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Patent Citation Analysis: A Policy Analysis Tool

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Summary

Patent citation analysis is a recent development which uses bibliometric techniques to analyse the wealth of patent citation information. This paper describes the various facets of patent citations and patent citation studies, and their important applications. Construction of technology indicators being an important use of patent citations, various patent citation based technological indicators and their applications are also described. © 1998 Elsevier Science Ltd. All rights reserved.

Introduction

Every business day more than 2000 new patent documents are issued world wide and each cite several other earlier related patents or published information.[1] Similarly, patents are also cited by patents, books and journal articles. However, the purpose and procedures of patent citations are somewhat different from scientific literature citation. The availability of this wealth of citation information has prompted the bibliometricians to apply the well-established techniques of technical literature citation analysis to patent citation analysis. When a patent applicant cites "prior art" in the text of the patent, such citations are called applicant citations. When the examiner grants a US patent, he will cite the key prior art on the front page of the granted patent; these citations are called examiner citations. The cited material has a similarity to the idea(s) being claimed. They are mainly previously issued US patents although they may also be foreign patents, journal articles, items from trade publications, etc.[2] When a typical US patent is issued, it has five or six references to earlier US patents. These patents also have, on average, about one non-patent reference which are direct references to the scientific literature.[3]

It normally takes five or more years from publication before a patent begins to be cited to any great extent. In general, 70% of all patents are either never cited, or cited only once or twice, so that even five citations place a patent in the top few percent of cited patents,[3] and only very few are cited very heavily. Any patent cited six or more times would be in the the most highly cited 10% of all patents.[2]

Patents (and the technology they represent) age and eventually become obsolete. Even though influential patents remain influential as they age, both highly and infrequently cited patents age at the same rate. This means that citations do not automatically beget more citations. In addition, the distribution of patents by number of citations received is stable over time.[4]

Patent citation studies

The citation-based patent study is called patent citation analysis which seeks to link patents in the same way that science citation links the references in the scientific papers. Citation to prior art is an indicator of the importance of the prior art to subsequent inventions. The key idea behind patent citation analysis is that when a patent is very highly cited (i.e. cited in 5, 10, 20, or more subsequent patents) then that highly cited patent is likely to contain an important technological advance — an advance that many later patents are built upon.[3]

So far, patent citation analysis has been used as a measure of technological quality and influence and in studying diffusion of technological information. Patent co-citation analysis has been used to "map" the inter-related development of technical fields.[5] Patent citations are also used to construct technological indicators. Even Engelsman and Van Raan[6] have worked on patent-based cartography using co-word and co-classification techniques.

The idea of studying the information in patent citation is not new and was suggested by Seidel in 1949. Since then, a few more sporadic attempts are reported in the literature. Perhaps the lack of a suitable database had held back the field. Systematic patent citation study is a more recent development.[2] In recent years, analysis of patent citation has been given great prominence by F. Narin of CHI Research/Computer Horizon Inc., New Jersey, USA.

So far, patent citation studies have used the US patent system. In fact, to hold a US patent has been a matter of great international prestige. The references cited to US patents are the basis for most citation analyses and then only front page (examiner) citations. Applicant citations are not generally available in machine-readable form; as a result, they are time consuming to obtain and used only in specialised studies. The advantage that the US patent system offers is: more than 5,000,000 citations from US patents issued from 1971 are available in computer readable form. And as mentioned earlier, these citations, which are placed on the front page of US patents by the patent examiner, refer to (cite) other US patents, foreign patents, and the scientific literature.[2]

CHI Research Inc., New Jersey, has constructed a unique databank on US patents which includes data on the references contained in each patent application both to previous relevant patents and to research papers reporting results on which the invention is based.[7] Patent citation analysis has also been possible online, as patent applications are available online.[8] Moreover, such citation studies[9] are also being done using the *Science Citation Index*, the last volume of which contains a Patent Citation Index. Based on the analysis of references of journal articles, Karki and Garg[10] have studied the "dependence of Indian industrial research".

In the present paper, patent citation studies have been divided into: (i) patent citations and (ii) citation indicators.

