HOW I LEARNED TO STOP WORRYING AND LOVE PATENTS

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ABSTRACT

The purpose of patents is "to promote the Progress of Science and useful Arts" by rewarding the inventor with exclusive rights to a disclosed invention. U.S. Const., art. I, § 8, cl. 8. These exclusive rights then serve as a barrier to competition and follow-on innovation. Thus, while patents incentivize initial innovation, they may cool follow-on innovation. But if patents are only awarded to those inventions that would not otherwise occur absent the patent incentive, then we are willing to accept these consequences because there would be no follow-on work to an invention that never happened anyway. However, there is growing concern that this traditional justification may no longer hold true. It may be that patents are awarded to many inventions that in fact would have occurred in the pursuit of profits anyway. If so, then on balance, patents may actually hurt more than help innovation. There have been a number of empirical studies aimed at settling this debate by measuring the effects of patents on innovation. Studies that have examined changes in patent citations, citations in scientific publications, and direct-follow on scientific publication in patented subject matter areas have indicated that patents may hurt innovation. However, patent citations are mostly added by the patent examiner or patent attorney, neither of whom

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had any influence over the inventive process. Scientific publication citations are completely voluntary. And direct follow-on work does not capture whether patents incentivized earlier initial invention (which is a key half of the effect of patents). There has never before been a study that examines publication behavior for the complete on balance effect of patents on both initial and follow-on innovation. In this paper, I continue to look at scientific publications as the metric for innovation. However, instead of looking only at direct follow-on work, I use broader subject matter areas in order to capture the effects of patents on initial invention as well as follow-on invention. In other words, this paper investigates whether patents have the effect of slowing research or merely shifting research to novel areas not yet patented, thereby increasing the breadth of innovation. I compare publication trends in patented subject matter areas that were upheld at the Federal Circuit with those in patented subject matter areas that were invalidated at the Federal Circuit. Contrary to the suggestions of other studies, I found some statistically significant evidence that publication counts were higher in subject matter areas after patents were upheld as valid than in areas after patents were invalidated. I examined both the fields of biotechnology and software.

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I. INTRODUCTION

Patents exist "to promote the Progress of Science and useful Arts."[2] Patents encourage this progress by providing a reward for the disclosure of innovation. That reward is a bundle of rights to prevent others from making, using, or selling the patented invention.[3] The financial benefits of these rights give inventors greater incentive to invent and then patent those inventions. Additionally, patents provide a countervailing incentive for inventors not to spend resources attempting to keep innovations as trade secrets.[4] Disclosure also promotes progress because it contributes information and understanding to the world's knowledge base and, in a more tangible sense, allows other parties to make follow-on innovations without duplicative discovery costs. Of course, the exclusionary patent rights themselves then serve as a barrier to follow-on innovation by adding transaction costs to license the patents and to avoid patent

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[2] U.S. CONST. art. I, § 8, cl. 8.

[3] 35 U.S.C. §§ 271(a)–(c) (2010).

[4] An invention must be adequately disclosed to be patentable. 35 U.S.C. § 112 (2012). This disclosure is a key goal of the patent system. *See* Bonito Boats, Inc. v. Thunder Craft Boats, Inc., 489 U.S. 141, 150–51 (1989).

infringement litigation. But this barrier is temporary and is the price paid to achieve higher levels of innovation.[5]

However, there is a growing concern that this balance of incentives and barriers is tenuous. The complexity and cumulative nature of modern technology increasingly requires multiple patents from diverse sources in order to continue to innovate.[6] This makes it more difficult for inventors to efficiently acquire all of the legal rights necessary to continue to innovate. This in turn exacerbates the ability of patents to impede innovation, and could in some extreme cases outweigh the incentives to innovate that justify the patent system in the first place.[7] But science and technology as fields can expand indefinitely, so the idea of a bounded subject matter area becoming over-congested with patents says very little about whether innovation as a whole is actually impeded.[8] In other words, instead of abandoning a field all together, an inventor would more likely search for a novel approach utilizing her same field of knowledge, thereby creating new territory for scientific exploration. This kind of innovation expands the field and is certainly the kind of activity the patent system encourages. The inability for theoretical analysis to settle this debate has led many scholars to design empirical tests.[9] A number of studies have relied on the apparent

[5] The lifetime of a patent is currently 20 years from the filing date. 35 U.S.C. § 154 (2015).

