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### Why do Inventors Reference Papers and Patents in their Patent Applications?

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# **Why do Inventors Reference Papers and Patents in their Patent Applications?**

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# Why do Inventors Reference Papers and Patents in their Patent Applications?

## Introduction

Patent citation analysis is a widely used technique in the evaluation of science and technology. The basic premise behind its use is that papers or patents cited as prior art by many later patents tend to contain important ideas upon which numerous inventors have built. This does not mean that every important document is highly cited, or that every highly cited document is important. However, numerous validation studies have revealed the existence of a strong positive relationship between citations and technological importance (see Breitzman and Mogege (2002) for a review of validation studies).

In several previous studies, 1790 Analytics has shown that papers appearing in IEEE journals, and papers presented at IEEE sponsored conferences, are cited heavily by later patents (Breitzman, 2009). This high citation impact suggests that these IEEE papers have had a strong impact on subsequent patented inventions. However, the nature of this impact is not explicitly examined in these previous studies, particularly in terms of why a patent inventor chooses to reference a particular paper or patent. In this paper, we summarize the results of a survey examining why inventors reference prior art. We then examine the implications of the survey findings for the results of previous IEEE patent studies.

## Background on Patent Citation Analysis

Economists speak of citations as “knowledge spillovers” through which knowledge is accumulated over time, and new technologies are created by building and improving upon earlier findings. This is based on the intuitive idea that a 2009 Lexus could not have been created at the time of Henry Ford’s Model T, since the Lexus contains many technologies developed and improved upon since the Model T was introduced. Many of the innovations in modern cars are discussed in thousands of patents, and each of these patents is in turn built upon thousands of earlier patents and scientific articles. These relationships between generations of technology can be traced via prior art citation links between patents and earlier patents and scientific publications.

In the US system, when a new patent is filed, the inventor references the existing prior art, and demonstrates how the new invention represents an advance over this prior art. The inventor’s patent attorney and/or the examiner may also add prior art references to either clarify or limit the claims of the new invention. In some cases, the new invention represents an incremental improvement over existing technology, while in other cases the invention may be a completely new use of a scientific discovery.

Citations have been accepted as a noisy but useful metric for measuring knowledge spillovers and for studying innovation in general. Much of the research on citations has been related to validating them as a proxy for measuring technological impact. For example, highly cited patents have been linked to measures of technological importance such as inventor awards and high-value inventions. Carpenter *et al* (1981) found that patents related to IR 100 invention awards (now known as the annual “R&D 100 Awards”) are cited twice as frequently as typical patents. Also, Albert *et al* (1991) demonstrated that patents identified as important by industry experts were cited frequently by later patents. Other studies have revealed a positive relationship between citation impact and various measures of commercial success, including stock market valuations (Breitzman and Narin, 2001), stock price movements (Thomas and Narin, 2004), and increased sales and profits (Narin *et al*, 1987).

## Key Results from the IEEE Patent Citation Studies

The prior art referenced in patents can be divided into two categories - patent references and non-patent references. As the name suggests, patent references are references to earlier patents, either domestic or foreign. Non-patent references (NPRs) are references to any document other than earlier patents. NPRs can be to any published document, from comic strips and brochures, to scientific articles and standards documents. In the IEEE patent citation studies, we were most interested in the subset of NPRs that can be regarded as scientific documents, including journal articles, conference papers, and standards documents.

