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Patent "Sightings": A Comparative Analysis of Patent Citation Search Tools Using Case Studies from the Engineering Literature

Mr. Michael J White, Queen's University

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Abstract

Citation searching is a well-known and widely used technique for locating relevant articles via networks of cited references. Specialized citation databases such as Google Scholar, Scopus, and Web of Science facilitate citation searching by indexing hundreds of millions of references from a vast body of journal and conference literature. In recent years, many other discipline-specific databases have added citation indexing and search tools. Academic researchers also use citation metrics such as the Impact Factor (IF) and h-index in order to assess the value and impact of their publications. The techniques used in citation searching and the calculation of citation metrics can also be applied, with appropriate care, to the patent literature.

Searching citations in patents and cited patents can retrieve new and relevant information on an infinite number of engineering topics. It can also reveal connections between the journal literature and patents and expose knowledge gaps for further exploration. Universities are increasingly interested in assessing the value and impact of patents awarded to their faculty. A small but growing number of universities led by the University of Maryland and Texas A&M now give credit for patents in faculty tenure and promotion reviews.

This paper explores the tools and strategies for searching cited patents and non-patent literature (NPL) references cited in patents using examples from the engineering literature. The author discusses patent citation practices and how citations appear in patent documents and databases. Strategies for searching patent and NPL citations in patents in selected databases are compared and discussed, noting their respective advantages and limitations. The author also explains the potential benefits and pitfalls of applying popular citation metrics to faculty patents and university patent portfolios.

1. Introduction

Patenting activity among college and university researchers has increased substantially over the past fifty years. According to the U.S. Patent and Trademark Office, in 1969 the total number of utility patents granted to universities was a mere 189, or 0.28 percent of utility patents granted that year.¹ In 2012, USPTO records show that universities received 4,797 patents, or 1.89 percent of patents granted.¹ The actual number of patents granted to academic researchers is probably higher, given that some colleges and universities allow their faculty to retain full ownership of their intellectual property. Faculty engaged in contract research may be required to assign all or part of their patent rights to their corporate or government sponsors, which further obscures the actual number of patents arising from academic research.

As interest in patenting has increased among academic researchers, some U.S. universities have begun to reconsider the role of patents in career decisions such as tenure and promotion. In 2006, the Texas A&M University System Board of Regents voted unanimously to recognize faculty patents as scholarship during the tenure review process.² A few years later, in 2012, the University of Maryland implemented a similar policy regarding patents and other forms of

intellectual property.³ A growing number of academic administrators are encouraging more universities to consider patents and entrepreneurial activities in faculty tenure and promotion reviews.⁴ Although this practice is relatively new in the U.S., universities and research organizations in other countries, notably Germany and Japan, have long recognized patents in faculty recruitment, promotion, and tenure decisions.⁵

The trend toward considering patents as scholarship for academic awards, promotion, and tenure may encourage individual faculty, tenure committees, and academic administrators to attempt to evaluate the impact of patents using qualitative and quantitative measures routinely applied to journal articles and other scholarly publications. Quantitative measures include citation metrics such as the h-index, including its numerous variations, and the journal Impact Factor. However, it is not clear that these metrics can be applied to patents in any meaningful way. Patents are very different from journal articles and may have substantially different citation patterns. Patent citation data and search tools are not as mature as journal citation data and search tools such as Web of Science and Scopus.

In order to support and encourage academic patenting and commercialization, numerous universities have created technology transfer and licensing offices. The Association of University Technology Managers (AUTM) estimates that approximately 300 U.S. universities and research hospitals provide technology transfer services to their researchers.⁶ Well-known examples include the University of Wisconsin's Alumni Research Foundation (WARF), which is celebrating its 90th anniversary in 2015, and Stanford University's Office of Technology Licensing, which was founded in 1970. Technology transfer and licensing offices may use citation searching to identify highly-cited faculty inventors and patents in their portfolios. They can also use citation searching to monitor patents and patent applications owned by potential competitors and partners. Citation data in combination with other factors can reveal the impact of university-owned patents in an industry, technology or economy, which may help to convince funding agencies, stakeholders, and decision-makers of the value of a research program or grant application.⁷

Finally, just as journal citations can reveal networks of related articles, patent citation data can lead researchers to relevant information that might not have been discovered via keyword, controlled vocabulary, or classification searches.