[6] Alberto Galasso & Mark Schankerman, *Patents and Cumulative Innovation: Causal Evidence from the Courts* 2 (Rotman Sch. of Mgmt., Working Paper No. 2247012, 2013), http://ssrn.com/abstract=2247011 [http://perma.cc/KMY3-JBPZ].

[7] *Id*.

[8] *See* David E. Adelman & Kathryn L. DeAngelis, *Patent Metrics: The Mismeasure of Innovation in the Biotech Patent Debate*, 85 TEX. L. REV. 1677, 1700–01 (2007).

[9] Galasso & Schankerman *supra* note 6, at 2–3.

complementarity between patenting and publishing papers.[10] That is, inventors tend to patent *and* publish, rather than patent *or* publish. The exact causality remains unclear. But one possible explanation is that once an inventor obtains a patent, he or she can then confidently continue to research and publish as much as possible because the subject matter area is protected. This publication behavior could explain how patents achieve adequate information disclosure even when they are written so cryptically and when so few researchers ever bother to read them.[11] After acquiring a patent, the inventor is actually incentivized to disseminate the information to increase the value of the patent.[12] Patent protection allows the inventor to benefit from selling or licensing rights to the patented information, thereby enabling the public to access the technological advance while also freeing the inventor to continue researching, producing, and publishing.[13] Those publications are read by other researchers who then conduct and publish follow-on work.

Of course, that important last step only happens if the original patent does not prevent or discourage third parties from conducting follow-on work. One study found evidence

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[10] Fiona Murray & Scott Stern, *When Ideas Are Not Free: The Impact of Patents on Scientific Research*, 7 INNOVATION POLICY AND THE ECON. 33, 53–54 (2007).

[11] *See* Alan Devlin, *The Misunderstood Function of Disclosure in Patent Law*, 23 HARV. J. L. & TECH. 401, 403-05 (2010) (Considering that the only disclosure mechanisms are the patent itself and the ability to reverse-engineer the product, Devlin concludes that this disclosure is too weak to be a primary justification of the patent system. However, Devlin does not explicitly address that patents may enable journal publications, conference presentations, formal research partnerships, and other informal communications.).

[12] Thomas Hellmann, *The Role of Patents for Bridging the Science to Market Gap*, 63 J. ECON. BEHAVIOR & ORG. 624, 625 (2007).

[13] *Id*. at 627–28.

of this important qualification. The study reported that citations to scientific publications describing a discovery decrease by 10–20% when the discovery is later patented.[14] However, the mechanism for this is not fully understood. While it is not contested that researchers regularly read scientific publications, there are few who believe that researchers regularly read patents.[15] Even if researchers did read patents, patent language can be so vague that it might not be clear whether there is enough of a risk of infringement to alter one's research.[16] Furthermore, over 98% of patent owners never sue.[17]

Therefore, some studies have instead focused on the effects of patent litigation. One such study found that patent invalidation at the Federal Circuit results in a 50% increase in subsequent patent citations to the invalidated patent.[18] The results were only statistically significant for patents owned by large firms in subject matter areas characterized by complex technology and high fragmentation of patent ownership.[19] But the results could not be completely

[14] Fiona Murray & Scott Stern, *Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-commons Hypothesis*, 63 J. ECON. BEHAVIOR & ORG. 648, 669–73 (2007).

