# Divide and conquer : relating patent quality and value in a conceptual framework based on a systematic review

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# Divide and Conquer: Relating Patent Quality and Value in a Conceptual Framework Based on a Systematic Review



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| Abstract: | Patents as intangible assets are subjects of burgeoning empirical research. However, there is limited knowledge of how patent quality and patent value can be conceptualized, distinguished, and related. Distinguishing these concepts and relating them in a theoretical framework would enable the assessment and improvement of patent quality, which has implications for all the stakeholders in patents. We ground this study in the emergent ex-ante theory of patent value and conduct a systematic review of 340 papers that investigate patent quality or value. Based on a comparative analysis of the patentability standards adopted by the patent offices in the U.S., Europe, and Japan, we delineate four dimensions of patent quality – subject matter, utility, non-obviousness or inventive step, and sufficiency of disclosure. Our study contributes to theory by providing an elaborated conceptual model that relates the different dimensions of patent quality and patent value and maps the different types of indicators of patent quality and value onto the corresponding patent quality or value dimensions. Our study suggests that patent policy makers can incentivize innovators to file patent applications of high quality, which would reduce the incidence of poor-quality patents in the system and improve the efficiency and reputation of the patent office. |

**Introduction**

Patents serve as rich sources of information on technological change (Basberg 1987). Expectedly, patent data are of extensive interest to innovators, economists, and management scholars. Patent quality and patent value are *distinct* but *related* concepts (de Rassenfosse and Jaffe 2018, Love, Miller et al. 2019). The quality of a patent has temporal precedence over its value; this emerges from Pitkethly (1997), who argues that the quality attributes of a patent such as the extent of advancement of the patented technology over what is known and the scope of protection obtainable for a patent can provide some hint on the *eventual* value of the patent. Even generally speaking, quality and value represent different concepts in management (see Reeves and Bednar 1994). In an exemplary work in the field of marketing, Zeithaml (1988) establishes a link between the quality and value aspects of a product from a consumer's perspective; the author asserts that the lack of clear differentiation between the concepts in *any* field limits research on these and the linkages between them.

The topic of patent value has generated longstanding research interest (Ribeiro and Shapira 2020). Unlike patent value which is well-defined by and understood among scholars (see Baron and Delcamp 2012), patent quality is seldom precisely defined; the more severe problem in the empirical literature is that the indicators of patent quality and value may overlap (de Rassenfosse and Jaffe 2018). Apparently, without a sound theoretical framework that grounds the relationship between patent quality and value, the complications in extant literature give an impression that the relationship between patent quality and value is correlational (i.e., bidirectional), or these attributes mean the same thing.

Perel (2014) advances the ex-ante theory of patent value which proposes a *positive* and *direct* relationship between the quality and value of patents; this theory is studied in the context of U.S. patents. While this development is a valuable starting point to address some of the problems in the extant literature stated above, we must remember that patents are filed by almost all industrial economies of the world; this fact renders the ex-ante theory formulated by Perel less generalisable, or put differently, not applicable *as such* for patents from jurisdictions outside the U.S. Weick (1989) argues that the more fully a generalisation satisfies the criteria of theory, the more it deserves the label theory.

To summarize, though a burgeoning body of empirical literature on patent value exists, patent quality remains relatively understudied and needs a more precise definition. A consolidation of the findings in these studies considering the emergence of the ex-ante theory of patent value (Perel 2014) is necessary to advance a *general* conceptual framework that links patent quality and value with each core concept having multiple dimensions and indicators (or lower-order constructs). Such a framework enables more theoretically grounded empirical research and helps predict, explain, and influence behaviour (see Locke and Latham 2020).

Kraus and Breier (2020) inform that in research areas with a broad range of fragmented literature based on inconsistent terminologies, a systematic literature review can help to consolidate the topic and create new insights in the form of a new (or better) theoretical framework. Accordingly, we use a systematic literature review as an effective interventional tool to provide answers to three related research questions:



1. *What are the dimensions of patent quality and value?*
2. *How are the different indicators of patent quality and value related to the different and respective dimensions of patent quality and value?*
3. *How are patent quality and value related in a conceptual framework?*

This review's central contribution is advancing the ex-ante theory of patent value (Perel 2014). We adopt the research approach of *theory elaboration* explicated by Fisher and Aguinis (2017) for making theoretical advancement. Specifically, we implement theory elaboration by using the tactics of *contrasting* which facilitates comparisons across contexts or levels of analysis to evaluate how constructs and relations apply in settings different from those in which they were originally developed and *construct specification* which creates clearer, more useful constructs and a better understanding of the nature of relations involving those constructs. This theoretical focus of the review distinguishes it from prior reviews in the field, notably a critical review of the "determinants" of patent value by van Zeebroeck and van Pottelsberghe de la Potterie (2011) and a systematic review of the "indexes" of patent value by Grimaldi and Cricelli (2020). The review advances the ex-ante theory of patent value by (a) delineating patent quality into four dimensions — subject matter, utility, non-obviousness or inventive step, and sufficiency of disclosure — based on the standards of patentability adopted by the three major (triadic) patent offices of the world in the U.S., Europe, and Japan and patent value into two dimensions — private and social value, (b) mapping the different types of indicators of patent quality and value obtained from the synthesis of the content from the relevant papers in the review on to the appropriate patent quality or value dimension, and (c) relating patent quality and value in an integrated conceptual model.



The review has concerted implications for practice, policy, and society. A theoretically grounded understanding of how the quality of a patent is linked to its value would strengthen the incentives of innovators to file high-quality patent applications and weaken their incentives to file low-quality patent applications (Perel 2014). Both these factors would enhance the value of patents for an applicant and minimize the costs associated with rejecting poor-quality applications by the patent office. Reducing the incidence of poor-quality patents in a patent system would improve the efficiency and reputation of the patent office as patent examiners would be spending less time on substandard patent applications and more time on high-quality (and, presumably, more societally beneficial) patent applications. Further, high-quality patents would be less subject to costly and cumbersome litigation (or other legal) proceedings related to patent rights, which would benefit all the parties to such transactions (see Wagner 2009).

This review is organized as follows. In the next section, we explain the theoretical foundations for the review. In the section thereafter, we describe the methodology to identify the relevant papers and provide findings at the publication level. In the following section, synthesize the content from the relevant papers and discuss the different subtypes of patent quality and value indicators. In the following section, we unfold the different dimensions of patent quality and value, map the different subtypes of indicators of patent quality and value onto the corresponding dimensions of patent quality or value, and present an elaborated conceptual model; in this section, we also discuss the critical issue of endogeneity in our model. In the penultimate section, we illuminate some worthy future research directions. Finally, we provide some concluding thoughts on the review.



**Theoretical foundations**

This review adopts the research approach of theory elaboration (Fisher and Aguinis 2017) that encompasses conceptualizing and executing empirical research using pre-existing conceptual ideas or a preliminary model as a basis for developing new theoretical insights. We ground this review in the emergent ex-ante theory of patent value (Perel 2014) that proposes a positive and direct relationship between patent quality and patent value; henceforth, we refer to this theory as the 'ex-ante theory' for brevity. The ex-ante theory proposes four dimensions for patent quality: subject matter eligibility, utility, novelty and non-obviousness, and clarity and definiteness. The choice of the ex-ante theory to underpin this review is based on two main factors.

First, consistent with Guerrini (2013) who posits that a reasonably acceptable definition for patent quality would depend on the perspectives of the major stakeholders in patent quality:

the patent offices, courts, patentees, and public, the ex-ante theory adopts a *regulatory* (of the patent office) definition for patent quality, which is the conformance of a (granted) patent to the statutory standards of patentability. The regulatory approach has merit because (a) the measurement of patent quality by this method is objective (Graf 2007), (b) the approach is consistent with the argument that quality, in general, is measured most precisely when defined as conformance to specifications (see Reeves and Bednar 1994), and (c) the approach is advantageous compared to alternatives such as the ex-post validity approach that involves measuring patent quality based on the validity of an issued patent (Graf 2007) and the economist's notion (Hall and Harhoff 2004) according to which a good quality patent is the one that protects a good idea (specifically, an invention) that is commercialized; the advantages of the regulatory approach stem from the fact that both the alternative approaches apply to substantially smaller sample sizes as only a small proportion of the universe of patents are commercialized (Higham, de Rassenfosse et al. 2021) or challenged on validity grounds either at a patent office (Hall and Harhoff 2004) or in a court (Higham, de Rassenfosse et al. 2021). Due to the methodological issues in dealing with small, disparate samples of patents, the findings from patent quality studies based on these alternative approaches are less generalizable (Love, Miller et al. 2019). Second, the regulatory lens adopted by the ex-ante theory allows for patent quality to be assessed the moment a patent is granted; this offers an additional benefit to the stakeholders in patents of being able to appraise the patent quality and to an extent, predict patent value *much earlier* in time along a patent's normal life.

The *presumption of validity* doctrine of a granted patent (for the doctrine in the three major patent offices of the world - the U.S, Europe, and Japan, see Oguri 2007, 35 USC 282 USPTO 2020, EPO 2021) is the core premise that lends credence to the regulatory perspective of patent quality. The fact that a patent is granted *only* after a substantive examination in correspondence with the applicant confers a certain *minimum* quality upon the granted patent (Popp, Santen et al. 2013). Thomas (2002) posits that granted patents are valid patents that may be reliably enforced in court, consistently expected to surmount validity challenges, and dependably employed as a technology transfer tool.

Burke and Reitzig (2007) inform that the supposition of presumed validity of a granted patent may involve an element of uncertainty as patent assessments are made by humans (examiners) that can involve subjectivity in the decision-making processes. This uncertainty in the validity of a granted patent (due to factors attributable to the examiner or the patent system) would introduce an error in (regulatory) patent quality assessments. Historically, the United States Patents and Trademark Office (USPTO) has particularly been criticized for issuing too many patents of inferior quality (for example, see Lemley and Sampat 2008); even recent studies continue to find an association between examiner attributes and patent quality at the USPTO (see Frakes and Wasserman 2017, Frakes and Wasserman 2020).