This paper reviews patent citation practices among patent offices and the availability of citation data in public patent databases. Strategies for searching cited references in patents will be compared and discussed.

2. Methods

There are numerous free patent databases on the internet. Some of the largest and most comprehensive are maintained by patent offices such as the European Patent Office (EPO), German Patent and Trade Mark Office (DPMA), U.S. Patent and Trademark Office (USPTO), and the World Intellectual Property Organization (WIPO). The EPO's Espacenet database contains more than 90 million patent documents from approximately 100 national and regional offices. The DPMA's DEPATISnet is similar to Espacenet in size and coverage.

For the purposes of this study, the author examined the citation search capabilities of the EPO, DPMA, USPTO, and WIPO patent databases. Selected cited patents and non-patent literature documents were searched in the EPO, DPMA, and USPTO patent database and the results compared. The WIPO patent database does not have citation searching capabilities, so no comparison could be made with the other three databases.

Other free and commercial patent databases, such as Patent Lens, FreePatentsOnline, Google Patents, and Derwent Innovations Index, and specialized databases that index patents, such as Chemical Abstracts/SciFinder, were not included in this study due to lack of time and space.

3. Citations in Patent Documents

According to ISO standard 690:2010, a citation is an “indication within the text or other form of content of a relevant reference” and a reference is “data describing a resource or part thereof, sufficiently precise and detailed to identify it and to enable it to be located.”⁸ The purpose of a cited reference in an article, conference paper, technical report or other written work is to direct the reader’s attention to information in a previously published (or unpublished) work that is related in some way to the author’s research. Professional and research ethics require authors to cite appropriately.

Cited references in patent documents serve a different purpose. Patents are legal documents that define the scope of an inventor’s intellectual property rights in a new invention or improvement on an existing technology. The World Intellectual Property Organization defines a citation as a reference to another (print or online) document, oral communication, use, exhibition, or other means of disclosure “which may affect the patentability of a (claimed) invention”.⁹ The inventor may cite prior art, both patents and non-patent literature, in order to establish the background of the invention and/or support his or her patent claims.

Under the patent laws of some countries, including Japan and the U.S., inventors are required to disclose known prior art in their patent applications.¹⁰⁻¹¹ However, this is not the case in other countries. In Canada and Europe, for example, disclosure of prior art is optional.¹²⁻¹³ The patent examiner who reviews a patent application may cite prior art in order to narrow or limit the inventor’s claims. The national differences in prior art disclosure requirements gives rise to major differences in citation practices. U.S. patents are more likely to include many cited references due to the disclosure requirement. It is not uncommon to see U.S. patents that cite dozens or even hundreds of U.S. and foreign patents. An extreme example is US7344507 which cites more than 1,700 U.S. and foreign patents.

Scientists and engineers are accustomed to seeing citations to materials referenced in journal articles, technical reports, and conference papers at the end of the document. Citation style formats may vary from discipline to discipline and journal to journal, but readers generally expect to see a list of cited references following an article’s concluding paragraph.¹⁴ Cited references in patent documents can be more difficult to locate and identify.

The World Intellectual Property Organization (WIPO) recommends that patent offices include all relevant prior art references in their granted patents and published patent applications on the

front page of the document or in an attached prior art search report.¹⁵ INID code 56 is specifically reserved for the identification of cited references on the front page of patent documents.¹⁶ Furthermore, the WIPO recommends that cited references be grouped into three categories: domestic patent documents, foreign patent documents and non-patent literature (NPL). Many, but not all patent offices adhere to these recommendations. The figure below shows how references appear on the front page of a recent U.S. patent document. The INID code (56) for cited references is visible in the upper left corner. The references are grouped under “U.S. Patent Documents,” “Foreign Patent Documents,” and “Other Publications”.