[15] Wesley M. Cohen & John P. Walsh, *Real Impediments to Academic Biomedical Research*, 8 INNOVATION POLICY AND THE ECON. 1, 11 (2008); Mark A. Lemley, *Ignoring Patents*, 2008 MICH. ST. L. REV. 19, 20–22 (2008); *The Disclosure Function of the Patent System (Or Lack Thereof)*, 118 HARV. L. REV. 2007, 2017–26 (2007).

[16] James Bessen, Jennifer Ford, & Michael J. Meurer, *The Private and Social Costs of Patent Trolls*, REGULATION, 26, 28 (2012).

[17] Shawn P. Miller, *What's the Connection Between Repeat Litigation and Patent Quality? A (Partial) Defense of the Most Litigated Patents*, 16 STAN. TECH. L. REV. 313, 317 (2013).

[18] Galasso & Schankerman, *supra* note 6, at 4.

[19] *Id*. at 5.

explained by the increased publicity surrounding the litigated patents. Unlike the mere existence of a patent, there is reason to believe that patent litigation does meaningfully affect researchers' behavior. A number of studies have shown that patent litigation decreases a defendant company's stock price and in turn the resources available for future research and development.[20] It has even been shown in some cases that new product offerings from a patent litigation defendant ceases all together.[21]

Unfortunately, there are serious flaws in using citations to measure innovation (whether publication citations or patent citations). Most of these flaws are acknowledged by those who use citation counts. The influence of past research on future innovation simply cannot be reliably traced through citation. For publications, citations are entirely voluntary. Thus, they may be under-inclusive with respect to the actual amount of published research that the inventor relied on in their own work. Worse, inventors could strategically choose not to cite information that has been patented. At the same time, publication citations may be over-inclusive of the work of friends and colleagues that may have had minimal or no actual impact on the inventor's own work. Similar issues exist for patent citations. Patent citations may be under-inclusive because inventors do not receive credit for cumulative improvements that are not patented.[22] At the same time patent citations may be over-inclusive. Most prior

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[20] Bessen, Ford, & Meurer, *supra* note 16, at 31–32; James Bessen & Michael Meurer, *The Private Costs of Patent Litigation* 11 (Boston Univ. Sch. of Law Pub. Law & Econ., Working Paper No. 07-08, 2007), http://ssrn.com/abstract_id=983736 [http://perma.cc/LHR6-8JVF].

[21] Catherine Tucker, *Patent Trolls and Technology Diffusion* 25–26 (TILEC Working Paper No. 2012-030, 2013), http://ssrn.com/abstract=2136955 [http://perma.cc/W47Q-BFQQ].

[22] Galasso & Schankerman, *supra* note 6, at 11.

art citations simply serve to limit the scope of the claims and in no way indicate that the current inventor built off of or even knew of those patents at the time of invention.[23] Thus, patent citations are most likely injected much later by the patent drafter or patent examiner during the prosecution process, neither of whom had influence on the innovative process that led to the patent application in the first place.[24]

Other metrics for innovation are also fundamentally flawed. Not every research dollar of input will produce an output. Not every innovation results in a product or service that can be sold competitively for a profit.[25] Not every advancement is worthy of a patent. But all of these advancements and innovations represent beneficial behavior that may have occurred in pursuit of the patent reward. Therefore, instead of tracing citations or any of these other proximity metrics, I propose counting research publications not only as a measure of follow-on innovation but also as a

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[23] *Id.*; *see also* Lemley, *supra* note 15, at 20–22; Mark A. Lemley, *The Myth of the Sole Inventor*, 110 MICH. L. REV. 709, 736 (2012); John M. Olin, *The Disclosure Function of the Patent System (of Lack Thereof)*, 118 HARV. L. REV. 2007, 2017–23 (2007).

[24] *But see* Christopher Cotropia, Mark A. Lemley & Bhaven Sampat, *Do Applicant Patent Citations Matter?*, 42 RES. POL'Y 844, 846–47 (2013).