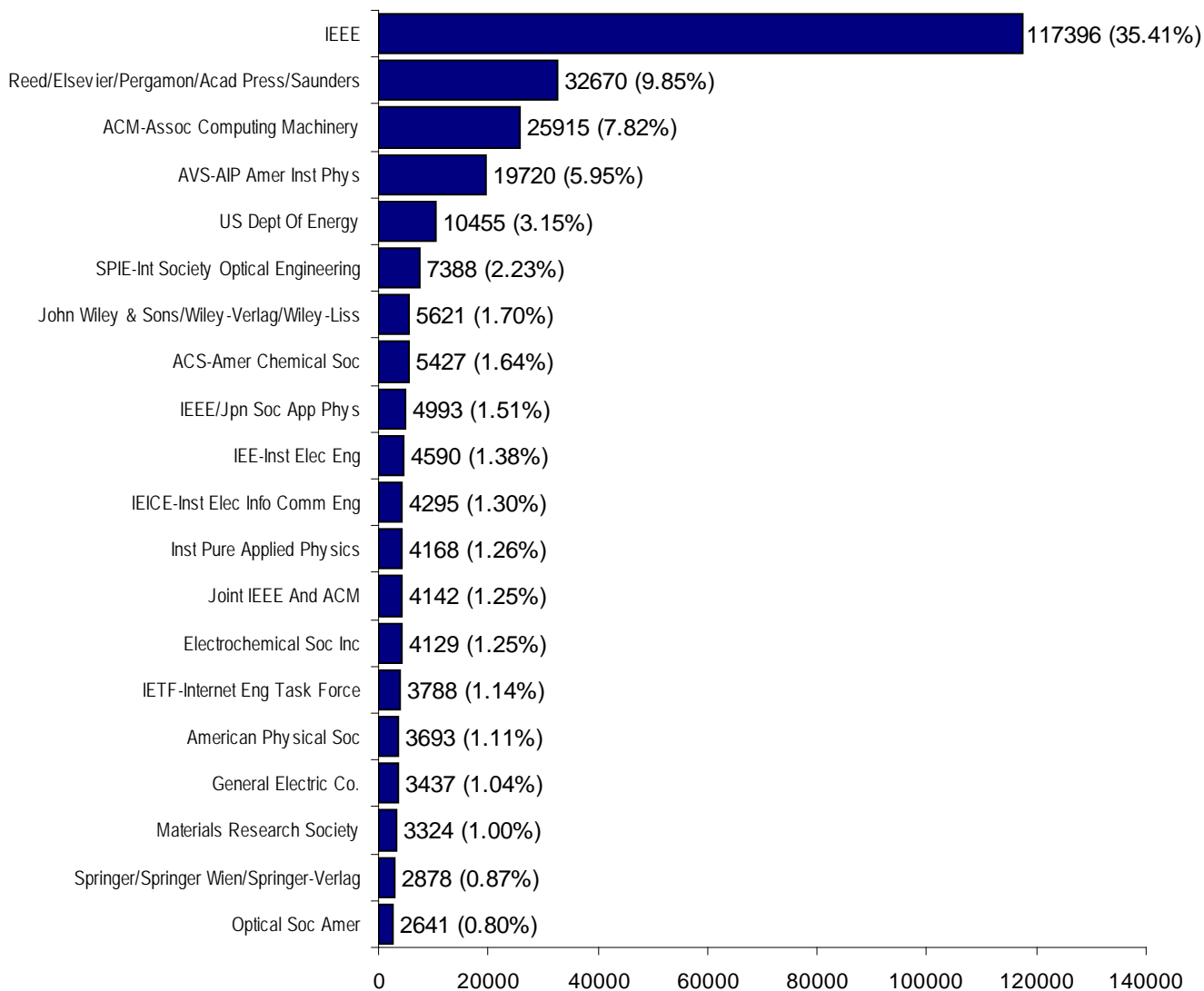
In a series of reports going back to 2004, we analyzed the impact of IEEE journals and IEEE sponsored conferences on technology developments. The key findings of those reports can be summarized as follows:

1. The top patent producing firms overwhelmingly reference IEEE publications and conferences. For instance, as shown in Figure 1, 35% of all scientific references from the top 25 patenting firms go to IEEE publications. Meanwhile, 10% of all scientific references from the top patenting firms go to second place Reed-Elsevier (Breitzman, 2009).
2. In Information Technology (IT) patents – i.e. patents in Telecommunications, Semiconductor Manufacturing, Computer Software and Hardware - IEEE provides an even larger portion of the science base of technology. For example, in the last 12 years, nearly 200,000 US patents have been issued related to Communications and Telecommunications. About 48% of all scientific references from these patents have been to IEEE journals or IEEE conference papers. During the same time period, only about 5% of all science references from these patents have gone to the second place publisher The Institute of Engineering and Technology (IET, formerly known as IEE) (Breitzman, 2009).
3. It has been shown that high-quality, high-impact, and valuable patents tend to be cited more frequently by later patents (Breitzman and Moguee, 2002). Citation impact is thus often used as a quantitative measure for evaluating patents. Our research shows that patents that reference IEEE papers are cited more often than patents that do not. Thus, not only do IEEE publications frequently provide the science base for new inventions, but inventions that build upon IEEE publications are more likely to be influential in the future than inventions that do not build upon IEEE publications (Breitzman, 2009).
4. The importance of scientific and technical literature to patented technology is increasing in all areas. Our research shows that US patents issued in 1997 had an average of 2.76 NPRs. That number increased to 5.28 by 2008 – a 91% increase. Over the same period, referencing from patents to IEEE publications has increased at an even faster rate (159%). This suggests that, in the overall patent system (and not just in IT categories), patented technologies are increasingly referencing scientific articles, and that IEEE provides an increasing portion of that science base (Breitzman, 2009).

