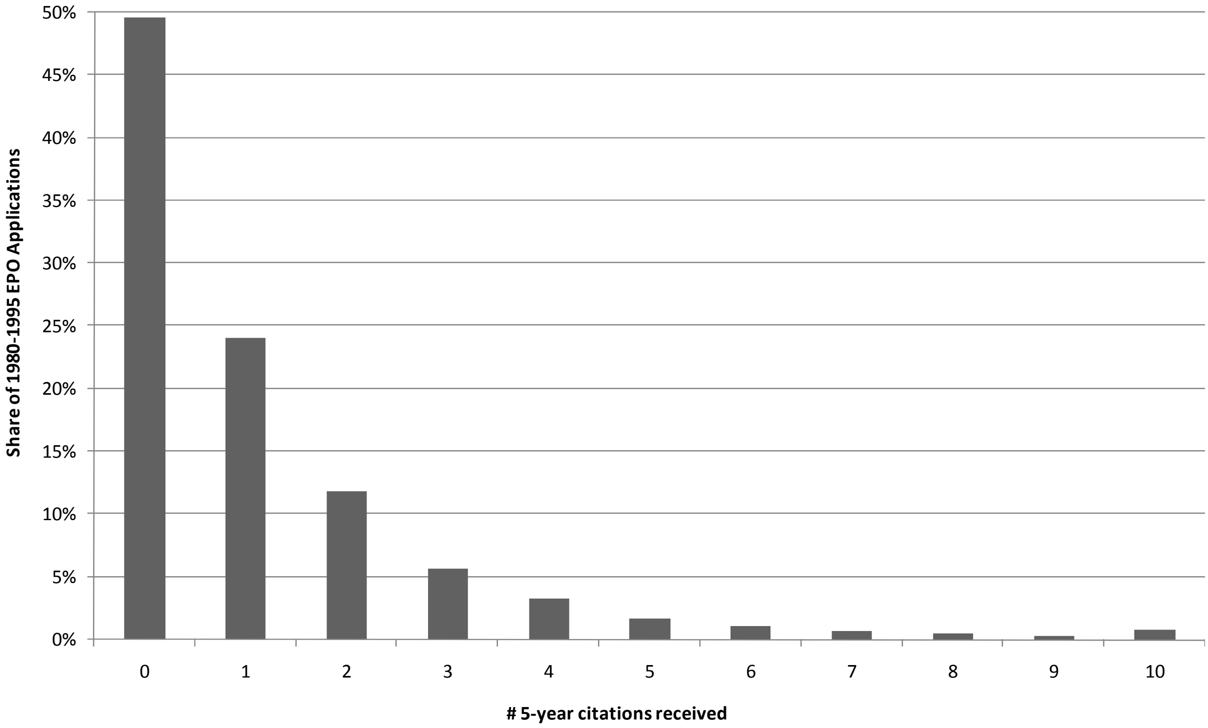
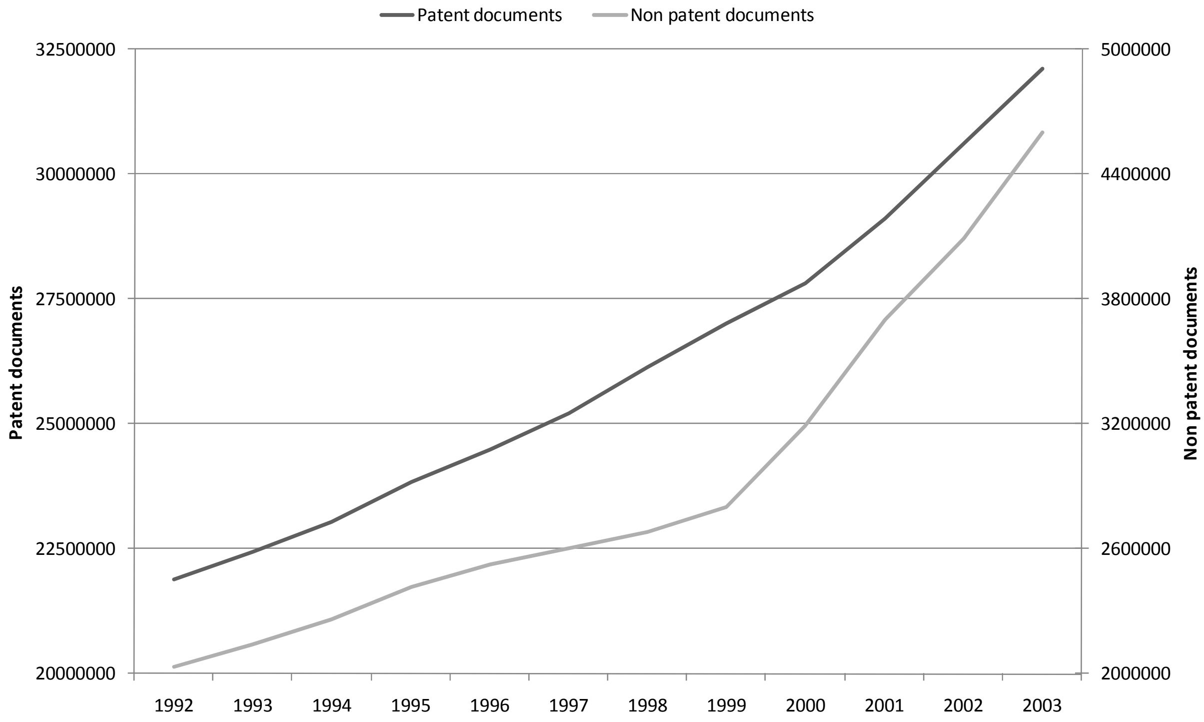