Nevertheless, the major patent offices of the world are wary of the responsibility to issue patents that pass the minimum quality standards consistently; to this end, they have instituted several patent quality improvement mechanisms in the past decade (see Love, Miller et al. 2019) such as the Patent Quality Initiative at the USPTO in 2015, Working Party on Patent Quality at the European Patent Office (EPO) in 2017, and Quality Policy on Patent Examination at the Japanese Patent Office (JPO) in 2014. As these reforms are welcome works-in-progress, one could predict that the magnitude of the measurement error in regulatory patent quality would *decrease* over time, rendering the quality assessments *more* precise.

It is noteworthy to make a distinction before we proceed further. The concept of patent value that we study in this paper differs from that of the value of the underlying technology or invention (see Pitkethly 1997). Bessen (2008) informs that innovators can appropriate value from technology by non-patent means such as lead-time advantage and trade secrets; generally, a patent protects neither all of the inventions nor all of the underlying technological knowledge.

**Review methodology and publication-level analysis**

In this section, we first describe the details of the systematic review protocol we employ to identify the papers relevant to the review. Then, we analyse the publication trend for the relevant papers, study the distribution of the types of papers, and identify the leading authors.

*The protocol for systematic review*

We follow a transparent and reproducible methodology for searching extant literature, assessing its quality, and synthesizing the content with high objectivity (Kraus, Breier et al. 2020). To ensure rigour in our review method, we borrow from the PRISMA standards (Moher, Liberati et al. 2009, Moher, Shamseer et al. 2015) that recommend preferred reporting items for systematic reviews and meta-analyses originating from medical research; similar standards are more recently introduced in other fields of research (Pullin et al. Pullin, Frampton et al. 2018). The most relevant PRISMA standards that we adopt for the current review include detailing the search strategies, listing the data sources, providing the eligibility criteria for including the papers in the review, and addressing the biases of the study.



We do not restrict the papers by publication date. In this review, as we expect to find hundreds of relevant papers from peer-reviewed journals alone (based on van Zeebroeck and van Pottelsberghe de la Potterie 2011), we exclude from the review the non-peer reviewed "grey" literature such as working papers, discussion papers, and web reports. Though this exclusion introduces a publication bias in our review, the review outcome remains robust to the exclusion (we check this in unreported studies). The grey literature we consider in our review includes Ph.D. theses, books, and book chapters which we expect to have a certain level of academic quality. Law reviews are edited by law students (Baker 2008) and are highly relevant in the field of intellectual property; we consider these papers at par with journal articles. As we do not have translation services, we only include papers in English in our study (consistent with Grant 2007). The review adopts the recommendation by Wanyama, McQuaid et al. (2021) and uses two subject-adequate databases — Web of Science Core Collection (henceforth, WoS) and Google Scholar (see Haddaway, Collins et al. 2015) — to retrieve relevant papers.

We conduct the keyword-based search in WoS in the 'topic search (TS)' field under the 'advanced search' option using the broad search string: *((quality OR valu*) AND (patent*))*. The search in WoS commenced on 26 January 2020 and repeated on October 10, 2021, and October 10, 2022, resulting in 13,539 unique results overall.[1] In the next step of database filtering, among the top 100 journal categories listed for the WoS search results, we choose 58 related to management, business, economics, finance, sociology, law, engineering, science, and technology; filtering the search results by these top journal categories yields 7,666 papers for screening in the next stage. Twice during the project window, we also conduct an extended search in WoS using an alternative search string *((patent AND (importance OR usefulness OR impact OR influence OR "knowledge flow" OR "knowledge spillover" OR "knowledge diffusion")) NOT (patent AND (valu* OR quality)))* to capture additional papers using terminologies that are alternatives to patent value (or quality).[2] The extended search yielded 10,968 unique results, which on database filtering as described above reduced to 5,321 unique papers for further screening.

At the second screening level, we check each search result from WoS for potential relevance based on its *full text* (because of this requirement, we are not able to qualify papers for the next level of analysis, even if they are potentially relevant based on their abstract if we do not have access to their full text using our institutional account). We qualify a paper for the next screening level if it provides: (a) *at least one* econometric specification or regression model that includes our attribute of interest – 'patent value', 'patent quality', or any concept used in the alternative search string discussed above - as an independent or dependent variable; or (b) a theoretical, conceptual, or qualitative study of one or more dimensions of regulatory patent quality. The qualification condition (a) helps us to efficiently screen several thousands of papers with a vast majority among them having a quantitative research orientation, which is the case with the topic of this review (see van Zeebroeck and van Pottelsberghe de la Potterie 2011), and condition (b) ensures that our study is not biased by quantitative papers. To help us screen papers at the second level, we also refer to the typology of patent characteristics from Marco and Miller (2019) to identify patent quality or value indicators. Sorting based on condition (a) results in 621 papers (462 from the basic and 159 from the alternative search strategies) for the next screening level. We qualify 13 papers based on condition (b) (we label this category as "qualitative papers" in Figure 1) and include these papers directly in the final review as they do not require further screening.

In the third screening level, we include each paper that qualifies condition (a) in the second screening level in the final review if there is *at least one* relevant econometric specification or regression model that satisfies *each* of the following criteria.

1. The model provides information on the statistical significance levels of the coefficients for the regressors. This is a formal procedure to infer knowledge about a population based on a statistic gained from a sample (Cowger 1984). This criterion excludes the 'machine learning' models that are termed black-box models, the results of which are notoriously difficult to interpret (see Zhao and Hastie 2021).
2. The sample for regression consists of *utility* patents as they are known at the USPTO or (invention) patents as they are known in general in most of the other jurisdictions. We

do not consider other major types of IP rights in this review such as design patents and plant patents in the U.S. (USPTO 2022), utility models and plant breeder's rights in Japan (Hervouet and Langinier 2018, JPO 2022), and utility model patents and design patents in China (see Chen and Zhang 2019) because for these IP rights (except plant patents in the U.S., which are very uncommon), the procedural rules and duration of protection are substantially different compared to those for utility patent rights.

3. The *unit of analysis* is a patent or a patent family (with each patent or family having a *single* observation in the sample). A patent family includes a group of patents filed in multiple jurisdictions for the same invention or a group of related patents filed in a jurisdiction that are linked by priority date(s) (Martinez 2011, Dechezlepretre, Meniere et al. 2017). Based on this criterion, two categories of papers are excluded: (a) papers that investigate the relationship between *firm-level* financial information such as Tobin's *q*, market value, R&D expenditure, and the like and patent characteristics *aggregated* at the firm level; and (b) papers with the unit of analysis as an aggregate of patents with no information on how the patents in the aggregate are linked.

4. The regression sample is restricted to *granted patents* (referred to in the literature as registered, issued, approved, successful, or authorized patents) as this criterion is necessary for patent quality and value relationship under the ex-ante theory that grounds this review. When the unit of analysis is a patent family, the rule implies that the family should include at least one granted member.

The multi-level screening of the results from WoS yields 285 papers (166 papers from the basic and 119 papers from the alternative search strategies) for the final review.

We use Google Scholar to identify peer-reviewed journal articles, Ph.D. theses, books, and book chapters; the search, using the search string below, was conducted at three points between 10 Nov 2020 and 10 Oct 2022:

*(regression OR econometric*) AND (licens* OR royal* OR renew* OR scope OR citation* OR opposition* OR litigat* OR assignment* OR transfer* OR collateral OR family OR trial* OR infringement* OR validity) AND ("patent value" OR "patent quality")*

Compared to WoS, the search on Google Scholar includes additional keywords related to the indicators of patent value or quality that were identified during the analysis of the relevant papers from the WoS search: licensing, renewal, scope, citations, oppositions, litigations, assignments, transfer, collateral, family, infringement, and validity. The search yields 4,350 unique results overall (after discounting those already identified as relevant through WoS). The results are screened at the first level based on their title or abstract and progressing through the result pages (10 results per web page) until the incidence of relevance per web page reduces significantly (logic adapted from Le 2019). By the 30$^{th}$ page, the rate of addition of papers to the second screening level is almost zero; this observation is consistent with the recommendation of Haddaway et al. (2015). The first level of screening from Google Scholar results in 190 unique papers.



At the second screening level in Google Scholar, each journal article is subject to the same inclusion criteria as that for WoS; we also use an additional criterion that the corresponding journal must be currently indexed in WoS. This additional criterion helps in identifying relevant journal articles that are not capturable through the search strategies employed in WoS. The screening of the results from Google Scholar yields 27 unique papers for the final review. Finally, snowballing (search for references of relevant references, Greenhalgh and Peacock 2005) and subjecting the resulting papers to the same screening criteria used for those from

WoS and Google Scholar adds 15 papers to the final review (340 papers in all). The flow diagram in Figure 1 illustrates the number of papers identified through the different stages of the screening process.