Figure 1. Cited References on the Front Page of a U.S. Patent

(56)	References Cited	
	U.S. PATENT DOCUMENTS	
	5,084,826 A	1/1992 Hariki et al.
	FOREIGN PATENT DOCUMENTS	
DE	29710026	9/1997
EP	1006694	6/2000
JP	9117888	5/1997
JP	1173201	3/1999
	OTHER PUBLICATIONS	
	E. Lo et al., Indoor Wireless Lan Access Methods for Factories, Communications and Science Laboratory, School of Engineering and Science, Simon Fraser University, pp. 113-118.	

The U.S. Patent and Trademark Office has included citations in granted patents since 1947. Originally, the USPTO placed citations at the end of the patent specification following the claims. Since the early 1970s, U.S. patents have generally conformed to the WIPO standards. U.S. patents include U.S., foreign and NPL references cited by both the inventor and patent examiner (indicated by an asterisk). However, U.S. published applications, which the USPTO began publishing in 2001, do not include cited references. These may be retrieved by accessing the application’s file wrapper located in the USPTO’s Public PAIR (Patent Application Information Retrieval) system. U.S. design, plant, and reissue patents may have references.

Other major patent offices that include references on granted patents are the European Patent Office (EPO), since 1978; the German Patent and Trade Mark Office (DPMA), since 1956; the Japan Patent Office (JPO), since 1970; the Korean Intellectual Property Office (KIPO), since 2007; and China’s State Intellectual Property Office (SIPO), since 2001.¹⁷ The EPO and WIPO and various other patent offices include prior art citations in examiner search reports. These reports can be published, depending on the country, with patent applications or as separate documents.

Citations that appear on the front page of a granted patent or in a search report accompanying a published application may not be comprehensive. Inventors often include additional references to the prior art in the patent specification, typically in the Background of the Invention section.

Some countries, such as Canada, do not require applicants to disclose known prior art in their applications. In addition, the search reports of Canadian patent examiners are only accessible in the Search Room of the Canadian Intellectual Property Office or by ordering copies via the internet. The table below summarizes the location of cited references in patent documents.¹⁷⁻¹⁸

Table 1. Location of Cited References in Patent Documents from Selected Patent Offices

Patent Office	Year	Cited Patents	Cited NPL	Possible Locations in the Patent Document
Canada	1948-	Yes	Yes	Description, search report
China	2001-	Yes	Yes	Front page, description
EPO	1978-	Yes	Yes	Front page, search report, description, file
Germany	1956-	Yes	Yes	Front page, search report, description
Great Britain	1978-	Yes	Yes	Front page, search report, description
Japan	1970-	Yes	Yes	Front page, description, file
Korea	2007-	Yes	No	Front page, description, file
US (Applications)	2001-	Yes	Yes	Description, file
US (Patents)	1947-	Yes	Yes	Front page, description, file
WO/PCT	1978-	Yes	Yes	Search report, description, file

4. Citation Data in Patent Databases

Several public web-based patent databases provide access to searchable (fielded) citation data. In the USPTO patent database, cited references are searchable from 1976 forward. The field codes REF, FREF, and OREF are used to retrieve cited patents, foreign patents, and other publications, respectively. In addition, individual patent records include a link to citing U.S. patents. Citation data for U.S. patents and published applications is consistent and high-quality. Data for cited foreign patents is less consistent due to variations in how applicants and patent examiners cite them. Data for cited non-patent literature is most problematic due to variations in how references are formatted. For example, below are five references to the well-known *Kirk-Othmer Encyclopedia of Chemical Technology* that are cited in U.S. patents. Note in some references the use of abbreviations and misspellings of the word “encyclopedia” and the absence of author names and chapter titles.

- Kirk-Othmer , vol. 22, 3rd edition (1983) on pp. 168 to 183. (Cited in US 8,962,715 B2.)
- James G. Speight, "Petroleum Refinery Processes," Aug. 19, 2005, John Wiley and Sons, Kirk-Othmer Encyclopeida of Chemical Technology vol. 18, pp. 11-12. (Cited in US 8,946,496 B2)
- Lo et al., "Extraction," Kirk-Othmer Encyclo. Chem. Technol., 4.sup.th ed. 10:125-180 (1993). (Cited in US 8,937,097 B2.)
- Ulrich, "Crystallization," Kirk-Othmer Encyclopeda of the Chemical Technology, 2002, Chapter 4, 8:95-147. (Cited in US 8,933,083 B2.)
- Kirk-Othmer Encyclopeda of Chemical Technology, vol. 1, pp. 324-369, 5.sup.th Ed., John Wiley & Sons, Inc., 2004 (Cited in US 8,884,050 B2.)