Table A1 – Average patent value indicators by Joint Cluster

Sector	5-yr Citations	Grant rate	Opposition Rate	SY Index	Share of Triadic
Industrial Chemistry	1.46	69%	7%	32.59	62%
Organic Chemistry	1.92	62%	8%	42.36	71%
Polymers	1.68	71%	8%	33.59	69%
Biotechnology	2.09	54%	7%	41.76	70%
Telecommunications	2.84	50%	2%	24.46	65%
Audio/Video/Media	1.89	64%	2%	24.09	77%
Electronics	1.46	67%	4%	25.91	66%
Electricity & Electrical Machines	1.21	67%	3%	25.94	64%
Computers	1.65	58%	3%	23.48	69%
Measuring Optics	1.37	62%	4%	27.69	67%
Handling & Processing	0.96	70%	6%	31.18	46%
Vehicles & General Technology	1.03	72%	5%	27.03	45%
Civil Eng. / Thermodynamics	0.94	69%	6%	29.17	37%
Human necessities	1.52	66%	6%	31.44	54%
JC Average	**1.57**	**64%**	**5%**	**30.05**	**62%**

Applications filed in 1995 – SY Index as proposed by van Pottelsberghe and van Zeebroeck (2008)

Figure A2 – Evolution of the search documentation available at the EPO



Source: EPO Annual Reports

Figure A3 – Average percentile scores by EPO Joint Cluster

Sample: All EPO applications filed in 1995. Industrial Chemistry = 100

Tables and figures

Table 1 – Main indicators of patent value in the literature

Indicator	Rationale	Main limitations
Citations received	Subsequent R&D Investments gave rise to further patents in same area + Technological importance	Censoring, interpretation
Grant	Limited legal protection if not granted and cost of validation in the European system	Censoring, large share (±60%), binary
Family size	Cost / targeted market	Scope considered, large share (60% EPO applications are triadic)
Renewals	Cost of maintaining a patent	Censoring, technology life cycles
Opposition	Market potential Cost and risks associated with legal disputes	Censoring, very small share (about 7%), inter-partes settlement?