Taken together, these findings suggest that IEEE publications have had a strong impact on subsequent patented inventions. This is based on an assumption that it is valid to regard citations as representing a flow of knowledge from cited document to citing inventor. To assess the validity of this assumption, below we assess the findings from a survey of inventors carried out by NBER/Case-Western Reserve. The study, authored by Adam Jaffe, Manuel Trajtenberg, and Michael Fogerty, was published in 2000, and is

referred to hereafter as the Jaffe study. We use the Jaffe findings to provide greater context for the results from the previous IEEE patent studies carried out by 1790 Analytics.

**Figure 1: Number and Percentage of Science References from Top 25 Firms to Top 20 Publishers**



### Data from the NBER/Case-Western Reserve Survey of Patentees

The Jaffe study was based on a survey of inventors covering the subject of prior art referencing. The authors surveyed both citing and cited inventors. In the citing inventor survey, the authors asked inventors about citations made in their patents to previous patents. Meanwhile, in the cited inventor survey, they asked inventors about citations received by their patents from subsequent patents. The idea of surveying both groups was to construct a more robust picture of knowledge flows.

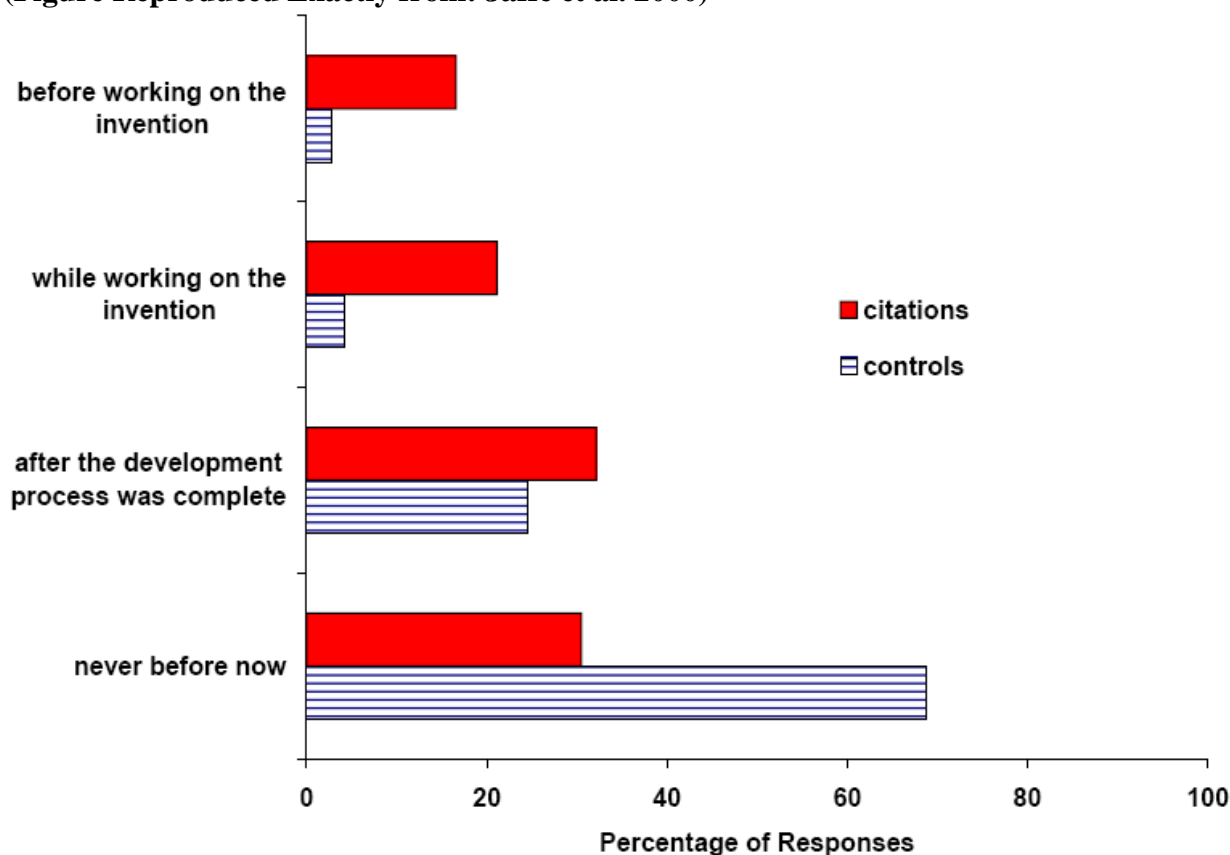
For our purposes, we are most interested in the citing inventor survey, which examined the extent, timing and nature of communication that inventors had with the patents they referenced as prior art. The survey design was rather clever in the use of a “control” cited patent. Specifically, inventors were shown three patents, two of which appeared among the prior art references made by their patent. The third patent was a “control” patent that was not cited by the surveyed inventor, but which was granted in the same patent

