# Patent Citation Cycles

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## ABSTRACT

A BASIC DESCRIPTION OF PATENT CITATION cycles is provided for 1,100 major companies and organizations covered by the TECH-LINE℠ database. The average U.S. patent has five to six "references cited-U.S. patent documents." The properties of these patent citations are shown to vary widely from one technology to another. For example, patents in Office Computing and Accounting, a relatively hot area, are cited almost three times as frequently as patents in Organic Chemicals, a less active area of patenting. Similarly, technology cycle times vary widely—from five to six years in fast moving electronics areas to twelve to fifteen years in some of the slow moving areas of mechanical technology. Citations to earlier patents peak at patents three to five years old, rather similar to the peak citation time for scientific literature. Since these citation peaks and cycle times are relatively short, and represent the difference between current art and prior art, this indicates, in one sense, that the technological lifetime of an invention may be much shorter than its legal and commercial life times.

## INTRODUCTION

Scientific and technological knowledge are the key driving forces behind the advance of Western civilization. Economists have concluded that a very large fraction of the economic growth that has occurred in the Western world has its origins in productivity advances: in turn, these productivity advances have resulted from the

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centuries-long compounded growth in technical knowledge (Price, 1963). This growth has now reached the point where worldwide, in every business day, there are more than 5,000 new scientific papers published, more than 1,000 new patent documents issued, and five new U.S. patents issued to the Japanese science and technology giant Hitachi.

Clearly, it is impossible to characterize the properties of this avalanche of knowledge by any techniques other than statistical. There are simply far too many papers and patents and far too much new knowledge in thousands of different research domains for any person, group, or even institution to comprehend—it can only be measured statistically.

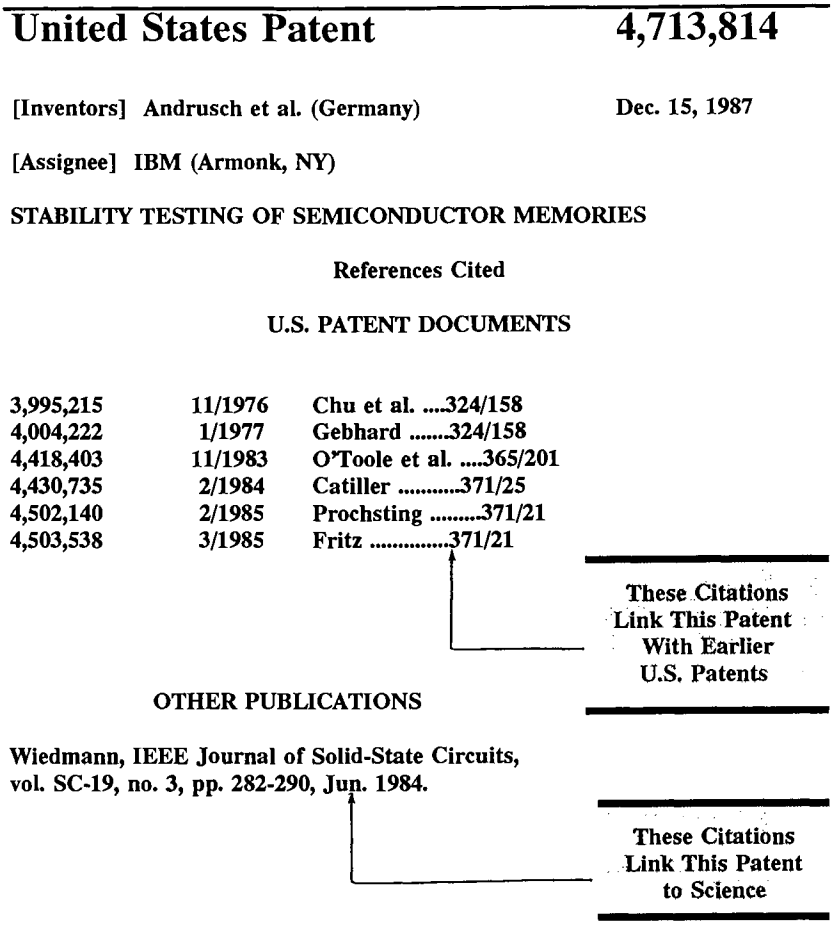
This article will briefly describe some statistical techniques which characterize the properties of patent citations (strictly the "references cited-U.S. patent document") on the front page of issued U.S. patents. These references play much the same role as references in scientific papers except that they are somewhat more strictly controlled. That is, each reference on the front page of a U.S. patent is put there either by the patent examiner, or suggested by the applicant and approved by the patent examiner, and serves to specifically identify the prior art upon which the patent improves.