Table 2 – Summary statistics of patent value indicators over the period 1980-2002

Variable	Period	Scope	T	A	Obs.	M	Mean	S.D.	Min	Max	AGR
CIT(5) (*5-year citations received*)	1980-2002	All	DIS	5	1,409,676	0	1.02	1.89	0	105	4.0
GRANT (*Granted and validated*)	1980-2002	All	0/1	5	1,411,223	0	0.49	0.50	0	1	-0.8
TRIADIC (*filed at JPO and granted at USPTO*)	1980-2002	All	0/1	3	1,411,223	1	0.51	0.50	0	1	0.8
SCOPE(at filing, world) (*# countries*)	1980-2002	All	DIS	3	1,405,656	4	4.98	3.68	1	50	-0.1
SCOPE(at grant, EPC) (*Initial EP family size*)	1980-2002	Grants	DIS	5	688,796	4	5.27	3.32	1	18	-0.1
SCOPE(10 yrs, EPC) (*EP family after 10 yrs*)	1980-1995	Maint. 10yrs	DIS	10	393,339	4	4.64	3.06	1	16	-0.5
SRV(10,{DE,FR,UK}) (*10 yrs renewal*)	1980-1995	Grants	0/1	10	497,137	0	0.48	0.50	0	1	1.3
SY Index (10 yrs, 10 countries)	1980-1995	Grants	DIS	10	497,137	37	43.26	23.82	0	100	-1.5
OPPOSED	1980-2002	Grants	0/1	6	765,380	0	0.06	0.238	0	1	-3.2
SURVIVED (*Opposition rejected or closed*)	1980-2002	Opposed	0/1	8	46,116	0	0.21	0.41	0	1	-1.5
Renewed beyond opposition	1980-2002	Opposed	0/1	9	46,116	0	0.49	0.50	0	1	-0.5

T: Type of variable | A: Average time to availability in years | M: Median | AGR: Average annual growth rate (%) from 1980 to 1995 | SY Index as proposed by van Pottelsberghe and van Zeebroeck (2008)

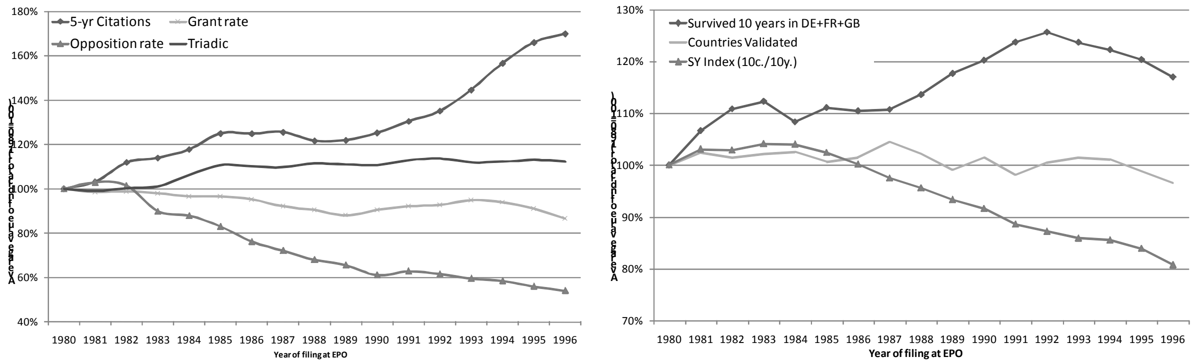
Table 3 – Renewal rates and opposition outcomes

	Maintenance beyond opposition (in years)			% Maintained 2 years after opp.	Maximum term (years) of maintenance reached (a)		
	Mean	*Median*	*S.D.*		*Mean*	*Median*	*S.D.*
Oppositions rejected	6.85	7.00	3.95	91.67%	14.28	14.00	3.91
Oppositions closed	6.86	7.00	4.33	89.01%	13.90	14.00	4.07
Patents amended	6.38	6.00	3.68	91.73%	15.03	15.00	3.60
Unopposed patents					11.97	12.00	4.11

Patents filed 1980-1995

(a) Maximum age reached over the EPC area (SRA as defined in Equation 4)