[25] There are some who argue that innovation has no value outside of commercialization. *See* Ted Sichelman, *Commercializing Patents*, 62 STAN. L. REV. 341, 402–12 (2010); Michael B. Abramowicz, *The Problem of Patent Underdevelopment* 41–55 (GW Law Faculty Pubs. & Other Works, Working Paper No. 231, 2005). Even if this were true, every incremental non-commercialized innovation still contributes to later innovation that will eventually find its way into a commercial product or service. However, it is this Author's opinion that contribution of knowledge is in itself "progress of science and useful arts" intended to be encouraged by the patent system and the U.S. Constitution. I firmly reject any notion that knowledge is only beneficial if it can be turned into a commercial product that can be packaged and sold.

total measure of innovation.[26] Publications are the most direct product of research and development. The minimum outcome of research and development is a publication, which ensures that the research results are sufficiently innovative and novel. And unlike patents, publications are a primary source of information disclosure in the research community.

If patents spur innovation (and subsequent disclosure), the number of publications should increase with the number of patents.[27] But if patents deter innovation, the number of publications should decrease with the number of patents. However, a raw increase or decrease in publications does not in itself reveal whether patents were the cause. To address the question whether patents spur or deter innovation, I examine patented subject matter areas that were held invalid at the Federal Circuit versus areas that were upheld as valid. Since patents are presumed valid until they are successfully challenged (i.e., invalidated), I am able to compare the publication behavior in subject matter areas before the patents were challenged to the publication behavior in the same areas after the patents were challenged.

This is a similar methodology as was used in a study conducted on specific human genome patents, which examined a set of genes first discovered and patented by

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[26] Publications obviously do not measure every form of innovation, just those that may be incentivized by patents (which is all the patent system should be concerned with anyway). For instance, trade secrets are of course valuable innovation that is not measured by publications. But the increased use of trade secrets is less preferable to patents in terms of the benefits of disclosure. Thus, a decrease in publications represents a true loss in innovation due to the costs of duplicative research associated with an increased use of trade secrets.

[27] Disclosure can use formats other than journal publications, such as presentations, information communications, and web articles. However, journal publications are formally approved for innovative and reliable content, and they are easier to search.

Celera that were later made publicly available when independently discovered by the Human Genome Project.[28] That study found that Celera's patents resulted in about 20–30% reduction of follow-on research and product development.[29] However, the study specifically focused on the effects of patents on follow-on work and acknowledged that patents may have incentivized faster initial discovery (Celera discovered the genes two years before the Human Genome Project).[30] The study also noted the possibility that the reduced follow-on work may have merely shifted to non-patented genes and techniques, which would exacerbate the apparent difference in publications between patented and non-patented genes.[31] Furthermore, this is not necessarily a net negative for innovation even in the narrow area of patented genes, if the shifted efforts found novel, non-infringing ways to achieve the same goals. Such innovation would be of great value. I avoid these intricacies by categorizing patents into broader subject matter areas, by examining a range of subject matter areas, and by investigating multiple scientific fields. In this way, I examine the general effects of patents on innovation as a net of both initial discovery and follow-on work. I also examine how many of the publications are authored by corporations, because the disclosure of corporate research would seem most likely to be influenced by the validity of patents.

In this paper, I focus on two particularly controversial fields: biotechnology and software. On one end of the spectrum, biotechnology would seem to present a

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[28] Heidi L. Williams, *Intellectual Property Rights and Innovation: Evidence from the Human Genome*, 121 J. POLITICAL ECON. 1, 2–3 (2013).

[29] *Id.*

[30] *Id.* at 4.

[31] *Id.* at 24.

strong case for patent rights. The field requires high capital expenditures and long development cycles. Outcomes of research are uncertain and investments take long periods of time to recoup. Because of the implications of biotechnology on healthcare, it is very important that patents encourage rather than discourage innovation. At the other end of the spectrum, software would seem to present a weak case for patent rights. Software has very low capital expenditures and very quick development cycles in comparison with biotechnology, such that investments can be recouped quickly. Given that software is implemented in written code, copyright protection seems more suitable for software. And because software is still a relatively new field, it is very important that patents encourage rather than discourage innovation.