## A U.S. Patent

Figure 1 shows the front page of a rather typical U.S. patent, in this case one issued to the U.S. company IBM in Armonk, New York, and relating to an invention by a group of inventors located in Germany. In the U.S. patent system, approximately 40 percent of all patents are U.S. invented and owned by U.S. and foreign companies, another 10 percent are U.S. invented and owned by the individual inventor (unassigned patents), 20 percent are Japanese invented and mostly Japanese owned, with 20 percent of the remainder from European inventors.

Figure 1 shows a U.S. patent issued in December 1987, which cited six earlier patents—those citations link this patent with the prior art contained in the cited patents. Note that the median age of those cited patents is 1983-1984. Technology Cycle Time is the median age of the references, when "age" is computed from the issue year of the citing patent—i.e., 1987. That is, for this patent, the technology cycle time is approximately four years as is appropriate for a patent in a fast moving area of technology such as Semiconductor Memories.

This patent also cites one "other publication," in this case a research paper in an IEEE journal and in every way is quite typical—the average U.S. patent cites five to six patent documents and one



**United States Patent** **4,713,814**

[Inventors] Andrusch et al. (Germany) Dec. 15, 1987

[Assignee] IBM (Armonk, NY)

STABILITY TESTING OF SEMICONDUCTOR MEMORIES

References Cited

U.S. PATENT DOCUMENTS

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|---|---|---|---|
| 3,995,215 | 11/1976 | Chu et al. | 324/158 |
| 4,004,222 | 1/1977 | Gebhard | 324/158 |
| 4,418,403 | 11/1983 | O'Toole et al. | 365/201 |
| 4,430,735 | 2/1984 | Catiller | 371/25 |
| 4,502,140 | 2/1985 | Prochsting | 371/21 |
| 4,503,538 | 3/1985 | Fritz | 371/21 |

These Citations Link This Patent With Earlier U.S. Patents

OTHER PUBLICATIONS

Wiedmann, IEEE Journal of Solid-State Circuits, vol. SC-19, no. 3, pp. 282-290, Jun. 1984.

These Citations Link This Patent to Science

1,100 TECH-LINE COMPANIES
have
290,000 Patents (1983-89)
2,000,000 Citations

Figure 1. Front page of a typical U.S. patent

other publication. However, in a highly science intensive area such as Drugs and Medicine and, within that biotechnology, the number of other publications cited is much higher. Drugs and Medicine patents average 2.5 other publications cited, and for the high tech company Genentech, the average patent has almost twenty-five of these references, most of which are to scientific papers (Narin & Olivastro, 1992).

The data in the rest of this article are based on the 1,100 companies in these authors' TECH-LINE[SM] database; as shown in Figure 1, these companies have 290,000 patents in the seven-year-period 1983-1989 and contain approximately 2 million different citations to U.S. patents, foreign patents, and other publications (TECH-LINE[SM]).

## Patent Citation Characteristics

The TECH-LINE[SM] database divides U.S. patents into fifty-seven different categories of which forty-three are unique product groups corresponding roughly to two digit SIC (Standard Industrial Classification) categories. Figure 2 shows the cites per patent to 1983 patents in each of these categories from the seven years 1983-1989 and indicates major differences in citation frequency. For example, patents in Office Computing and Accounting Machinery, category 27 at the top of the chart, receive more than twice as many cites on average as patents in category 07, Organic Chemicals, which is a relatively quiescent area. Note, in general, the concentration of Electronics, Motor Vehicle, and Instrumentation patents categories toward the top in citations, and the Chemical, Metallurgical, and Mechanical categories toward the bottom. The number of times a patent is cited varies quite dramatically with its technology.