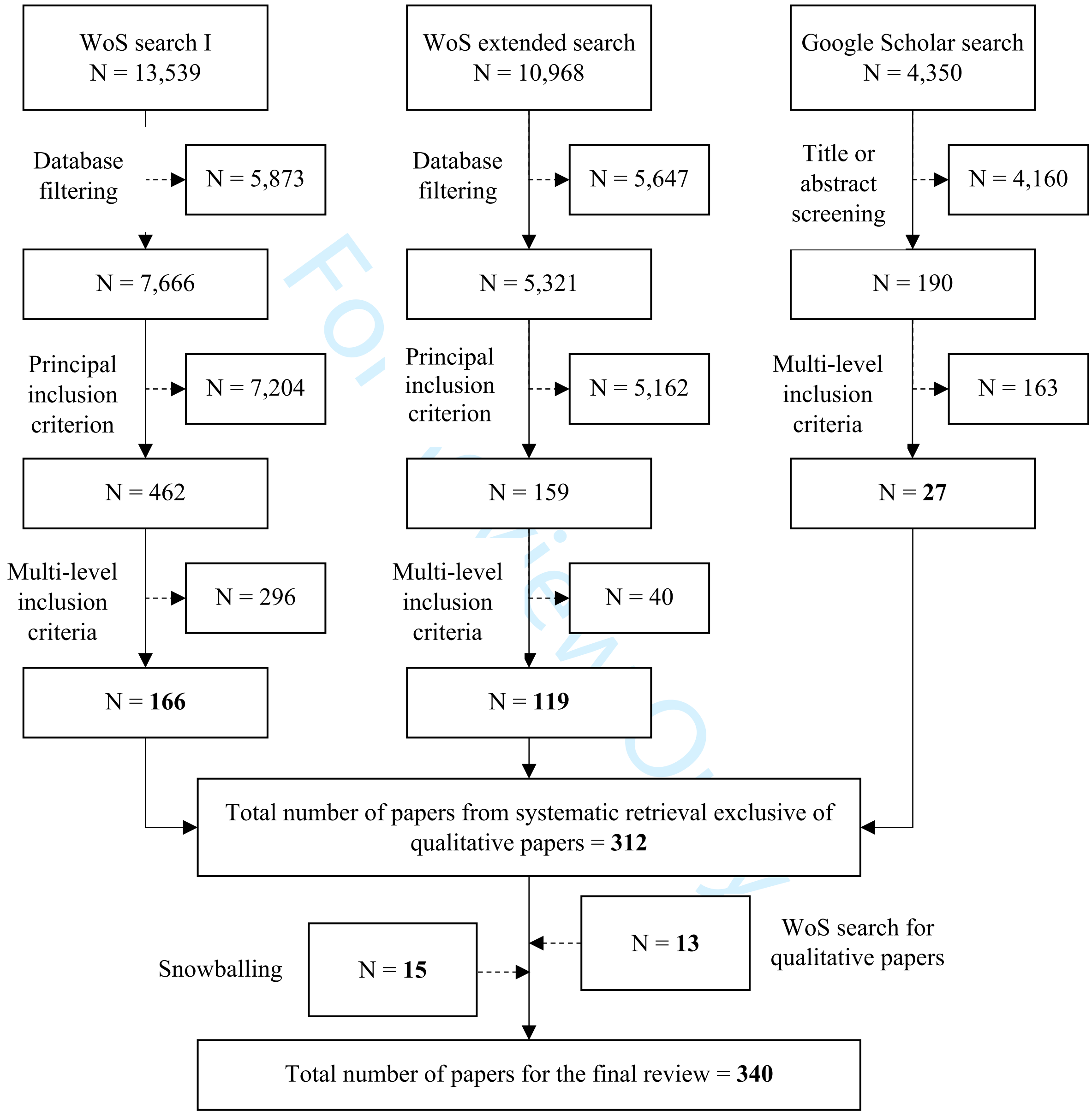


**Figure 1.** Flow diagram of the screening steps in the systematic literature review. The figures in boxes correspond to the number of papers.

*Publication-level analysis*

The publication trend for the 340 papers is presented in Figure 2. The publication year spans from 1974 to 2022 (since we conducted the last search on 10 Oct 2022, the publication count for 2022 is right-truncated and the interval size for 2019-2022 is only four years compared to five years for other intervals).

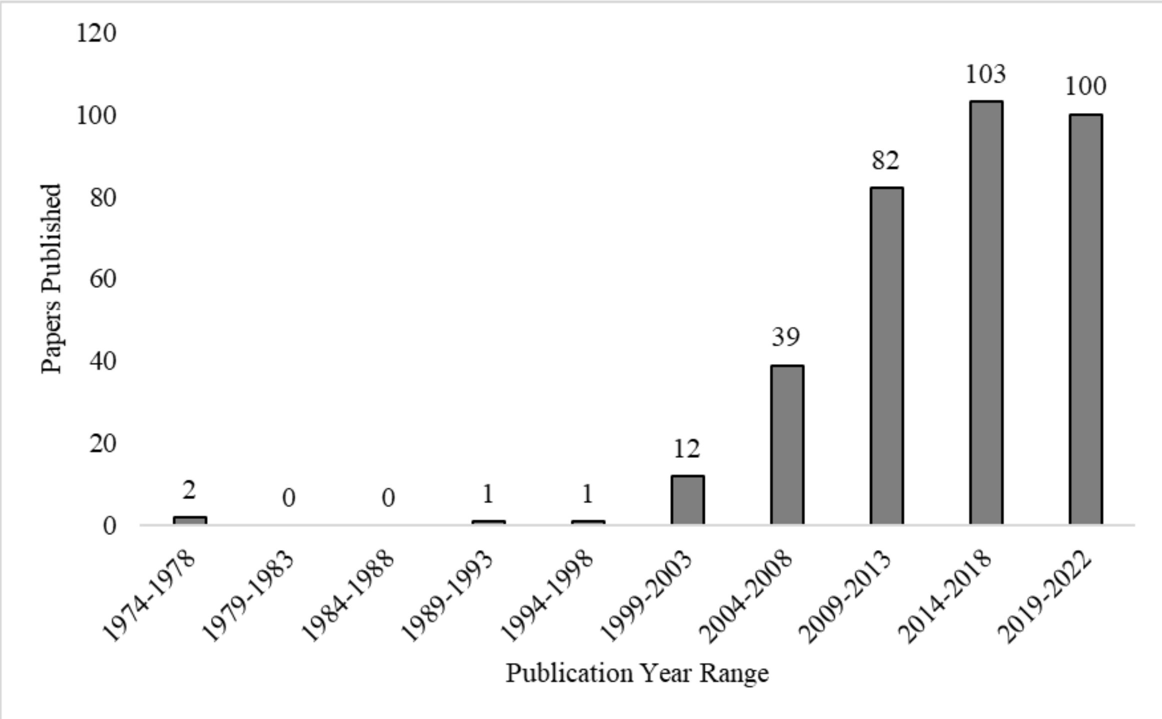


**Figure 2.** Publication trend of the 340 papers in the review



Figure 2 shows that the trend is flat from 1974 until 1998, after which a sharp and visible rise begins, resembling the early exponential phase of sigmoidal curves. This observation concurs with the general understanding among scholars of a burgeoning academic interest in patents. Several reasons can be attributed to this growth such as the relative ease of availability of patent data (more so in the recent past), explosive patenting in the 21st century, the significance of patents as intangible assets to society and practice, and the multi-disciplinary nature of patents as information sources. The earliest article in the field is by Sears (1974) who laments the inadequate application of the patentability standard of obviousness at the USPTO resulting in poor quality patents. Silverstein (1974) provides a comparative discussion of the patentability standards in the United States with those abroad. An early seminal paper by Trajtenberg (1990) establishes the importance of citing patents (commonly known as "forward" citations) as indicators of patent value.

The distribution of papers by publication type is presented in Table 1. Between the peer-reviewed and grey literature categories, the former accounts for a majority of 334 papers (98.2 per cent). Among the peer-reviewed publications, journal articles have a maximum share of 97.3 per cent (325 papers), whereas conference proceedings and conference papers have a combined share of 2.7 per cent (9 papers). Among the grey literature articles (6 papers), three are Ph.D. theses and an equal number are book chapters. Among the peer-reviewed publications, the top six journals by count are Research Policy (66 papers), Scientometrics (21 papers), Strategic Management Journal (13 papers), Management Science (12 papers), Industrial and Corporate Change (10 papers), and Journal of Technology Transfer (10 papers).

**Table 1.** Distribution of literature type and paper type in the review

| Literature type | Paper type | Papers | Share of total (per cent) | Marginal share (per cent) |
|---|---|---|---|---|
| Peer-reviewed | | **334** | 98.2 | 100 |
| | Journal article and law review | 325 | | 97.3 |
| | Conference paper and proceeding | 9 | | 2.7 |
| Grey | | **6** | 1.8 | 100 |
| | Ph.D. thesis | 3 | | 50 |
| | Book chapter | 3 | | 50 |
| Total | | **340** | 100 | |

Next, looking at the distribution of authors (irrespective of their order of authorship in the papers with co-authors), Antonio Messeni Petruzzelli has the highest count of 10 papers, followed by Dietmar Harhoff with nine papers, each of Alan Marco and Federico Caviggioli with five papers, and each of Alfonso Gambardella, Deepak Hegde, Henry Delcamp, Sam Arts, Sean Seymore, and Yong-Gil Lee with four papers. These scholars are the most frequent contributors to the subject of this review.

To summarise, this section provides an overview of the research methodology adopted in this review and the descriptive analysis of the 340 relevant papers identified. In the next section, synthesise the content from these papers. The objective is to identify and extract relevant information about patent quality and value indicators and group them based on their similarities and differences into higher-order constructs.

**Patent quality and value indicators**



First, we present the temporal partitioning scheme for the distribution of patent characteristics uniquely into those associated with patent quality or value. In the following sections, we discuss the different types of patent quality and patent value indicators.

*Temporal partitioning of patent characteristics*

To establish *internal validity* between variables x and y, a necessary (but not sufficient) condition is the temporal precedence of x over y (see Calder, Phillips et al. 1982). The information gleaned from the analysis of 340 relevant papers in this review yields a text corpus of patent characteristics used as regressors or response variables (regressands) based on idiosyncratic considerations of "patent value" or "patent quality". The first step in synthesising this information involves partitioning the patent characteristics along the temporal dimension *exclusively* into those associated with patent quality or patent value; based on the ex-ante theory, the event of the patent grant is the cut-off point that allows for this partitioning. Marco and Miller (2019) provide a taxonomy of patent characteristics that includes *application characteristics* that are observable at the time of filing a patent application, *examination characteristics* that capture the details of the examination of a patent application, *patent (grant)* *characteristics* that are associated with the grant of a patent, and *post-grant characteristics* that are observable after a patent's grant. The first three types of patent characteristics along the patent timeline can be clubbed into a bigger group - *pre-grant characteristics.* This temporal partitioning results in the first level of organisation of patent characteristics into those associated with patent quality (pre-grant characteristics) and patent value (post-grant characteristics). The time-measuring patent characteristics such as the filing year, priority year, or grant year of patent, and the age of the patent, which is typically measured as the duration between the priority date, filing date, or grant date of a patent and a later, study-defined cut-off date in the post-grant life of a patent (Sapsalis, van Pottelsberghe de la Potterie et al. 2006), are excluded from this partitioning as these variables are, by design, used as controls in patent quality or patent value regressions (e.g., see Popp 2006) to account for possible structural changes in patent quality or value over time.