The EPO’s Espacenet system, which includes more than 90 million patent documents from approximately 100 countries, has searchable citation data for a number of national and regional patent offices. Citation data coverage varies from country to country, depending on when the country began publishing cited references on its patent documents. The field code CT (in Smart Search) is used to retrieve cited patents and non-patent literature. Espacenet contains more than two million non-patent literature records for journal articles, websites, technical reports, books, and theses that have been cited in an EPO search report or classified under the Cooperative Patent Classification (CPC). These records are identified by numbers with the prefix “XP”. For example, XP009113654. Figure 2 shows a typical XP record for a journal article. XP records cannot be retrieved by author name or title keyword.

Figure 2. Espacenet XP Record for Non-patent Literature (Journal Article)

Bibliographic data: XP055031298	
★ In my patents list	EP Register
Report data error	Print
Industrial Silicon Wafer Solar Cells	
Page bookmark	XP055031298 - Industrial Silicon Wafer Solar Cells
NPL reference number:	XP 055031298
Publication date:	
Author:	Dirk-Holger Neuhaus; Münzer Adolf
- cooperative:	
Publication data:	Advances in OptoElectronics, 20070101 - ISSN 1687-563X
DOI:	http://dx.doi.org/10.1155/2007/24521
Source information:	Vol:2007
Publisher accession number:	
Patent applicant:	
Publication number:	

The German Patent and Trade Mark Office’s DEPATISnet system is similar in coverage to Espacenet. The Expert Search field code for cited patents is CT; the code for non-patent literature is CTNP. The WIPO’s PatentScope system, which now includes 43 million patent documents from more than 30 countries, does not permit citation searching.

Table 2. Summary of Citation Data Coverage in Patent Databases

	Domestic Patents	Field Code	Foreign Patents	Field Code	Non-patent Literature	Field Code
Espacenet (EPO)	Yes	CT	Yes	CT	Yes (XP)	CT
DEPATISnet (DPMA)	Yes	CT	Yes	CT	Yes	CTNP
PatentScope (WIPO)	No	-	No	-	No	-
PatFT (USPTO)	Yes	REF	Yes	FREF	Yes	OREF

5. Searching Citations in Patent Databases

Searching citations in patent databases that have searchable citation data is relatively straightforward. Normally, the searcher can simply search the number of the patent document in the appropriate field in order to retrieve the citing documents. However, the task is complicated by the fact that there can be variations in how a patent number is formatted in a given patent database. This is especially true for foreign patent numbers. For example, the table below shows the number of variations in how European patent EP0216221, which has two published applications (A1 and A2 documents), a search report (A3 document) and an issued patent (B1 document), is cited in U.S. patent documents retrieved from the USPTO patent database.

Table 3. Citation Search Syntax and Results for EP0216221 in the USPTO Database

Search	Number Format	Search Syntax	# of Citing U.S. Patents
S1	0 216 221	FREF/"0 216 221"	4
S2	0 216 221 A1	FREF/"0 216 221 A1"	1
S3	0 216 221 A2	FREF/"0 216 221 A2"	2
S4	0216221	FREF/0216221	1
S5	216221	FREF/216221	2
S6	216221B1	FREF/216221B1	4
S7	216 221	FREF/"216 221"	6

Search S1 retrieves the patents in S2 and S3, which are broken out to illustrate variations in how EP0216221 is cited in U.S. patents. After accounting for duplicate documents in S1 through S7, a total of 17 U.S. patents cite EP0216221 using at least seven versions of its number. Therefore, searchers should design their citation search strategies to account for all likely variations in patent number. Of course, this also increases the likelihood of false hits as the same number might be assigned to patent documents published by different patent offices. For example, Hungarian patent HU216221 is cited in several U.S. patent documents.