Figure 3 shows an overall categorization of the age of the patent references, specifically the percent of the "references cited-U.S. patents" from the current year to the previous years. We have divided this into references to U.S. and foreign patents from U.S.-invented U.S. patents and from foreign-invented U.S. patents. Note that there is a peak in referencing to U.S.-patents at about three years in both cases; the peak is four to five years for referencing to foreign patents.

This difference is probably the product of two factors. First, the U.S. patent attorney and the U.S. patent examiner are much more familiar with U.S. patents, and, in fact, the examiner knows about them even before they are issued. The second factor is that, when a foreign patent is applied for in the United States, it is typically applied for between eleven and twelve months after the foreign application and typically appears as a granted patent in the U.S. system six months to a year later than it will appear as a granted patent in the foreign system. As a result, reference to the priority foreign patent, equivalent of a U.S. patent, will typically be to a patent that is a year or so older than its U.S. equivalent.

Nevertheless, the difference is not very large, and, in fact, these peak citing years are quite similar to the peak citations from scientific papers to scientific papers, and from patents to scientific papers so that, in fact, the technological prior art is not much older than the scientific prior art (Narin & Noma, 1985).

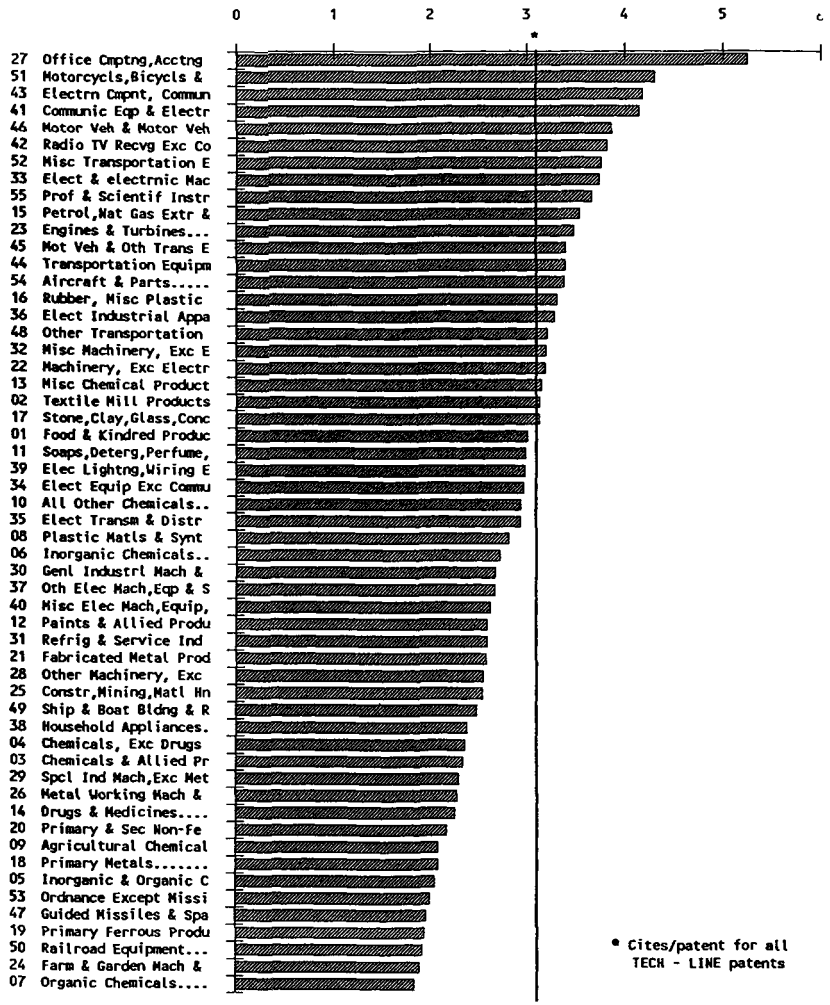


Figure 2. Cites per patent to 1983 patents from 1983-1989 patents