*Types of pre-grant patent characteristics as patent quality indicators*

A patent document is a source of technology, business, and legal aspects (Danish, Ranjan et al. 2019). The application characteristics of a patent (discussed earlier) can be further classified into six subtypes based on the nature of business or technical information they provide: (1) *filing strategy* of a patent that informs on the decision made by an applicant to opt for national filing vis-a-vis an international patent filing or choose the countries for protecting the claimed invention; the filing strategy may signal the market potential or the stage of maturity of the underlying invention (see van Zeebroeck and van Pottelsberghe de la Potterie 2011); (2) *application claims* that informs on the semantics (meaning of words) (see Cotropia 2005), category (subject matter) (Reitzig 2004), structure (layout of dependent and independent claims) (Marco, Sarnoff et al. 2019), or length (wordiness) of claims of a patent application (Marco, Sarnoff et al. 2019); (3) *disclosed content* that provides details of the claimed invention that's made public in the patent specification (the descriptive sections of a patent) to disseminate the codified knowledge among a wider audience (Seymore 2010); (4) *applicant cited literature* (commonly known as "backward" citations) that captures information on the technologically related patents (Harhoff and Reitzig 2004) as well as scientific literature (Carpenter, Cooper et al. 1980) (also known as "non-patent literature") based on the citations to these made by the applicant; (5) *team composition* that conveys information about the team size or nationality of the inventors (for e.g., see Sapsalis, van Pottelsberghe de la Potterie et al. 2006, Singh and Fleming 2010); and (6) *ownership* that informs on whether a patent application has singular or joint ownership, and when jointly owned, the nature of the entities in the ownership (Sonmez 2018). The patent application characteristics appeal to researchers studying patent quality or value as these are available in a patent document at time-zero – the date a patent application is first published (Reitzig 2004). The various measures corresponding to the different types of patent application characteristics are provided in Appendix List A1.

The examination-cum-grant characteristics of a patent can be grouped into four subtypes based on the nature of the technical or legal information they provide such as (1) *prosecution history* that reflects the nature of the transaction between the applicant and the examiner until a patent's grant (Marco and Miller 2019); (2) *granted claims* that captures the semantics (meaning of words), category (subject matter), structure (layout of dependent and independent claims), or length (wordiness) of claims of a patent at grant; (3) *external cited literature* that captures information on the technologically related patents or scientific literature based on the citations to these made by an examiner (Hegde and Sampat 2009) or a third party (Kapoor, Karvonen et al. 2016); and (4) *technology scope* that provides information on the assignment of a patent into one or more standardized technology classes by an examiner (Lerner 1994).[3]

The various measures corresponding to the different types of patent application characteristics and patent examination-cum-grant characteristics are provided in List A1 and List A2 in the appendix. Among the subtypes of patent application characteristics, the *applicant cited literature* is the most studied (198 papers); *team composition* is the second most studied (152 papers), followed by *filing strategy* (123 papers), *ownership* (101 papers), and *disclosed content* (10 papers). The *application claims* patent characteristic is the least studied (nine papers).

Among the examination-cum-grant characteristics, *technology scope* is the most studied (198 papers) followed by *granted claims* (182 papers) and *prosecution history* (82 papers); *external cited literature* is the least studied with 18 papers.[4] Many papers in this review use "derived" (or composite) measures as regression variables. These measures are obtained from custom combinations of two or more items of the same or different kind in the pre-grant and/or post-grant patent characteristic groups and tend to average out different patent quality measures (see Higham, de Rassenfosse et al. 2021). Because of the heterogeneity of such measures, they do not fit into the synthesis scheme of this review. Refer to a recent review (Grimaldi and Cricelli 2020) for more information on such measures.

*Types of post-grant patent characteristics as patent value indicators*

Perel (2014) studies patent value in the context of patent licensing fees. Based on the precision of the measurement method, the measures of patent value can be broadly classified into three types: *direct measures*, *estimates*, *and indicators* (Giummo 2010). The *direct measures* of patent value include the monetary value of patents observed during patent-based transactions (Kramer 2007) such as patent auctions, patent infringement awards, and patent licensing deals. The *estimates* of patent value are indirect measures such as the economic value of patents obtained from surveys of inventors or patent owners (Harhoff, Scherer et al. 2003), renewal model of patent value (Schankerman and Pakes 1986), abnormal stock market returns to a firm around the grant date of a patent (Kogan, Papanikolaou et al. 2017), sales of products protected by patents (Guo, Hu et al. 2013), and returns to patented inventions based on inventors' compensation records (Giummo 2010, Giummo 2014). A characteristic feature of patent value is that it has a skewed distribution with a very long tail into the high-value side (see e.g., Scherer 1965); because of this feature, estimates of patent value, for example, based on renewals, do not directly reflect the value of patents in the "upper tail" of the distribution (Bessen 2008).

The indicators of patent value are the post-grant patent characteristics; these indicators can be classified into five subtypes based on the nature of their impact such as: (1) *legal impact* that includes litigation of a patent (Lerner 1994), reissue of a patent, post-grant opposition or validity challenge of a patent at a patent office (Harhoff and Reitzig 2004); (2) *economic impact* that includes licensing (Gambardella, Giuri et al. 2007) or reassignment (Serrano 2010) of a patent, commercialization of a patent (Chandy, Hopstaken et al. 2006), pledging of a patent as a collateral for securing funds (Fischer and Ringler 2014), renewal of a patent (Bessen 2008), or sale of a patent in an auction (Fischer and Leidinger 2014); (3) *technological impact* that includes the conferral of a prestigious award to a patented invention (Arts, Hou et al. 2021) or the inclusion of a patent as an essential patent to comply with a technical standard (Kramer 2007); (4) *knowledge internalization* that includes *self-citing patents* — citations from patents having the same assignee as the focal patent — which are indicative of the research investments made by the focal assignee to build a proprietary technology base (Hall, Jaffe et al. 2005); and (5) *knowledge diffusion* that includes *external citing patents* — citations by a third party such as a non-focal assignee or a patent examiner (see Criscuolo and Verspagen 2008, Alcácer, Gittelman et al. 2009) — which are proxies for spillover of the knowledge embodied in the focal patent among the public (see Jaffe, Trajtenberg et al. 2000).

The various measures corresponding to the different types of post-grant patent characteristics are provided in List A3 in the appendix. The direct measures of patent value are the least studied (nine papers). The infrequent usage of this precise and reliable measure of patent value is due to the rarity of events that provide such measures (Schankerman and Pakes 1986). The value of a patent is mainly inferred based on specific indicators. The indicators corresponding to *knowledge diffusion* are the most studied by 218 papers followed by *knowledge internalization* (201 papers), *economic impact* (116 papers), legal impact (65 papers), and *technological impact* (11 papers).[5]

Now that we have the information on the various subtypes of indicators of patent quality and value extracted from the literature, in the next section, following Fisher and Aguinis (2017), we elaborate the ex-ante theory by implementing the tactics of *contrasting* which facilitates comparisons across contexts or levels of analysis to evaluate how constructs and relations apply in settings different from those in which they were originally developed and *construct specification* which creates clearer, more useful constructs and a better understanding of the nature of relations involving those constructs.



**Towards an integrated conceptual model of patent quality and value**

Following the systematic literature review findings, we conceptualise patent quality and patent value as multidimensional phenomena. In the following sections, we develop an integrated conceptual model of patent quality and value by (a) delineating patent quality and value into their corresponding dimensions, (b) mapping the different types of indicators of patent quality and value (from the earlier step) on to the appropriate patent quality or value dimension, and (c) relating patent quality and value in a conceptual model.

*Dimensions and indicators of patent quality*

Patent quality is a multidimensional concept (Higham, de Rassenfosse et al. 2021). The emergent ex-ante theory proposes four dimensions for patent quality: *subject matter eligibility, utility, novelty and non-obviousness, and clarity and definiteness*. The variable conceptualisations of the ex-ante theory are centred around the patentability standards of the USPTO. To understand the dimensions of patent quality from a broader perspective, a comparative analysis of the requirements for patentability in the three *major* patent offices of the world known as the 'triad' (Frietsch and Schmoch 2010) - the USPTO, EPO, and JPO – should serve as a reliable starting point; this comparison is presented in Table 2. It should be noted that the definitions in Table 2 are excerpts taken from the legal statutes to facilitate a reasonably accurate comparative analysis without getting deep into the complicated legal connotations of terms. It is apparent from Table 2 that three of the patentability requirements of novelty, non-obviousness (or inventive step), and utility are shared among the triadic patent offices; Martinez and Guellec (2004) inform that though the definitions for these three standards differ only slightly, their interpretability and application by the patent examining authorities may vary to a greater extent. Our objective is to conceptualize patent quality broadly so that it is usable in empirical investigations of patent quality in any jurisdiction. We do this by finding a common theme across the triadic patent offices for each patentability standard.



The novelty standard, from Table 2, seeks to determine whether a claimed invention is new public knowledge. Thus, for all granted patents, the concept of novelty as a variable reduces to a *constant*, rendering this aspect of patent quality redundant for empirical analyses. In discussing the ex-ante theory, Perel (2014) proposes 'novelty and non-obviousness' as an integrated aspect of patent quality; our analysis excludes novelty from patent quality measurements under the ex-ante lens.