Patent citations

Patent citations are the count of citations of a patent in subsequent patent or non-patent literature. The count of citations is an indicator of the technological impact of the patented invention. Generally, citations per patent have been used as an indicator of relative importance of the patent.[11] Patents related to significant innovations are more highly cited than any other group of patents.[12] Fewer citations mean less importance of patents to the developmental process.[13] Patent citation networks reveal key patents and important clusters.[14]

Patent citations allow the analyst to assess the quality and impact of cited material, as well as the linkages between cited and citing countries, between cited and citing companies, and between cited and citing scientific and technological areas.[2] Important practical applications of patent citation analysis are described in the following sections.

Identification of leading-edge technological activity

Based on the assumption that a patent which is highly cited contains a technological advance of particular merit, leading-edge areas of technological activity are identified.[2] In one study[2] patents associated with outstanding new products have been shown to be highly cited. Similarly, studies on the automotive, electronics, photographic and pharmaceutical industries have demonstrated the areas of leading-edge Japanese technological activity based on the study of the most highly cited US patents of Japanese origin.[2] Yet another study[5] suggests that highly cited US patents are often those that would be recognised by technological experts as major innovations. Carpenter *et al.*[12] found that patents related to significant innovations are more highly cited than a control group of randomly selected patents.

Measurement of national citation performance

Such comparative studies are performed on the basis of the presence of highly cited patents in the US patent system using the top decile citations performance ratio (CPR). A patent is in the "decile" if it is among the most highly cited 10% of patents in a particular year and its category.

$$\text{CPR} = \frac{\%\text{ of a country's patents in the top decile}}{\%\text{ of all patents in the top decile}}$$

A ratio of >1 is good, a ratio of <1 is relatively low.[2]

Technological mapping

"Maps" of technological domains are constructed by examining the inter-relations of heavily cited patents. This helps in assessing relative position of companies (or countries) within each domain. This information is also used for keeping track of "hot" technological areas.[7]

Links between cited and citing patents enable one to map the relationship between companies to determine which companies are original producers and which companies are subsequent users of specific technical innovations. If there is a company whose patents are cited by many of the other companies, it will show up as the centre of a dense cluster of arrows. If no individual company shows up in this manner, it indicates that technology is not dominated by one company.[3]

Competitive intelligence

Patent citation analysis is a useful competitive intelligence tool. Narin *et al.*[15] have shown how to use the patent citation counts to identify technical complementarities and competition among patenting firms. In fact, many of the techniques of competitor assessments like citing and cited patents, citation impact, technology profiles and maps have been discussed by Narin *et al.*[2] Mike Harvey[1] has shown that ratio and ranking obtained from patent citation analysis can unearth clues that can be very interesting.

In the USA, there are specialised consultancy services available which have become increasingly valuable in providing corporate technological intelligence. Their activity is based on systematic monitoring of publicly available research and patent literature.[7] Patent citation analysis however, is a more controversial technique. When used correctly it can have a valuable role to play in competitive intelligence work.

Linkages to science

Patent citations may quantify the dependence of technology on science and provide an indicator of how near a set of patents is to science.[2] They also show the economic utility of basic research. Patents in highly scientific areas of technology contain as many citations to the basic research literature as the scholarly literature does.[16] This illustrates how closely related some technologies are to science and gives a useful description of the interaction of science and technology, yielding a measure of how science intensive or how "high-tech" a particular firm or country is.[8]

In one study, the time-lag for citations from patents to the literature is as short in some biotechnology areas as the time-lag for citations from papers to papers, indicating that biotechnology and bioscience are contemporaneous.[2]

Noyons *et al.*[17] have explored the science and technology interface in laser medicine research. In one study,[7] in a particular US patent set, some 40% of citations to scientific research were found to chemistry, while physics accounted for just 13%. Carpenter *et al.*[16] have shown that in biotechnology, citations tend to be to published academic science, while in electronics, they are to published industrial science. Smith[2] has used non-patent links (NPLs) to construct the technological data profiles of companies. Collins *et al.*[18] have also studied citations in patents to the basic research. Carpenter *et al.*[19] have studied patent citations as indicators of science. Van Vianen *et al.*[20] have studied the science base of recent technology. In yet another study,[2] a high degree of association was found between the peer rankings and bibliometric measure of science dependence of a set of patents.