I found that, for both biotechnology and software, the number of publications have grown at roughly the same pace as the number of patents issued. More importantly, I found that publications grew at a faster rate in subject matter areas after patents were upheld as valid by the Federal Circuit than in areas where patents were invalidated by the Federal Circuit. In biotechnology, the difference in publication behavior was as much as 63% growth in subject matter areas after being held valid compared to a 5% reduction in subject matter areas after being held invalid. The results based on Web of Science publications were statistically significant, but the results based on PubMed publications were not statistically significant. In software, the difference in publication behavior was as much as a 93% growth in subject matter areas after being held valid compared to a 54% growth in subject matter areas after being held invalid. However, these results based on Web of Science publications were not statistically significant. Overall, these results contradict what past studies using citation rates have reported about the effects of patents on innovation. Because these results are based on actual measured progress in subject matter areas, rather than a mere approximation based on citation counts or products in the market, they represent a more meaningful metric. Furthermore, these results do not necessarily contradict studies that show a reduction of follow-on work, as my goal was to examine the aggregate of initial and follow-on innovation.

These results suggest that for-profit corporations prefer to publish papers only if their results can be protected (e.g., by patents). When innovations are made, legal departments analyze them and determine whether to approve publication based on the perceived protectability of the innovation. If the protection is never achieved or is later removed (e.g., patents are invalidated), corporations are more likely to compel their researchers to stop disclosing their innovations. I found that, in both biotechnology and software, corporate publication behavior is consistent with this theory. Corporations publish much more in subject matter areas where patents are upheld as valid, compared to subject matter areas where patents are held as invalid. In biotechnology, this difference is as great as a 44% growth compared to a 21% reduction, a statistically significant difference. In software, this difference is as great as a 3% reduction compared to a 38% reduction; however, this difference is not statistically significant because of the large standard deviations and small data set. Surprisingly, the data suggest that non-corporate researchers follow the corporate publication behavior. That is, they also publish more papers in subject matter areas where patents were validated and published fewer papers in areas where patents were invalidated.

One possible explanation for this observation (which would be an alternative to my theory that for-profit corporations prefer to publish papers only if their results can be protected) is that patent law is very accurately aligned to identify truly innovative ideas. So patents are more likely to be validated in areas rich with novel research ground. And patents are less likely to be invalidated in areas where only minor, trivial advances are made. However, if this were true, then there should be more total publications in valid subject matter areas than in invalid subject matter areas. My data do not exhibit any such trend. Instead, my findings are consistent with the notion that the standards of patentability do not so easily predict the productivity of research areas and that innovation continues even in the absence of patents but to a lesser degree. Rather, the productivity of a research community seems linked to its total number of contributors, and that non-corporate research does not fill the gap left by reduced corporate publications. This would suggest that corporate secrecy decreases the information available for non-corporate researchers and thereby decreases the rate of progress for the entire field.

The next section provides the details of the methodology for counting publications, patent validity decisions, and corporate authorship. Section III compares publication growth rates generally in the fields of biotechnology and software. Section IV compares publication growth rates and corporate authorship in areas where patents were upheld as valid versus areas where patents were invalidated. Section V provides conclusions.

II. METHODOLOGY

A. Patents and Publications Counts

The United States Patent & Trademark Office ("PTO") provides a classification system to count the number of patents in a subject area. In the area of biotechnology, past studies have suggested that the relevant PTO classes are 023, 047, 071, 111, 117, 127–28, 201–05, 210, 260, 422–24, 435–36, 504, 514, 516, 518, 530, 532, 534, 536, 540, 544, 546, 548–49, 552, 554, 556, 558, 560, 562, 564, 568, 570, 585, 600, 604, 606–07, 800, 930, and

987.[32] This list can be reduced to a "short list" of just 424, 435, 514, 530, 536, and 800.[33] In the area of software, past studies have suggested that the relevant PTO classes are 341, 345, 370, 375, 380–82, 700–07, 715–17, 726, and 902.[34] Some researchers have doubted the accuracy of the PTO classification system for software and therefore devised keyword searches in order to provide more accurate patent counts.[35] The keywords are provided in Table 1.