**Table 2.** Patentability standards at the USPTO, EPO, and JPO

| Patentability standard | Triadic patent office | Definition of the standard |
|---|---|---|
| Subject matter eligibility (SME) | USPTO | The patent is directed to a process, machine, manufacture, or composition of matter, or any new and useful improvement thereof; exclusions are determined by the law on a case-to-case basis (35 USC 101 USPTO 2020) |
| SME | EPO | The claims shall define the matter for which protection is sought. The EPC refers to different "categories" of claim ("products, process, apparatus or use"). (EPC Article 52, 84 EPO 2021) |
| SME | JPO* | There are two basic kinds of claims – physical entity (product, apparatus, system, etc) and activity (method, process, use, etc) (see requirement for claims, JPO 2017) |
| Utility | USPTO | A claimed invention must be useful or have a utility that is specific, substantial, and credible (35 USC 101, USPTO 2020). |
| Utility | EPO | The patent can be made or used in any kind of industry, including agriculture (EPC Article 57 EPO 2021) |
| Utility | JPO* | The invention for which the patent is sought has industrial applicability vide Article 29 (1) of JPO (2021) |
| Novelty | USPTO | The patent, prior to its effective filing date, was not patented or described in any printed publication, or in public use, on sale, or otherwise available to the public (35 USC 102 USPTO 2020) |
| Novelty | EPO | The patent does not form part of the state of the art that comprises everything made available to the public by means of a written or oral description, by use, or in any other way, before the date of filing of the European patent application (EPC Article 54 EPO 2021) |
| Novelty | JPO* | The invention for which a patent is sought is not public knowledge, publicly known to be worked, described in a distributed publication, or made available for public use over telecommunications lines within Japan or in a foreign country before the filing of the patent application under Article 29 (1) of JPO (2021). |
| Non-obviousness | USPTO | The difference between the patent and the prior art is such that the patent would not have been obvious before its effective filing date to a person having ordinary skill in the art to which the patent pertains (35 USC 103 USPTO 2020) |
| Inventive step | EPO | The patent is not obvious to a person skilled in the art with respect to the state of the art (EPC Article 56 EPO 2021) |
| Inventive step | JPO* | A person may not obtain a patent if before the filing of the patent application, a person of ordinary skill in the art of the invention would have easily been able to make that invention vide Article 29 (2) of JPO (2021). |
| Disclosure | USPTO | The patent's specification contains a written description of the invention, and the manner and process of making and using the invention in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and the best mode contemplated by the inventor of carrying out the invention (35 USC 112 USPTO 2020) |
| Disclosure | EPO | The patent discloses the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (EPC Article 83 EPO 2021) |
| Disclosure | JPO* | The description must contain a detailed explanation of the invention that is clear and sufficient to enable a person ordinarily skilled in the art of the invention to practice the invention vide Article 36 (1) of JPO (2021) |

* The rules are excerpts taken from the Japanese law translation in English of the Japanese Patent Act provided by the JPO.

The statutory requirement of non-obviousness (or equivalently, inventive step) calls into question a person having "ordinary skill in the art" as per the USPTO or JPO or "skill in the art" as per the EPO. This definitional element makes this quality attribute markedly different and perhaps more difficult to measure than the other patentability standards. This variable, though dichotomous, has an additional relevant attribute to consider — for a granted patent, a relevant obviousness inquiry would be: *how much* different is the claimed invention from the prior art (Sears 1974, Barton 2003, Eisenberg 2004)? Therefore, the *non-obviousness or inventive step* of a patent as the first dimension of patent quality can be defined as *the extent of advancement of a patented invention over prior public knowledge*.

We adapt the definition of Perel (2014) for the *utility* of a patent as *the extent of the specific and practical usefulness of a patented invention*. This definition reflects the examination guidelines for the utility requirement at the USPTO (under section 2107 of the Manual of Patent Examining Procedure) (USPTO 2020). The aspects of specificity and practicality in the definition also broadly capture the essence of the 'industrial application' of inventions (see Machin 1999) for the utility standard as per the EPO and JPO.

As apparent from Table 2, the requirement of subject matter eligibility differs significantly among the triadic patent offices, particularly considering what is *excluded* from this doctrine (for a detailed discussion, see van Pottelsberghe de la Potterie 2011). The presumption of validity rule would imply that a granted patent has eligible subject matter; understanding *what* this subject matter is would be important to measure this dimension of patent quality. Perel (2014) does not specify subject matter as a patent quality attribute. Based on the common theme in the definitions for subject matter in the triadic patent offices, we define *subject matter,* which is the third dimension of patent quality, as *the categories of claims of a patented invention*. The measure for subject matter would have the lowest variability compared to that for any other dimension as the categories of claims allowed in the triadic patent offices are limited, with the most common ones being process, product (or composition of matter), system, and method of use.

Finally, turning attention to the disclosure standard, it is apparent from Table 2 that the USPTO differs from the other triadic offices in having the "best mode" requirement (also see Martínez and Guellec 2004), whereas a substantial commonality among the offices is whether the disclosure of a patent would *enable* a skilled artisan to practice the claimed invention. After the U.S. transitioned to the 'first-to-file' patent system in 2011 as a part of its objective to harmonize its patent obligations with the other major patent offices of the world, the patent statute has made an exception to the disclosure requirement that failure to disclose the best mode shall *not* be a basis for invalidity of claims (Braga, Ribeiro de Souza et al. 2018); this concession essentially makes enablement the *core* element of the disclosure standard across the triadic patent offices. As per Holbrook (2006), the enablement doctrine implies that (among other things) once the patent term expires, the public will be able to practice the invention freely, strictly based on the patent disclosure; more importantly, the disclosure requirement implements the *quid pro quo* canon of the patent system wherein an inventor receives exclusionary rights in exchange for the public disclosure of the claimed invention. In comparing the definitions for the disclosure standard in Table 2, we define the *sufficiency of disclosure* as the fourth dimension of patent quality as *the extent of clarity and completeness with which a patented invention is described in a patent specification that would enable a person skilled in the art to practice the invention*. While Perel (2014) names this aspect of patent quality as 'clarity and definiteness', we adopt the naming convention of the patent offices to appreciate its importance *prima facie* from a public perspective.

Among the papers discussing one or more dimensions of regulatory patent quality, five each discuss *sufficiency of disclosure* and *non-obviousness or inventive step* and four each discuss the *utility* and *subject matter* aspects of patent quality. In the next step, we map the patent quality indicators (from the earlier section) onto the corresponding patent quality dimensions.

Perel (2014) suggests an open list of patent quality indicators. The different types of pre-grant patent characteristics and patent quality indicators discussed in the earlier section provide a good frame of reference to map these characteristics onto the appropriate dimensions of patent quality. Whereas the patent application characteristics provide information about the technical and business aspects of a patent, the examination-cum-grant characteristics capture the technical and legal aspects. The patent quality indicator subtypes of *filing strategy, team composition*, *ownership,* and *technology scope* are arguably associated with the industrial usability of the claimed invention; these could be considered indicators of the *utility* dimension of patent quality.

Both *application claims* and *granted claims* of a patent have at least four features — semantics, category, structure, and length. For both *application claims* and *granted claims*, structure is the most explored feature (see List A1 and A2 in the appendix for the different measures), whereas length is a more recently explicated measure of patent "scope" (Marco, Sarnoff et al. 2019). The semantic and category features are relatively understudied (evidently based on the elements in List A1 and A2). Logically, we consider the attribute of *category* for both *application claims* and *granted claims* under the *subject matter* dimension of patent quality. We map the remaining features of both *application claims* and *granted claims* onto the *utility* dimension of patent quality as claims reflect the strength of exclusionary rights of patents (see Cotropia 2005); since claims are priced by the patent office (see Harhoff 2016), their inclusion in a patent has a straightforward association with the potential benefits of the patent.

The choice of indicators for *non-obviousness or inventive step* is relatively straightforward. Evaluation of the body of knowledge that qualifies as the prior-art for a claimed invention is critical to ensure that an issued patent is non-obvious (Cotropia, Lemley et al. 2013). Therefore, the application characteristic of *applicant-cited literature*, together with the examination characteristic of *external cited literature,* can be considered as indicators of the *non-obviousness or inventive step* dimension of patent quality. The patent quality indicator of *disclosed content* is a logical assignment as an indicator of the *sufficiency of disclosure* dimension of patent quality.



Finally, the patent characteristics included under the *prosecution history* subtype reflect the intensity of examination of a patent application, which Marco and Miller (2019) label as "patent examination quality". The events and interactions during the examination of a patent application reflect the applicant's intentions in getting a patent issued. They are likely to convey meaningful signals about the quality of the patent. Several studies suggest this link. Investigating a large sample of patents at the EPO, Harhoff and Wagner (2009) find strong evidence that applicants expedite grant proceedings for their most "valuable" patents through requests for accelerated examination. Harhoff and Reitzig (2004) posit that the duration of interaction between patent applicants and examiners is driven by the inherent "complexity" of the invention. Regibeau and Rockett (2010) suggest that applicants push the more "important" patents through the patent approval process more eagerly. Marco and Miller (2019) posit that a plausible reason behind applicants filing a request for continued examination (US patents) is the high "perceived value" of these inventions. As the examination-cum-grant patent characteristic subtype of *prosecution history* can be linked to patent quality in general, we consider these characteristics as indicators of each dimension of patent quality. The organization of the patent application, examination, and grant characteristic subtypes into the different categories of indicators of patent quality and the mapping of the indicators onto the corresponding patent quality dimensions are shown in Figure 3.