As mentioned earlier, one way of measuring the citation cycle is to measure the technology cycle time, which we define as the median age of the references cited in the current U.S. patent. Figure 4 shows the technology cycle time by product group for all of the TECH-LINE[SM] categories and again shows dramatic differences. Specifically, communications and electronics tend to have rather short cycle times—five to seven years—whereas patents in older technologies such as metals and metallurgy, Ordnance, Ship and Boat Building, and

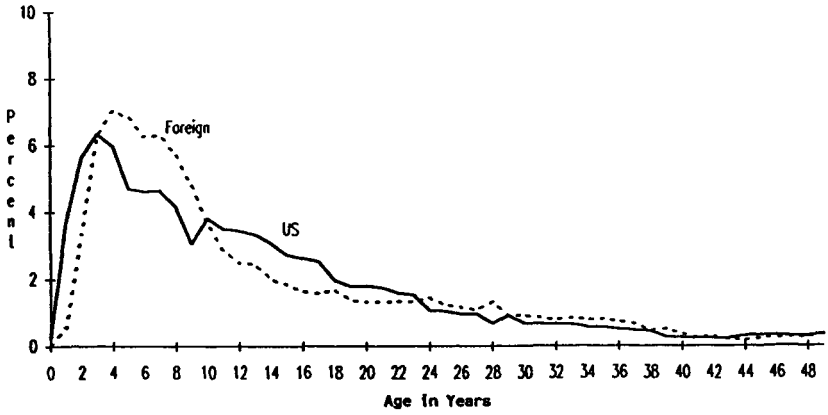


Figure 3a. References to U.S. and foreign patents from U.S.-invented patents

so forth have cycle times that are twice as long, typically twelve to fifteen years. Furthermore, within these specific categories, there are specialized subcategories, such as semiconductors, where the cycle times may be as short as two or three years.

One extremely interesting aspect of cycle time, which is quite general, is that it is very different for U.S., European, and Japanese companies patenting in the U.S. patent system, even within the same technologies. Figure 5 shows this relationship for three prototypical companies in a major area, Communications Equipment and Electronic Components. In general, Japanese-invented U.S. patents tend to have a half-year to a year shorter cycle time than U.S. invented patents which, in turn have a half-year to a year shorter cycle time than European-invented patents. This is due to many interacting effects, but certainly seems to reflect the rapidity with which Japanese, American, and European companies are able to bring new products to market and is a strong indicator of the challenge that the Japanese are providing to U.S. companies (Broad, 1991; Narin & Frame, 1989).