classification and year as one of the two cited patents. In the survey questionnaire, this control was not identified or distinguished in any way, with all three patents being referred to as cited patents.

One key result from the survey is shown in Figure 2. This figure reveals that over 40% of respondents were aware of the cited prior art before or during the invention process. A further 30% learned about the prior art after the development process was complete, while another 30% only learned about it during the survey.<sup>1</sup> We interpret this to mean that approximately 40% of the prior art had some influence on the invention, 30% of the prior art was found in a subsequent search that occurred during the patent filing process, and the other 30% of the prior art was added by the applicant's attorney or the patent examiner, and the inventor had no knowledge of it.

The results for the control patents are also instructive, with about 70% of responses showing no prior knowledge of the control patent. This suggests that inventors were much more aware of patents cited as prior art than they were of other patents describing similar technology. Again, this suggests there is noise in citations, but there appears to be a relationship between citing patents and prior art that is far from random.

**Figure 2: Distribution of Answers to: When did you learn about previous patent?**  
(Figure Reproduced Exactly from: Jaffe et al. 2000)



Another key result from the Jaffe study is shown in Figure 3. This figure shows responses to questions about how the inventor learned about the prior art patents. In about 8% of the cases, the inventor communicated directly with the inventor of the prior art; in a further 12% of the cases, the inventor saw a demo or presentation about the prior invention; and in another 18% of the cases, the inventor heard about

<sup>1</sup> The percentages taken from Figures 2 through 4 are approximate. The Jaffe paper did not label the figure with the exact percentages. The figures are reproduced here, but the percentages are estimates from the figures.

the prior invention via word of mouth. About 40% of the citations were made at the time of the patent application, and 23% were unfamiliar to the surveyed inventor, and were presumably added by the inventor's attorney or the patent examiner. There is a slight inconsistency between Figure 1 and Figure 2 in terms of the percentages in the various categories. However, it remains the case that at least one-third of the citations occurred before or during the invention, and we can assume they had at least some influence on the invention.

**Figure 3: Distribution of Answers to: How did you learn about previous patent?**  
(Figure Reproduced Exactly from: Jaffe et al. 2000)