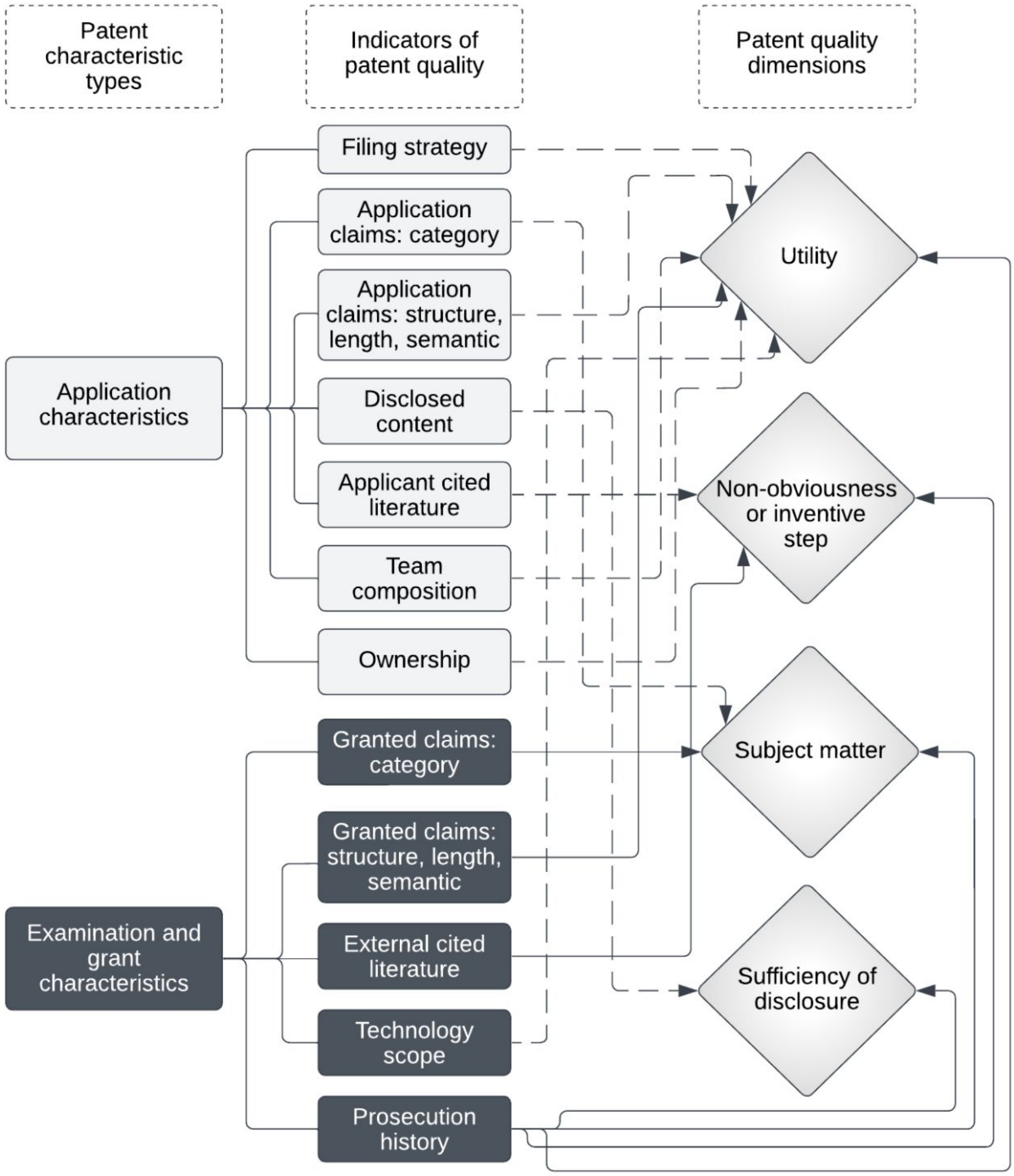


**Figure 3.** An organizational map of pre-grant patent characteristic types, indicators of patent quality, and patent quality dimensions

*Dimensions and indicators of patent value*

Conceptualising the phenomenon of patent value appears less complex than patent quality. It is often used as a unidimensional construct. For instance, Perel (2014) does not differentiate between two or more aspects of patent value. However, in line with the two-fold objective of the patent system of incentivising innovation for the benefit of the patentee and facilitating knowledge diffusion for the public good, patent value has two discernible dimensions — *private value,* which is defined as *the measure of the financial returns from a patented invention to the patent holder* (Ribeiro and Shapira 2020) and *social (or public) value* which is defined as *the measure of the contribution of a patented invention to social welfare* (Baron and Delcamp 2012).

Consistent with the literature and based on the nature of the information that the different subtypes of post-grant patent characteristics contain, we map *legal impact*, *economic impact*, *technological impact*, and *knowledge internalization* onto the *private value* dimension. We map the indicator *knowledge diffusion* onto the *social value* dimension of a patent. The mapping of the different indicators of patent value onto the corresponding patent value dimensions is shown in Figure 4.

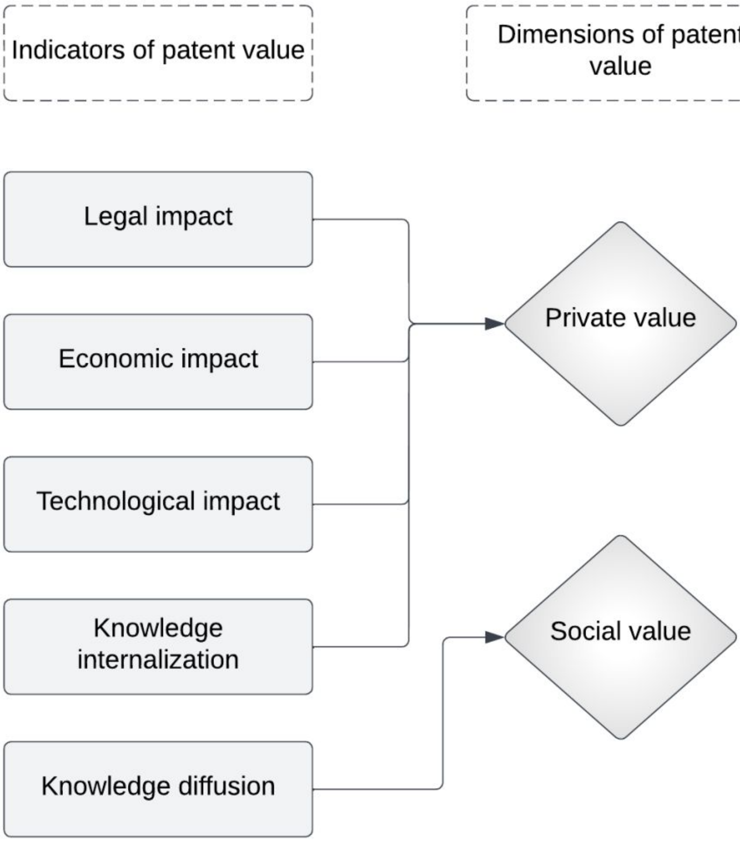


**Figure 4.** An organizational map of indicators and dimensions of patent value

*A conceptual model relating patent quality and value*

Now that we have identified the different subtypes of indicators of patent quality and value from a systematic literature review, delineated patent quality and value into their component dimensions, and mapped the different indicators of patent quality and value onto the appropriate patent quality or value dimension, we present an integrated conceptual model (in Figure 5) linking patent quality and value by drawing upon the emergent ex-ante theory of patent value (Perel 2014) that proposes a positive and direct relationship between these core concepts. The conceptual model shows each of the four dimensions of patent quality — subject matter, utility, non-obviousness or inventive step, and sufficiency of disclosure — as a temporally precedent variable for the two dimensions of patent value — private and social value. The model in Figure 5 builds on the organizational maps shown in Figures 3 and 4. In the fully elaborated form, the model has all the subtypes of indicators of patent quality and value as shown in Figures 3 and 4 mapped onto the appropriate dimension of patent quality or value.

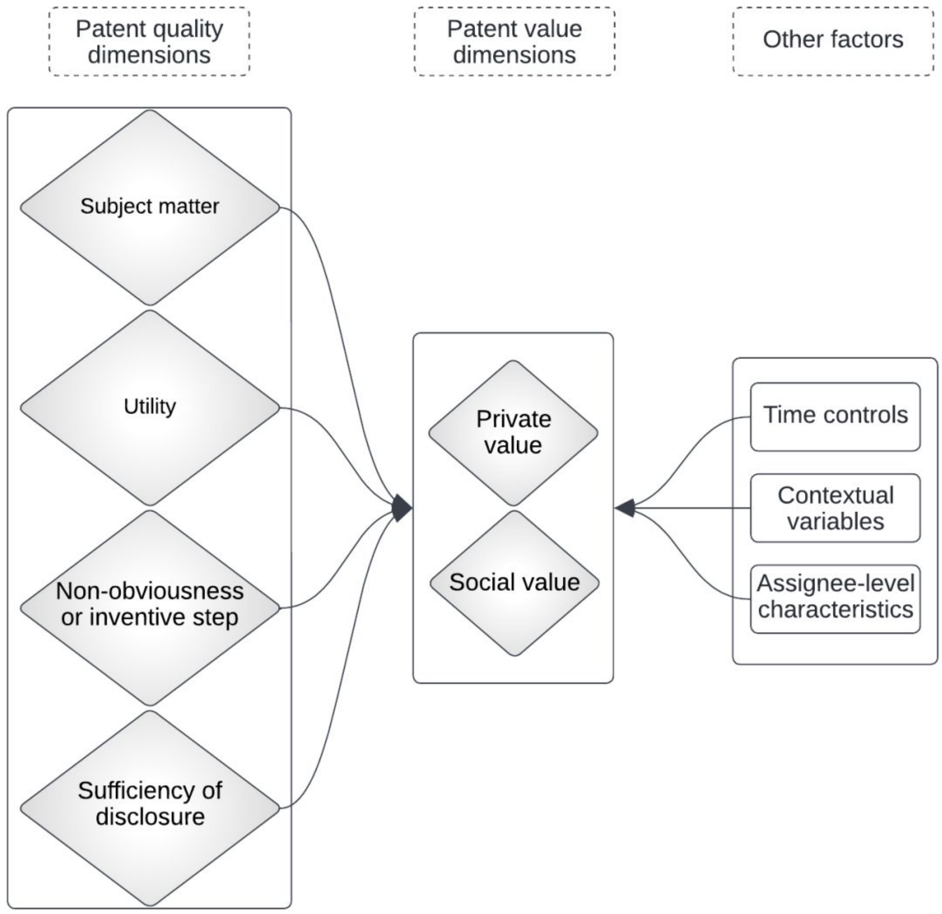


**Figure 5.** Conceptual model showing the relationship between the different dimensions of patent quality and value

Notably, the conceptual model in Figure 5 would be inadequate if the patent quality is shown as the *only* variable "influencing" patent value, which certainly cannot be the case. In a historical study, Pitkethly (1997) surmises that the eventual value of a patent would *also* depend on several market and competitive factors as circumstantial variables. This review also identifies several studies that use assignee-level characteristics as being associated with patent value. Including such variables is based on the rationale that patent value depends on the synergies among all the managerial functions of the patent holder (Hsu, Lee et al. 2020). An organized typology of such assignee-level characteristics is beyond the scope of this review. Further, this review identifies several contextual factors that could influence patent value such as information about the inventors (not obtainable from patent documents), litigating courts, patent examiners, and patent offices. Accordingly, we include such contextual variables as a factor of patent value. Finally, as discussed earlier, we include time-based controls as another factor of patent value in the conceptual model. Consequently, the integrated conceptual model in Figure 5 shows that patent value is a function of patent quality, assignee-level characteristics, contextual variables, and time.