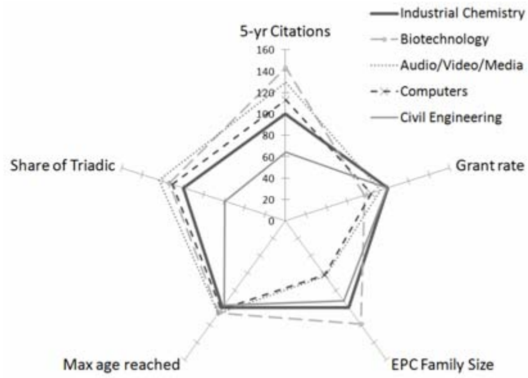
Figure 1 – Evolution of value indicators of EPO Applications



Sample: All EPO applications filed 1980-2000. 1980 = 100%

SY Index as proposed by van Pottelsberghe and van Zeebroeck (2008)

Figure 2 – Average value by EPO Joint Cluster



Sample: All EPO applications filed in 1995. Industrial Chemistry = 100

Table 4 – Spearman's rank correlation matrix of patent value indicators

Indicator	1	2	3	4	5	6
1. CIT(5)	1.00					
2. GRANT	0.12	1.00				
3. TRIADIC	0.21	0.23	1.00			
4. SCOPE(At Grant, 10 countries)	0.15	0.85	0.21	1.00		
5. SRA(10 years)	0.24	0.72	0.34	0.67	1.00	
6. OPPOSED	0.09	n.a.	-0.02	0.07	0.03	1.00

All coefficients significant at the 1% probability level

Dataset: Applications filed between 1980 and 1995 | Pending applications excluded for "grant" indicator

Non-granted applications excluded for "opposed" indicator

Table 5 – Factor analysis of patent value indicators (factor loadings and unique variance)

Indicator	Factor1	Factor2	Factor3	Uniqueness
1. CIT(5)	0.22	0.26	0.10	0.88
2. GRANT	0.85	-0.14	-0.03	0.27
3. TRIADIC	0.32	0.29	-0.04	0.81
4. SCOPE(At Grant, 10 countries)	0.70	-0.17	0.04	0.47
5. SRA(10 years)	0.78	0.12	-0.05	0.38
6. OPPOSED	0.20	-0.03	0.18	0.93

Number of observations: 1,409,567 - LR test (independent v. saturated): chi2(15) = 2.2e+06 Prob>chi2 = 0.00

Figure 3– Map of the value of patent applications filed to the EPO between 1990 and 1991