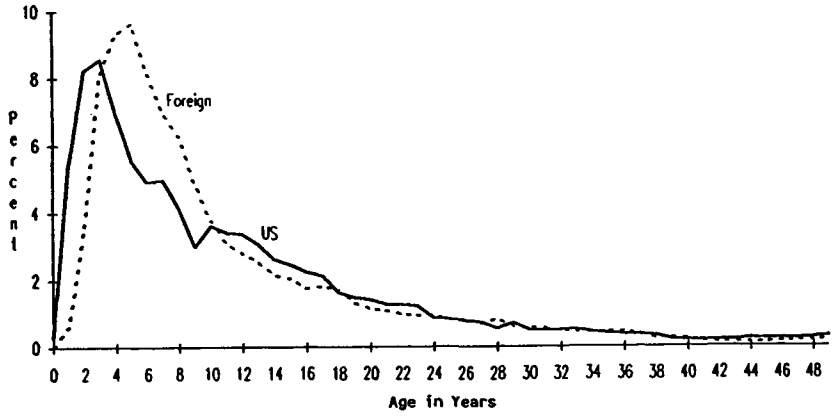


Figure 3b. References to U.S. and foreign patents from foreign-invented patents

The final figure, Figure 6, shows the percentage of each year's patents that are cited one or more times from 1989 patents. TECH-LINE[SM] and its indicator, Current Impact Index, use a five year window and calculate how frequently a company's recent patents are cited by patents in that citation window. The key point is that, within that citation window, the peak is about three years earlier than the current patent, and, in that peak year, 40 percent of the patents are cited one or more times. However, it should be remembered that this is for the TECH-LINE[SM] patents, which are roughly 60 percent of the U.S. patents assigned to these 1,100 major companies, and major company patents are cited, in general, far more highly than patents of individual inventors and government agencies. Overall, for the patent system, more than half of the patents are never cited, and two-thirds of the patents are never cited more than a few times so that even five citations puts a patent in the upper few percent of cited patents. The point of Figure 6 is that, in the first five or six years after it is issued, most of the patents that are ever going to be cited will be cited.

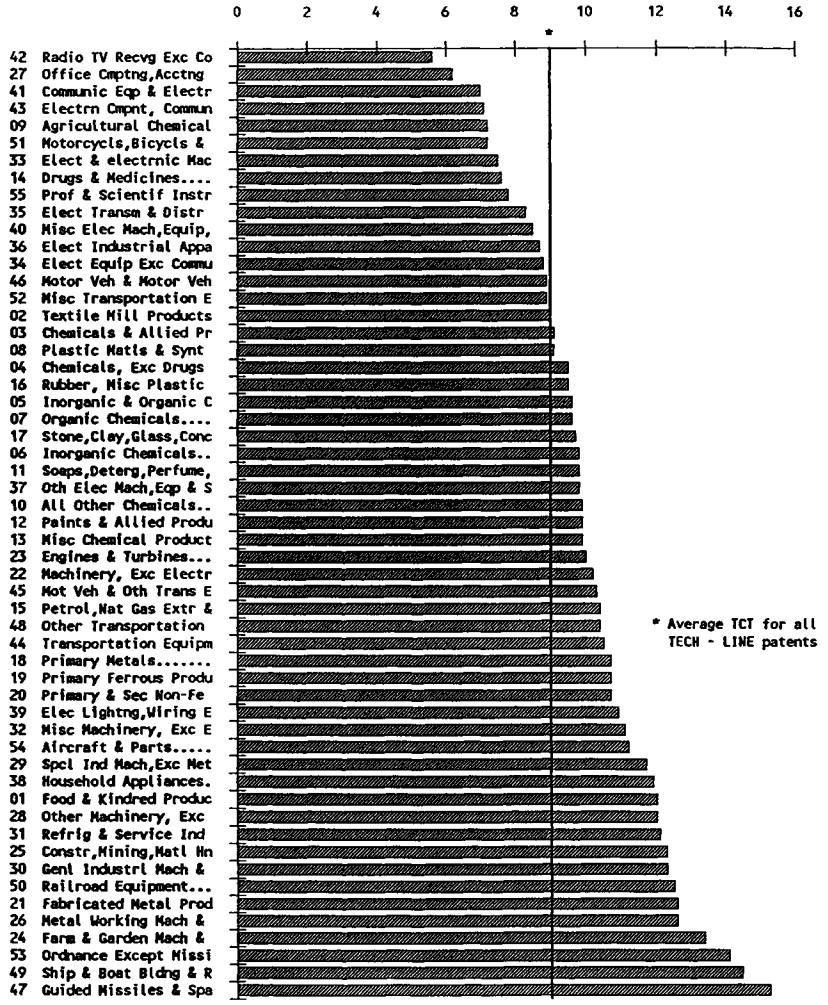


Figure 4. Technology cycle time of 1985-1989 TECH-LINE[SM] patents by product field

## Final Observation

The final observation of this article is that the citation patterns of patents, like the citation patterns of papers, vary widely from subject to subject. The ages of the citations, however, are not widely different from citations in papers. The peaks in patents are perhaps a year or two older, but are certainly not massively different from papers,