Table 1: Software patent keywords

> spec/(software OR (computer AND program)
> ANDNOT ("antigen" OR "antigenic" OR "chromatography"))
> ANDNOT ttl/("chip" OR "semiconductor" OR "bus" OR "circuit" or "circuitry")

In this paper, I extend the PTO classification approach to counting publications. For biotechnology, I performed keyword searches on the PTO classification system titles. I did this for both the "extended list" of patent classes and the "short list."[36] I conducted these keyword searches on two online databases where biotechnology publications were available and routinely used by the scientific research community: PubMed and Web of Science. For software, I again used keyword searches on the

[32] Adelman & DeAngelis, *supra* note 8, at 1741 n.244.

[33] *Id*.

[34] James Bessen, *A Generation of Software Patents*, 18 B.U. J. SCI. & TECH. L. 241, 252 (2012).

[35] James Bessen & Robert M. Hunt, *An Empirical Look at Software Patents*, 16 J. ECON. & MGMT. STRATEGY 157, 163–65 (2007).

[36] *See infra* app. tbl.1 (providing search terms used).

PTO classification system titles,[37] but I also searched the keywords suggested by past studies (provided in Table 1). I performed both of these keyword searches on Web of Science. Using this method, I was able to record the number of publications each year in biotechnology and software.

B. Court Decisions' Effects on Publications

In order to examine the effects of patent validity on publications, I searched all Federal Circuit decisions from the years 2003 to 2006 for any opinions that made a validity holding on a patent in the area of biotechnology or software.[38] I recorded the end decision, the court's basis for that determination, and the patent's subject matter keywords. I excluded any cases where the patent validity holding was reviewed by the Supreme Court of the United States. Thus, every Federal Circuit decision analyzed in my data set was a final decision.[39] Based on the subject matter keywords identified, I performed searches in the same two online databases described in the previous section and recorded the number of publications per year for the six years preceding and the six years succeeding the Federal Circuit holding. I removed from the data set any subject matter that returned a total of zero or one publication over the examined twelve-

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[37] *See infra* app. tbl.2 (providing search terms used).

[38] I searched on Westlaw for "(software & patent) and ((pharmaceutical or biotechnology) & patent)" for years 2003–2006 at the Federal Circuit. I then filtered the results for cases with a holding on patent validity.

[39] "Final" in the sense that no higher court reviewed the decision. If an invalidity decision at the district court was vacated at the Federal Circuit, I counted that as a validity holding for my analysis, and vice versa: if a validity decision at the district court was vacated at the Federal Circuit, I counted that as an invalidity holding for my analysis. Although legally the patent would not actually be invalid at that point, the decision casts doubt on the validity, and I looked for publication behavior in line with that uncertainty.

year time frame. If multiple cases dealt with the same patents, they were grouped and dated by the most recent decision. If different patents dealt with the same subject matter, they were grouped and dated by the most recent decision.

The subject matter keywords were necessarily a subjective choice based on the patent disclosures. However, patented subject matter itself varied in its breadth. Thus, while I did not expressly examine levels of granularity, my subjective choices of keywords spanned from narrow to broad subject matter simply by virtue of what the underlying patents covered. Therefore, there is little reason to suspect bias from examining only a particular level of subject matter granularity. I did, however, seek to reduce substitution effects. That is, innovation did not decrease but actually shifted slightly within the same subject matter area or field of study. Thus, I attempted, albeit subjectively, to avoid using keywords that were too narrow to categorize subject matter areas. More importantly, by examining many subject matter areas and multiple fields, my results capture the net effects of patents on the aggregate of initial and follow-on innovations.