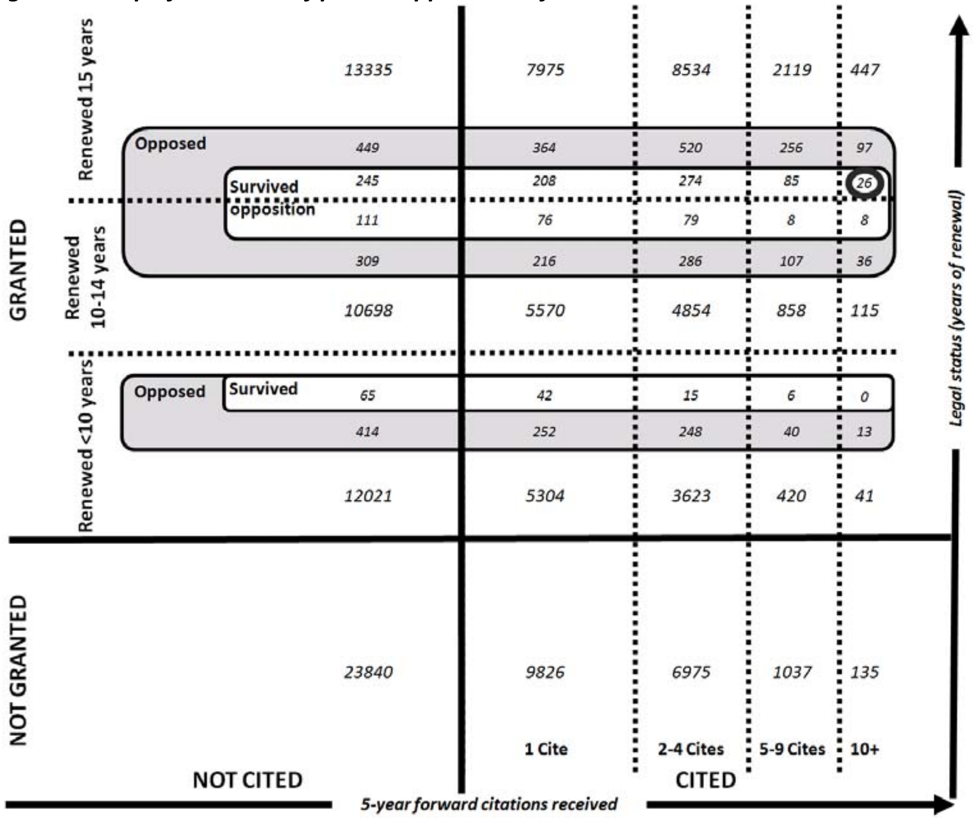


Figure 4 – Map of the value of patent applications filed to the EPO in 1990 and 1995