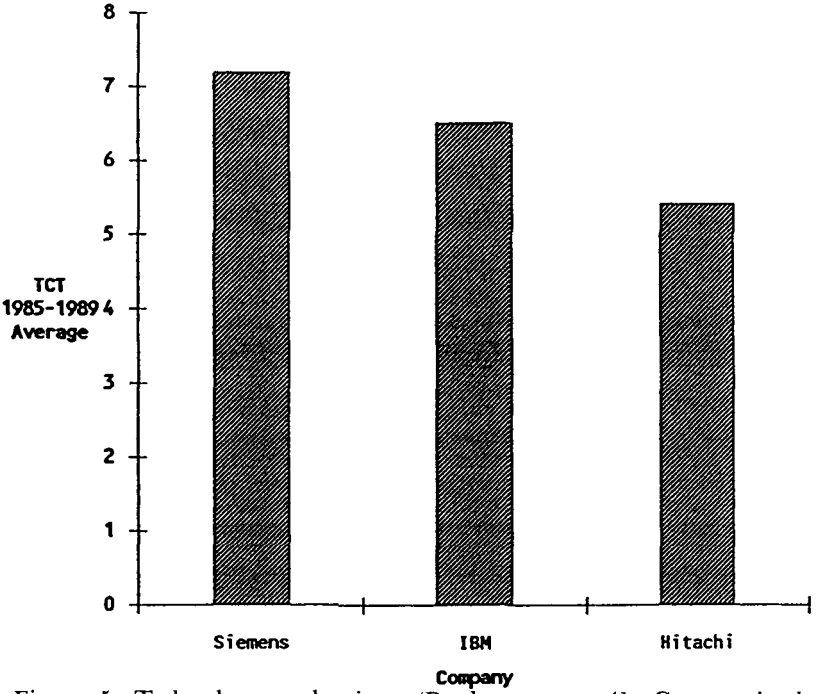


Figure 5. Technology cycle time. (Product group 41: Communications equipment & electronic components, 1985-1989 average.)

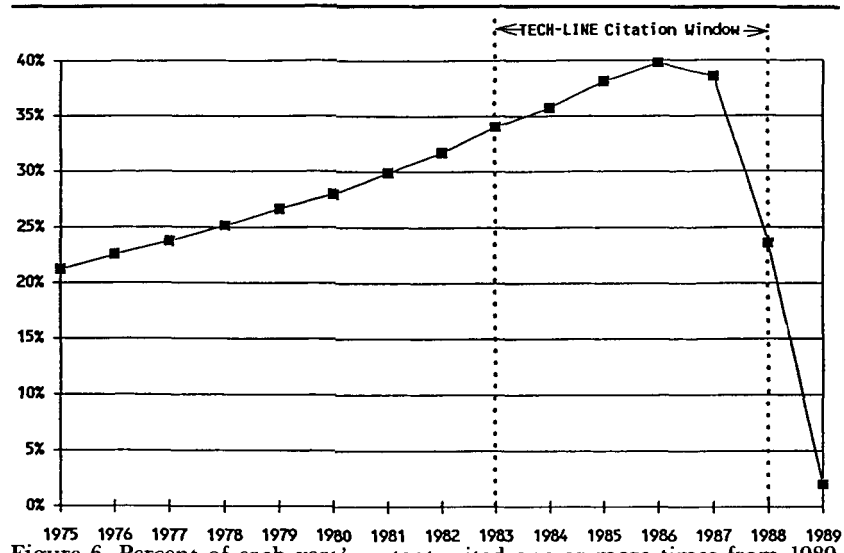


Figure 6. Percent of each year's patents cited one or more times from 1989 patents

and some of that difference can be accounted for by the eighteen months to two years it takes between application and grant of a patent. Furthermore, in technology as in science, hot areas have quicker and much more intense citation, and this provides, at least in principal, a means of identifying the leading areas of active technological development.

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