A discussion of a conceptual model would only be complete by addressing the issue of *endogeneity* which could manifest in an empirical research setting. To establish causality in our conceptual model, since patent quality and value are *temporally* related, the condition of internal validity (see Calder, Phillips et al. 1982) of the model is satisfied. However, the other necessary condition of the absence of endogeneity — which occurs when a dependent variable depends on some unmodeled factors that also drive the independent variable (Antonakis, Bendahan et al. 2014) — appears extremely difficult to prove in our model

Hamilton and Nickerson (2003) inform that in the field of strategy, management's decisions are endogenous to their expected performance outcomes. Patents are not exempt from this field. For example, Reitzig (2004) posits that the disadvantage of patent quality indicators lies in their endogeneity because a patent is drafted by a proprietor who can "infer on" the value of the invention. Bessen (2008) argues that innovators can exert varying degrees of effort in the examination and enforcement of their patents, which could make the patent more resistant to invalidation challenges. Galasso and Schankerman (2014) inform that technologies with greater commercial potential are more likely to be protected by patents (with strong rights).

In the next section, we illuminate several paths that empirical researchers can choose to build on the findings in this review.

**Future research directions**

First and foremost, in the spirit of Zeithaml (1988), our work provides a sound theoretical basis for separating and studying the concepts of patent quality and value. Going ahead, we urge researchers to appreciate this distinction and use the concepts more prudently. Future research opportunities stemming from our conceptual model can lead to significant conceptual or methodological contributions. Along the conceptual path, first, one might adopt an *interpretive* research philosophy and investigate patent quality and its dimensions based on the regulatory perspective thereof (which is the fundamental premise of the ex-ante theory of patent value) in a social setting. This qualitative research approach could further elaborate our conceptual model.



Second, one can investigate whether the relationship between the dimensions of patent quality and patent value is direct as proposed by the ex-ante theory, or *indirect* with one or more *mediator* variables (see MacKinnon, Coxe et al. 2012). Such a study would implement theory elaboration (Fisher and Aguinis 2017) by structuring theoretical constructs in which theoretical relations are elaborated so that they accurately describe and explain empirical observations. For example, in financial markets, the "effect" of disclosure quality on information asymmetry is inverse (Brown and Hillegeist 2007). Since patents as intangible assets are usable as finance instruments (Zuniga and Guellec 2009), one might think of an intriguing research question: how does information asymmetry act as a mediator variable in the relationship between the sufficiency of disclosure dimension of patent quality and the private value of patents?

Third, the dimensions of patent quality we explicate may change over time due to macroeconomic factors. Firstly, national, regional, or international policies or agreements in the future might change the patentability requirements, which would necessitate re-conceptualisation of regulatory patent quality or its dimensions which we advance in this review. To provide a context, Mahne (2012) informs that European countries have been striving to create a Unitary Patent valid in all these countries upon issuance and a Unified Patent Court with nearly EU-wide jurisdiction over European and Unitary Patents. As per the current EPO notification (see EPO 2022), Unitary Patents will operate on the rules of the EPC and have the same standards of examination as European patents. Though our broad conceptualizations of patent quality and its dimensions are consistent with what would become the standards of patentability for a Unitary Patent, we expect that future legislation like this may affect our specifications of patent quality.

Along the methodological path, first, although artificial intelligence (AI) and machine learning (ML) techniques have been used to study patent quality or value, these studies are not a part of this review as the models in these papers do not have the explainable power (e.g., see Goebel, Chander et al. 2018) of traditional econometric or regression models. Nevertheless, we expect that explainable AI and ML models in the future can identify *latent* dimensions of patent quality. Accordingly, our conceptual model remains amenable to future refinements and elaborations.

Second, future research could address endogeneity in our conceptual model reasonably well. Shadish and Cook (2002) inform that though randomized experiments such as those used in medical research are the gold standards to test and establish causality among variables, such experiments may be undesirable for researchers in management for practical or ethical reasons; the authors also inform that prudent use of *quasi-experimental designs*, which do not qualify the "true" random assignment criterion but provide means to conduct experiments, are valuable to a researcher in testing causal hypotheses. Representative papers in our review that use quasi-experimental research designs are Marco and Miller (2019) (propensity score matching), Galasso and Schankerman (2014) (instrumental variable), Martinez-Ruiz and Aluja-Banet (2009) (structural equation modeling), and Baruffaldi and Simeth (2020) (regression discontinuity design). To understand the principles behind these econometric methods, refer to seminal expositions by Angrist, Imbens, et al. (1996), Angrist and Pischke (2009), Rosenbaum and Rubin (1983), Imbens and Lemieux (2008), and Anderson and Gerbing (1988). We call for future researchers to deviate from the often-chosen path of correlational analysis and strive for a *causal interpretation* of the results. If the problems with experimental designs cannot be circumvented, future studies could use quasi-experimental designs to test and validate our conceptual model and further advance the empirical adequacy of the ex-ante theory of patent value.

Third, in research, construct validity generally refers to the vertical correspondence between an unobservable construct and its purported measure (Peter 1981). Nomological validity is the extent to which the relationship between constructs is supported by hypotheses drawn from the underlying theory (Peter 1981, O'Leary-Kelly and J. Vokurka 1998). The current review informs on various measures and indicators for patent quality or value to choose from in future empirical inquiries related to our work. For example, if one has to study the dimensions of regulatory patent quality, the outcome of a *factor analysis* would contribute to the construct validity of our conceptual model (see Peter 1981). One can also test our conceptual model based on several *hypotheses*, the outcome of which would help to establish our model's nomological validity; ultimately, a study's research question(s) or design, the researcher's accessibility to data, and the method of analysis would determine the outcome of the study. Future methodological papers might introduce more *precise measures* of patent quality or value to the current body of knowledge. Essentially, future empirical studies that test our conceptual model's construct and nomological validities might also refine, validate, reorganize, or advance the core ideas underpinning our conceptual model.

Fourth, to be considered a theory, Calder, Phillips et al. (1982) point to the need for *external validity*, which examines whether or not an observed causal relationship should be generalised to and across different measures, samples, contexts, and times. Since external validity is contingent on causality, the problems with the latter (already discussed) also affect the former. Nevertheless, for an empirical researcher, the "applicability" of our conceptual model across different settings can be assessed to an extent by a *meta-analysis*, which Glass (1976) defines as the statistical analysis of a large collection of analysis results from individual studies to integrate the findings. In their critical review of patent value determinants, van Zeebroeck and van Pottelsberghe de la Potterie (2011) do a similar analysis under the heading "consistency study". Meta-analysis of the studies that study the relationship between patent quality and value is a worthy research avenue in the future.



**Conclusions**

Patent value is a subject of burgeoning empirical research. However, the extant literature on patent value and quality does not differentiate between these concepts. Drawing upon the emergent ex-ante theory of patent value (Perel 2014) that proposes a positive and direct relationship between patent quality and value, this systematic literature review synthesises the content from 340 papers that study patent value or quality from multiple research fields.[6]

We conduct a rigorous systematic review of a research topic with a burgeoning academic interest. Such a task is not solved without potential limitations. We screened several thousand papers after applying multiple search strategies and used widely accepted quality controls to ensure that we correctly included and analysed the relevant works. Though we have taken adequate precautions to minimise bias in our methodology, we could have inadvertently excluded some relevant papers due to the sheer volume of work. However, we have a very high level of confidence in our findings and assume that our results would be robust to such exclusions.

The papers in this review predominantly use data from the USPTO and EPO. This origin makes the indicators and measures of patent quality and value in our conceptual model biased toward these geographies. This situation arises because, historically, the patent data from these offices were more accessible to the research community. Plausibly, even the researchers were residents of these geographies. We expect this situation to change when more patent authorities make their data available for research and scholars from a broader geographical spectrum engage in research on patent quality.

Overall, the review presents a comprehensive organization of the different subtypes of patent quality and value indicators, conceptualizes patent quality from a regulatory perspective based on the standards of patentability adopted by the triadic patent offices, delineates the dimensions of patent quality and value, maps the patent quality and value indicators onto the corresponding patent quality or value dimension, and advances an integrated conceptual model linking patent quality and value.