This example contains another level of complexity. In addition to being cited on the front page of patent documents, references can also appear in the specification or description of a patent document. In the case of EP0216221, it is cited in the specification of at least two U.S. applications.

The quality and consistency of cited non-U.S. patent numbers in the Espacenet system is generally better than the USPTO database. However, it is always useful to cross-check results in two or more databases.

6. Patent Families and Citations

Citation searching in the patent literature is further complicated by the existence of patent families. A patent family is a group "of published patent documents relating to the same invention, or to several inventions sharing a common aspect, that are published at different times in the same country or published in different countries or regions."⁸ A patent family may range

in size from a handful of documents to dozens of documents published over many years. For example, U.S. patent US4615579 is a member of a patent family, depicted in the table below, consisting of twelve patent documents published over ten years, 1986 through 1996.

Therefore, in order to determine an accurate citation count each family member must be searched separately. Table 4 shows the number of citing documents for each member of the patent family of US4615579 in selected databases. The USPTO database has two columns, one for cited references located on the front page (Front) of the patent and the second for in-text references (Text). Six members of this family have been cited in later patents. Published applications (“A” documents) are more likely to be cited than issued patents (“B” and “C” documents) because they become public eighteen months after filing. This is true for the German (DE), French (FR), British (GB) and Japanese (JP) members. The U.S. did not begin publishing applications until 2001, so the US “A” documents in this family are actually issued patents. The citation counts in Espacenet and DEPATISnet are almost identical due to the similarity in country coverage. All told, this patent family has been cited in approximately 208-212 patents. The U.S. members account for approximately 85 percent of all citations. Approximately 4.4 percent of references in U.S. patent documents were located in the specification. It is not uncommon for patent examiners to prefer to cite their own national patent documents. The JP member, JPS6070603A, has been cited in six patent documents, five Japanese and one U.S.

Table 4. US4615579 Patent Family with Citation Counts from Selected Patent Databases

Family member	Year	Espacenet	DEPATISnet	USPTO Front	USPTO Text
CA1215957 (A1)	1986	0	0	0	0
DE3430191 (A1)	1985	6	6	2	0
DE3430191 (C2)	1996	0	0	0	0
FR2551180 (A1)	1985	2	2	0	0
FR2551180 (B1)	1988	0	0	0	0
GB2145760 (A)	1985	17	17	8	0
GB2145760 (B)	1986	0	0	0	0
IT1175644 (B)	1987	0	0	0	0
JPS6070603 (A)	1985	6	6	1	0
JPH027123 (B2)	1990	0	0	0	0
US4615579 (A)	1986	103	105	92	5
US4750798 (A)	1988	74	76	68	3
Totals		208	212	171	8

Table 5 shows an example of an individual engineering faculty’s patent citation counts for six patent families containing 20 documents. The U.S. family members (1, 2, 4, 5, and 6) are US4865973 A, US4942129 A, US6284523 B1, US2004161842 A1, and US2009270670 A1. The Polish family member (3) is PL297896 A1. The European family members (1 and 2) are EP0216221 A2, EP0216221 A3, EP0216221 B1, and EP0301777 A1. The Japanese family members (1 and 2) are JPS6265675 A, JPH0829108 B2, and JPH01127037 A. The German family member (1) is DE3689966 T2. The Canadian family members (1, 4, 5, and 6) are

CA1280705 C, CA2247779 A1, CA2216327 A1, CA2216327 C, CA2458420 A1, and CA2604418 A1.

Table 5. Example of an Engineering Faculty’s Patent Citation Counts

Patent Family	Family Members	Years	Espacenet	DEPATISnet	USPTO
Family 1	CA, DE, EP, JP, US	1987-1994	52	54	49
Family 2	EP, JP, US	1989-1990	76	75	50
Family 3	PL	1994	0	0	0
Family 4	CA, US	1999-2001	1	1	1
Family 5	CA, US	2004	3	3	0
Family 6	CA, US	2009	1	1	0
Totals	All	1987-2009	133	134	100

These examples highlight two rules of thumb for searching patent citations. First, the searcher should select databases with care. Multinational patent databases are recommended over national patent databases for obvious reasons. Second, in order to obtain an accurate count, the searcher must conduct citation searches for all members of a patent family or families. Obviously, this task could be quite laborious and time-consuming if a large number of families is involved.