Measure of foreign dependence

Foreign patents cited may be used to provide linkage between citing patents and foreign inventions. In a validation study of patent citations as indicators of foreign dependence, a high degree of association was found between the peer ranking and bibliometric measures.[2]

Patent citation indicators

Patent and patent citations have been used for construction of technology indicators. The "References Cited" section of US patent documents provide an important source of data for technological indicators work. This section contains references to US patents, to foreign patents, and to other publications.[2] One fundamental indicator of technological quality or impact is how frequently a patent is cited in later patents. Aggregation of data from the individual patents may be used for constructing technological performance indicators for laboratories, companies and countries.[2] Similarly, heavily cited patents are also important technological indicators, since a patent which is referenced (cited) by many later patents is typically an important patent. These patents are used in identifying leading-edge technological areas.

The other publications cited are also an important piece of technological indicator data, since these may be used to establish the linkage between patented technology and science.[2] The technological indicators based on patent citation analysis reported in the literature are: (i) citations per patent; (ii) highly cited patents; (iii) non-patent links; (iv) technical impact index; (v) current impact index; (vi) technology cycle time; and (vii) technology strength.

Highly cited patents

There are valid reasons for believing that highly cited patents are patents of more than average technological impact. Highly cited material, such as highly cited earlier US patents, tend to be important, seminal inventions. As a result, these citations are used as indicators of technical quality. They are also important as indicators of linkage between the citing and cited material. Patents associated with outstanding new products are found to be highly cited. However, highly cited patents occur relatively infrequently.[2] As mentioned above, only a very few are cited very heavily. One study suggested that highly cited US patents are often those that would be recognised by technological experts as major innovations.[5] So far, it has been observed that Japanese-invented US patents are the most highly cited patents in the US patent system.[2]

Number of non-patent links (NPLs)

The "other publications" cited in a patent may be used to quantify the dependence of technology on science.[2] The number of these other publications or "other references" are its non-patent links. Non-patent links show how tightly linked a patent is to scientific literature. That is, such citations are indicators of science dependence of patents. In general, a US patent has on average, about one non-patent reference.[3]

Technical impact index (TII)

This is the percent of patents in a particular period which are in the most highly cited 10% of all patents. The expected value of the TII has been normalised to equal 1. A TII below 1 indicates that patents are not especially highly cited.[3]

Current impact index (CII)

The current impact index is a measure of how often patents are cited in other patents, which shows how frequently they are used as the foundation for other inventions. It is calculated on the basis of how highly cited the past five years' patents in a particular field are. For example, a company's 1991 index is computed by first calculating the average number of times the patents it was granted in each of the previous five years were cited in new patents granted in 1991. Those figures are divided by the average number of 1991 citations for all US patents in each of the previous five years, which yields a citation ratio for each year. A ratio of 1 means that the company's patents were cited as often as the overall average. A ratio of 1.2 means that the company's patents were cited 20% more often than average. Finally, the citation ratio for each of the five years is averaged to obtain the 1991 rating.[3,21] A CII below 1 indicates an area of modest citation activity.

Technology cycle time (TCT)

This is the median age, in years, of the earlier US patents reference cited in the company's new patents. This varies quite widely, from four to five years for some of the rapidly moving electronics areas to more than fifteen years for some of the slow moving mechanical areas of patenting. A company with very short technology cycle time is certainly a major player in its area. The lower the number, the more quickly the company is replacing one generation of inventions with another.[3,21]

Technology strength

The technology strength is a product of the number of company patents and current impact index. That is, the number of patents multiplied by the current impact index.[3]

Patent citation indicators are used in: (i) construction of technology performance indicators for laboratories, companies and countries; (ii) construction of technology profiles of companies; and (iii) characterisation of the patent activities of laboratories, companies or countries.

Conclusions

On the surface, patent bibliometrics looks very interesting, but some experts are highly sceptical about the use of patent data. In fact, patent citation analysis has equally vocal champions and critics. Perhaps because patents never give a complete indicator of industrial R&D activity, they only partially describe commercial developments.

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