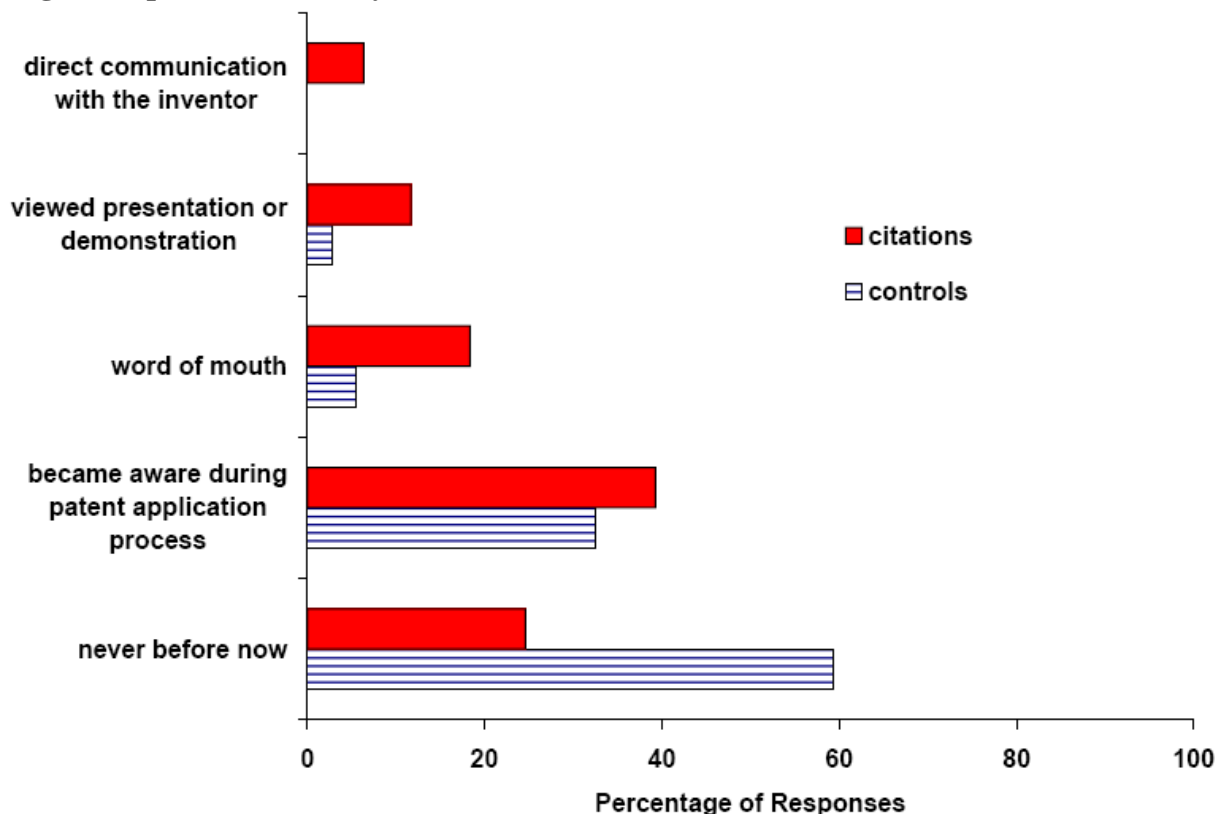


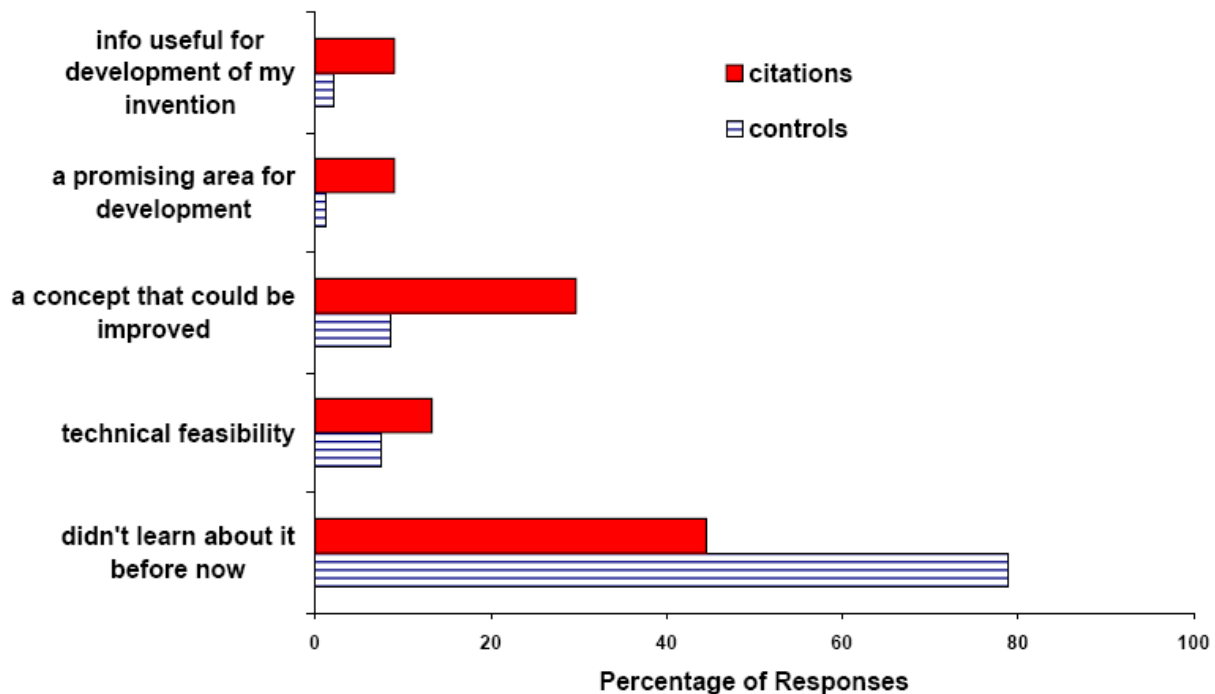
Figure 4 contains probably the most interesting result from our perspective. This figure shows the distribution of responses related to what was learned from the cited patents. The figure reveals that about 8% of the citations occurred because they provided good background information for the new invention, while another 8% revealed a promising area for development. About 28% were cited because they showed an invention that could be improved upon, and an additional 13% were cited because they showed a process was technically feasible. Hence, about 57% of the cited patents could be regarded as providing useful knowledge for the citing patent.