7. Searching Cited Non-patent Literature in Patent Databases

Patents often contain references to non-patent literature such as journal articles, books, and websites. Like cited patent references, these can be searched in patent databases that have searchable non-patent literature cited reference data. As mentioned earlier, non-patent literature references that have been cited in an EPO search report or classified under the Cooperative Patent Classification system can be retrieved in Espacenet. In the USPTO database, searchers can use the OREF field to retrieve non-patent literature references in patents from 1976 to the present.

For example, the book *Fundamentals of Microfabrication: The Science of Miniaturization* (CRC Press, 2002), by University of California at Irvine engineering professor Marc Madou, has been cited in 270-300 patents, as shown in Table 6.

Table 6. Citations to *Fundamentals of Microfabrication* in Selected Patent Databases

Database	Front Page	Text
Espacenet	NA	272
DEPATISnet	300	22
USPTO	271	300

8. Patent Citations in Non-Patent Databases

Patents cited in non-patent literature, e.g., journal articles, etc... can be tracked in databases such as Web of Science and Google Scholar. As an example, Table 7 shows the number of articles indexed in Web of Science and Google Scholar that cite at least one member of the six patent

families described in the Table 5. In Web of Science, it is possible to search the patent number in the journal title field in the cited reference search form.

Table 7. Citing Non-patent Literature for Six Patent Families (See Table 5)

Patent Family	Family Members	Years	Citing NPL (Web of Science)	Citing NPL (Google Scholar)
Family 1	CA, DE, EP, JP, US	1987-1996	8	5
Family 2	EP, JP, US	1989-1990	2	2
Family 3	PL	1994	0	0
Family 4	CA, US	1999-2001	2	3
Family 5	CA, US	2004	0	0
Family 6	CA, US	2009	0	0

9. Discussion and Conclusions

Interest in patent citation searching is likely to increase as more universities recognize patents as a form of scholarship that should be recognized during tenure and promotion processes.

University technology transfer and licensing offices can use citation searching to track key patents and identify potential competitors and partners. Academic researchers can search patent citation data in order to evaluate the impact of their patents and journal articles cited in patents, and to locate additional information relevant to their research interests.

Current patent databases provide access to citation data, but in many cases the ability to retrieve cited references is not as advanced as databases such as Web of Science and Google Scholar. Inconsistencies in patent number formats and the existence of patent families are challenges to citation searching. However, it is possible to search for cited patents and non-patent literature efficiently and effectively as long as the number of documents in a patent family or families is relatively small. This study has suggested several techniques for improving search results. Patent databases that cover multiple countries, such as Espacenet and DEPATISnet, have a clear advantage over single-nation patent databases. Searchers must also be familiar with the citation data coverage and formatting in patent databases. It is recommended that searchers consult several databases in order to account for differences in database coverage and update frequency. Searchers should also remember that tracking non-patent literature references is complicated by inconsistent and non-standardized citation formatting.

In recent decades patent offices have standardized citation practices and improved access to cited references in patent documents. It is likely that patent citation data will become easier to track as patent database search capabilities improve and patent data becomes better integrated with traditional citation databases. However, patents are different from journal articles and other scholarly publications in that they are legal documents. Cited references in patents serve a different purpose than publications cited in a scientific article. Citation patterns in patents may differ from country to country because of different prior art disclosure requirements and patent examining practices. Patents that are members of large patent families may accrue many more

citations than families consisting of a few patents. These are important factors to keep in mind when evaluating the importance and impact of a single patent or a portfolio of patents.

10. Acknowledgements

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11. Selected Patent Office Databases

Espacenet, European Patent Office, <http://worldwide.espacenet.com/>

DEPATISnet, German Patent and Trade Mark Office, <http://www.dpma.de/english/service/e-services/depatismet/index.html>

PatentScope, World Intellectual Property Organization, <http://www.wipo.int/patentscope/en/>

PatFT: Patents and **AppFT: Applications**, U.S. Patent and Trademark Office, <http://patft.uspto.gov/netahtml/PTO/index.html>

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