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## Appendix

**List A1:** Measures corresponding to the different types of patent application characteristics

1. *Filing strategy*: country of filing of a patent, patent family size (count of national or international family members), patent belongs to an international family, occurrence of a paired publication with the patent, presence of a triadic patent in a family (a patent whose family comprises U.S., European, and Japanese patents), count or type of patents in a jurisdiction in a family (for example: divisional, continuation, or continuation-in-part patents in the U.S. or divisional patents in Europe), count of designated European Patent Convention (EPC) contracting states, count of priority filings, count of priority filings by geography, priority claim for a provisional application, domestic or Patent Cooperation Treaty (PCT) filing route, type of PCT filing based on the period between filing date and entry into the regional phase (type I: period is 20 months or less, type II: period exceeds 20 months), priority filing country, presence of a foreign priority, presence of a family member from a particular country, GDP-weighted patent family size, the ratio of patent family size to the number of countries where a patent was applied for, time span between the priority date and the filing date, time span between the first and last priority or filing dates in a patent family, time span between the filing dates of patent family members.
2. *Application claims*: Count of claims, count of words in the independent claims, count of characters in the first independent claim, difference between the number of claims (independent, dependent, or total) of a patent application and the corresponding granted patent.
3. *Disclosed content*: count of specific terms in the description, number of words describing the state of the art, number of words describing the technical problem, number of technical advantages, number of technical preferences, count of figures or drawings, count of words in the abstract, count of words in the complete specification, ratio of the number of words in the complete specification to claims, presence of particular words or phrases in the abstract, number of pages in the patent specification, readability measures of disclosure such as Gunning-Fog Index, Flesch-Kincaid Index, and the like, ratio of unique words to total number of words in the disclosure, disclosure of specific chemical or medicinal formulations

4. *Applicant cited literature*: count of cited patents or cited non-patent literature (at the level of the focal patent or its family); count, presence, or share of cited patents or cited non-patent literature; count or share of cited patents by the applicant that are assigned to the same firm as the focal patent or to other entities; age of cited patents; count or share of cited patents by the applicant classified in the same or different technology class as the focal patent; type of non-patent literature (research article, conference proceeding, conference paper, or others); mean (or median) lag time between the application or grant year (or other reference year) of the focal patent and that of the cited patents or scientific literature (backward citation lag); count or share of cited patents by jurisdiction (country of filing of cited patents); presence of cited patents that do not cite any reference; type of citations labelled as X or Y in the examiner search report; or the ratio of cited patents to claims.
5. *Team composition*: count of inventors, or count or share of inventors by their country of residence, count or presence of inventors of academic origin (doctoral title holders or those affiliated to universities or other academic entities), country of inventor, presence of a person as the first inventor, number of co-inventors excluding a particular inventor, inventor (fixed effects).
6. *Ownership*: singular assignee, count or presence of co-assignees, type of assignment (public research institute, university, technology transfer office, government, foundation, firm, hospitals, or individual), country of assignee, size of filing entity based on record at patent office (small, large), type of assignment or co-assignment between entities categorized based on their business, operation, or specialization, assignee (fixed effects)

**List A2.** Measures corresponding to the different types of patent examination and grant characteristics

1. *Prosecution history*: decision to use "grace period" option in the U.S. for filing a patent application after having disclosed the invention to public, incidence of claim amendment prior-to the first office action, number of information disclosure statement (IDS) filings by the applicant at the patent office, incidence of an IDS filing by the applicant, accelerated search request by the applicant, accelerated examination request or other fast-tracking procedures by the applicant, request for continued examination by the applicant, choice of international preliminary examination authority following PCT filing by the applicant, filing of an appeal to the patent board by the applicant, seeking review from the patent board by the applicant, number of interviews requested by the applicant, issue of supplementary search report in response to request by the applicant, time span (days, months, or years) between the earliest priority date or filing date of a patent and its date of allowance or grant date (pendency time or grant lag), average pendency time of patents in a patent family, time span between the date of allowance and the grant date, time span between filing date and the first office action date, time span between the date of first office action or request for examination and the grant date, incidence of claim amendment at any point during prosecution, time span between the filing date and the publication date, number of examiner actions, number of responses to office actions by the applicant, number of transactions between the examiner and the applicant, number of rejections by the examiner, commercial databases used by the examiner for search, decision by the patent board, incidence of third party observations at the patent office prior to a patent grant, record of government interest in a patent, first action allowance of a patent application, year of first office action, patent term extension awarded by the patent office, nature of the person corresponding with the examiner (attorney, firm, patent agent, or third parry), and year of disposal of a patent case by an examiner.
2. *Granted claims*: count of claims (independent, dependent, or total), number of claims that incur extra filing fees, type of claims (machine, molecule, process, method, product, composition of matter, application, article, system, formulation), the ratio of dependent and independent claims, number of claim amendments during the examination, difference between the number of claims (independent, dependent, or total) of a patent application and the corresponding granted patent, the difference

between the number of words or characters in a claim of a patent application and its granted patent, total number of words in all the claims, "clarity" of claims based on linguistic features, presence of figures in claims, presence of Markush structure in claims, total number of alternatives covered by Markush structures, count of nouns in a claim; presence of functional limitations in claims, and count of words in the independent claims, count of characters in the first independent claim.

3. *External cited literature*: count, presence, or share of cited patents or non-patent literature by the examiner or a third party, type of citations labelled as X, Y, or A in the examiner search report.
4. *Technology scope:* count of unique first n-digit (typically 4 digits) International Patent Classification (IPC), Cooperative Patent Classification (CPC), United States Patent Classification (USPC), or European Patent Classification System (ECLA) sections, classes, or subclasses, share of declared IPC subclasses that belong to the main IPC class, IPC classes belonging to particular categories of interest, more than one IPC class, USPTO Technology Centre, categorization of the distribution of classes or subclasses into broad technologies to reflect the industry of operation of the focal patent (mostly used as a control variable).

**List A3:** Measures corresponding to the different types of post-grant patent characteristics as indicators of patent value

1. *Legal impact*: incidence or outcome of litigation, validity challenge in a court or a patent office, or opposition to patent grant, threat of litigation, reissue of a patent, damage awards in litigation, disputed at the International Trade Commission.
2. *Economic impact*: time to an event, probability of occurrence, success, or frequency of occurrence of an event such as licensing or renewal, renewal fees, termination of licensing, achievement of first sale of product or service from a licensed patent, commercialization of the patented invention, using the patent for founding a company, extent of profitability of an innovation, pledging as collateral to secure funding, sale of a patent in an internet marketplace, bidding of a patent in an auction, sale of a patent after a start-up goes bust, patent reassignment (or ownership transfer), reassignment based on nature of buyer (e.g., non-practising entity), the record of a security interest in a patent, regulatory (example, FDA) approval of a patented drug, or number of control rights held by the licensor in a license contract, exclusive or non-exclusive licensing, presence of a grant-back clause in a license, estimates of patent value from renewal model, estimates of patent value from stock market returns to firms, number of licensees of a patent included or prior to inclusion in a patent pool.
3. *Technological impact*: conferral of a prestigious award (Nobel Prize, National Inventor Hall of Fame in the US, Queen's Award in the UK, R&D100 Award by the R&D magazine), time to an event, probability of occurrence or success of an event, or frequency of occurrence of an event such as declaration of a patent as an essential patent to comply with a technical standard, labelling of a patent as "wacky" (for technical weirdness), inclusion of a patent in Woodcroft's Reference Index, inclusion of an essential patent in a patent pool, number of standard sections in a pool
4. *Knowledge internalization*: count or share of self-citing patents (citing patents from the same assignee as the focal patent), count or share of self-citing patents classified in the same or different technology class (based on IPC, CPC, or USPC technology codes) as the focal patent, count of self-citing patents (granted or otherwise) from the date of priority, filing, publication, or grant of the focal patent or its family to a study-defined cut-off time (generally 3-15 years window), citing patents by geography, yearly (single or multiple) rate or average of citing patents, time elapsed from the patent grant date to the date of first forward citation (forward citation lag), ratio of citing patents in two periods of time, ratio of citing patents to claims, ratio of citing patents to patent family

size, presence or absence of citing patents, count of self-citations prior to the event of maintenance, type of citations labelled as X, Y, A, or D in the examiner search report, count of citations from patents filed by small entities, count of citations from patents filed by individual inventors, adjusted measures (average or cumulative) of citations at the family level.

5. *Knowledge diffusion*: count or share of external citing patents (citing patents from assignees other than the assignee of the focal patent), count of citing patents excluding those having at least one inventor in common with the focal patent, count or share of citing patents classified in the same or different technology class (based on IPC, CPC, or USPC technology codes) as the focal patent, count of citing patents (granted or otherwise) from the date of priority, filing, publication, or grant of the focal patent or its family to a study-defined cut-off time (generally 3-15 years window), count of citing patents from a particular jurisdiction, yearly (single or multiple) count or average of citing patents, time elapsed from the patent grant date to the date of first forward citation (forward citation lag), ratio of citing patents in two periods of time, ratio of citing patents to claims, ratio of citing patents to patent family size, presence or absence of citing patents, count of citations prior to the event of maintenance, type of citations labelled as X, Y, A, or D in the examiner search report, count of citations from patents not having inventors from certain geographies, citations from patents filed by small entities, citations from patents filed by individual inventors, citations from patents filed by small entities without individual inventors, count or proportion of citations from examiners, count or proportion of citations from applicants, citations from a corporate or an academic assignee, adjusted measures (average or cumulative) of citations at the family level.

**Endnotes**

[1] An alternative search strategy using an identical search string, but in the fields of title or abstract under the ‘‘advanced search’’ option produces 9,139 results. A check reveals that *all* the results from this alternative search strategy are captured using the first search strategy, making the first search more comprehensive.

[2] These keywords were identified during the detailed analysis of papers identified from the first stage of the WoS search.

[3] The International Patent Classification (IPC) codes are used universally in patents and are the basis for the creation of two other classification systems - the Cooperative Patent Classification (CPC) system jointly adopted by the EPO and USPTO, and the FI system of the JPO. See details here: https://www.wipo.int/classifications/ipc/en/faq/ and here: https://www.jpo.go.jp/e/system/patent/gaiyo/seido-bunrui/index.html

[4] If a paper does not distinguish between *applicant-cited literature* and *external cited literature*, we consider the type of backward citation under the former category. This inclusion is likely to bias the distribution of these patent characteristic subtypes.

[5] If a paper does not distinguish between self-citing and external-citing patents, we consider the type of forward citation under both the categories of *knowledge internalization* and *knowledge diffusion*. This scheme is likely to bias the distribution of these post-grant patent characteristic subtypes.

[6] We are profoundly thankful to the three anonymous reviewers for their remarkable patience in thoroughly reading the prior versions of this manuscript and their constructive and comprehensive comments. We realize that working on the corrections has improved the quality of this paper by several notches. We also thank the editor for the valuable suggestions to make the paper more readable.