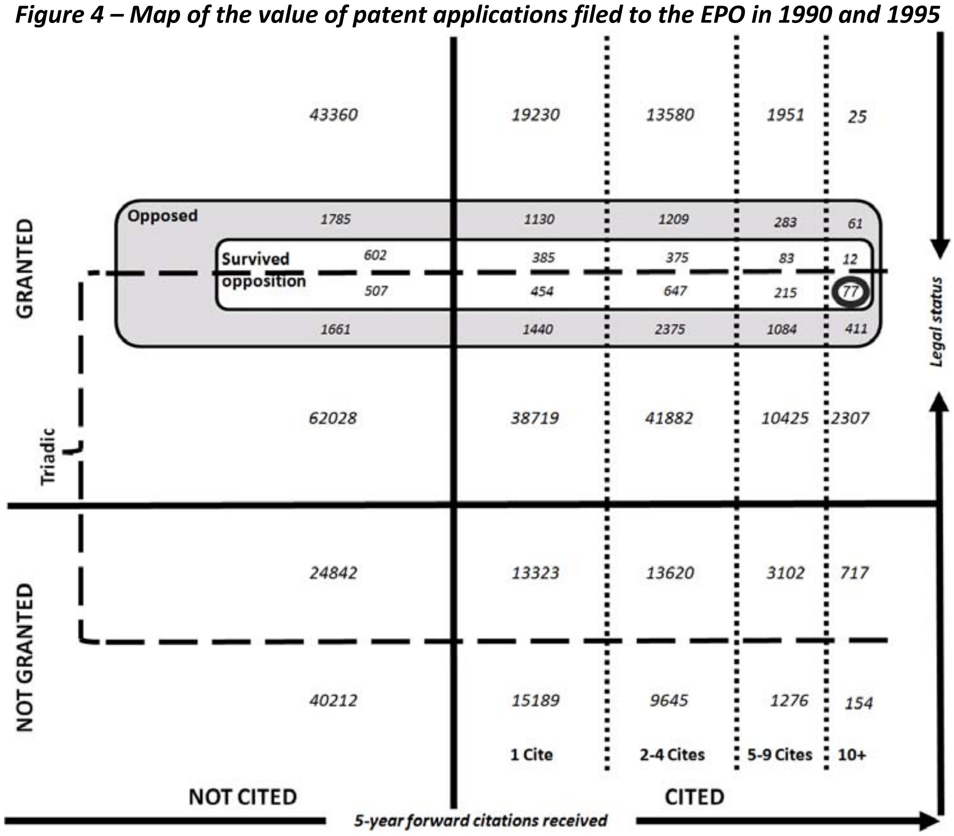


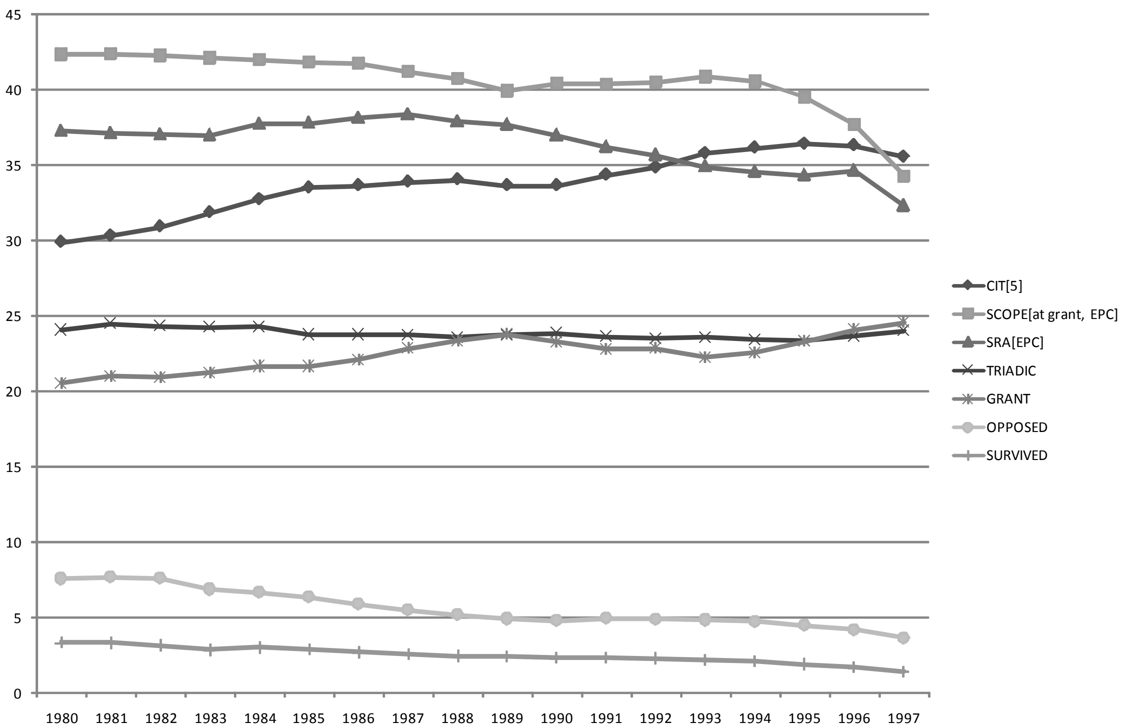
Table 5 – Descriptive statistics of the percentile score indicators

Indicator	Obs.	Mean	Std Dev	Min	Max

P(CIT[5])	1,409,567	31.33	35.88	1.00	100.00
P(SCOPE[At grant, EPC])	1,411,111	31.37	35.64	1.00	100.00
P(SRA[EPC,10])	1,411,111	30.31	17.56	1.00	64.00
P(TRIADIC)	1,411,111	23.30	23.82	1.00	93.00
P(GRANT)	1,411,111	20.07	22.12	1.00	99.00
P(OPPOSED)	1,411,111	4.09	16.83	1.00	100.00
P(SURVIVED)	1,411,111	1.88	9.28	1.00	100.00
MIN(P)	*1,411,111*	*1.11*	*1.83*	*1.00*	*44.00*
MAX(P)	*1,411,111*	*58.63*	*29.14*	*1.00*	*100.00*
MEDIAN(P)	*1,411,111*	*14.35*	*18.11*	*1.00*	*99.00*
MEAN(P)	*1,409,567*	*20.35*	*13.60*	*1.00*	*80.29*
MEAN(P) - Applications filed in 1990-95	*743,792*	*23.70*	*13.17*	*1.00*	*77.86*
MEAN(P) - Granted patents filed in 1990-95	*497,068*	*30.68*	*9.47*	*4.43*	*77.86*

Sample: All applications filed to the EPO in the period 1980-2002, unless otherwise mentioned

Figure 5 – Evolution of the percentile score indicators



Sample: All applications filed to the EPO in the period 1980-1997

Figure 6 – Evolution of the composite percentile index and the national propensity to patent