As shown in the bottom bar in Figure 4, the other 43% of the patents cited as prior art contained no useful knowledge for the citing inventors. This may seem like a high percentage, but it should be compared with the 80% of control patents that provided no useful knowledge. The difference in these percentages suggests that the cited patents are closer to the inventions than random patents drawn from similar technologies. It thus further supports the idea of citations representing a useful, if noisy, method for tracing technological developments. Also, in terms of the survey, it suggests that respondents took their

task seriously, since the control patents were not highlighted as being control patents, but were treated as regular cited patents.<sup>2</sup>

It is also worth noting that, in comparing the results of the citing and cited inventor surveys, a discrepancy was highlighted by the authors of the Jaffe study. Specifically, while citing inventors were inclined to understate their reliance on the work of prior inventors, cited inventors tended to overstate the extent to which they had influenced subsequent developments. Thus it would be reasonable to assume the 57% of citations that citing inventors said provided useful knowledge for their patents is really a lower bound, and that the percentage may be somewhat higher.

**Figure 4: Distribution of Answers to: What did you learn from the previous invention? (Figure Reproduced Exactly from: Jaffe et al. 2000)**



## Discussion and Conclusions

The IEEE patent citation studies outlined above show that IEEE publishes a large percentage of the scientific papers cited in patents. Meanwhile, the Jaffe study provides insights into the motivations behind prior art referencing. One important point is that the Jaffe study was based only on prior art references to earlier patents, not references to publications. To our knowledge, there has been no significant survey of the motivations behind non-patent referencing. However, if we accept as reasonable the idea that motivations for patent and non-patent referencing are similar, the results of the Jaffe study should be largely applicable to non-patent referencing. The results of the Jaffe study can therefore be used to provide greater context for the findings of the IEEE patent citation studies.

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<sup>2</sup> Interestingly, the authors noted that several of the survey respondents sent comments back that the control patents were mistakes. This suggests that several of the respondents actually looked up their old patents and found the control patents to be missing from the prior art lists.



One of the key findings of the Jaffe study was that 57% of prior art references represent some knowledge spillover, while 43% of the references were of no value to the inventor, and were presumably added by the inventor's attorney or the patent examiner. Specifically, the Jaffe study suggests that:

1. About 8% of the references are cited because they provide useful background.
2. About 8% are cited because the articles showed a promising area for development.
3. About 28% are cited because they discuss a technology that can be improved upon.
4. About 13% are cited because they show an idea is technically feasible.
5. About 43% are cited by the patent attorney or patent examiner as part of the patenting process.

Based on these percentages, approximately six of ten scientific papers referenced in patents should provide some form of knowledge spillover that influences a new invention. These papers may provide background, suggest promising new areas for development, or describe technologies that offer opportunities for improvement. Given that a great deal of the scientific literature referenced in patents is published by IEEE, this suggests that IEEE published research has a vital role in these three fundamental areas of innovation.

If six out of ten publications cited in patents provide some form of knowledge spillover, the other 40% of publications should not be disregarded. These publications may have been added by the patent attorney or patent examiner at the time of prosecution, and could be just as important as the publications that represent knowledge spillovers. Specifically, scientific papers provide a public forum where scientists can publish findings for the public good. Meanwhile, a patent is a monopoly right that allows an inventor to sue others that try to practice his/her invention. When a patent examiner references a published article to limit the scope of a patent, this reinforces the idea that concepts already in the public domain cannot be taken away from the public in general, and can continue to be used by all. Hence, while IEEE provides a huge resource of ideas available to companies and inventors through knowledge spillovers, it also provides an invaluable repository of scientific advances that will remain in the public domain.

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