Finally, I analyzed both the numbers of, and the percentage of, corporate authorship for publications in each of the searched subject matter areas. I performed this only for the Web of Science data sets because PubMed did not aggregate authorship information. But while Web of Science aggregated authorship information, I still had to individually identify those publications with corporate entities. For the purposes of this research, I focused on the behavior of corporate entities that were most likely to stop publishing in the absence of patent protection. Thus, I excluded not-for-profit or government entities, hospitals, clinics, research institutes, and universities on the presumption that these entities have sufficient incentive to disclose rather than hide innovation, even in the absence of patent protection. I based the corporate authorship analysis on the top one hundred authors who published the most papers in that subject matter area for the given year.

I compared all averages and standard deviations using the statistical Z-test, which provides a p-value for the likelihood that the two averages and standard deviations come from the same distribution.[40] I considered any p-value of less than 0.05 as statistically significant evidence that the two averages and standard deviations come from different distributions.

III. PATENTS AND PUBLICATIONS COUNTS

Table 2 lists the number of patents issued each year from 1990 to 2012 in the areas of biotechnology and software. Both the numbers of biotechnology and software patents increased over this time frame, regardless of the search terms used. But the total number of patents issued also increased over this time frame as well. As a relative percentage of the total, the number of biotechnology patents decreased slightly, while the number of software patents increased dramatically. So the number of biotechnology patents grew much slower than the number of software patents. This is also displayed in Figure 1. These numbers are consistent with those published by other researchers.[41]

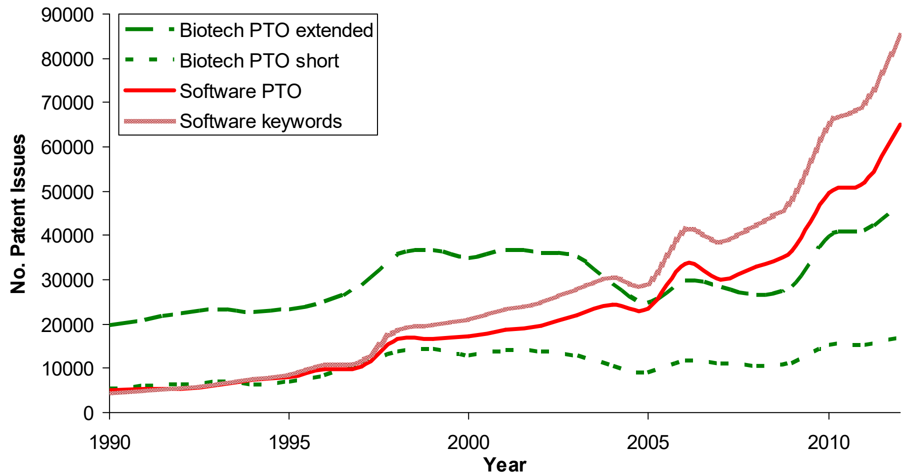
[40] $Z = (\mu_1 - \mu_2) / \text{sqrt}((\sigma_1/N_1)^2 + (\sigma_2/N_2)^2)$; then Z is converted to a p-value by Z-test data tables.

[41] Bessen & Hunt, *supra* note 35, at 169 (Bessen and Hunt exclude reissues and non-utility patents, but the differences in counts are small).

Table 2: Patent Issues From USPTO.gov (Not Excluding Reissues or Non-utility Patents)

		Biotechnology				Software			
Year	**Total (all classes)**	**PTO Extended**	**% of Total**	**PTO Short**	**% of Total**	**PTO terms**	**% of Total**	**Key words**	**% of Total**
1990	99220	19747	20%	5366	5%	4956	5%	4531	5%
1991	106840	20833	19%	5872	5%	5347	5%	5150	5%
1992	107511	22153	21%	6215	6%	5483	5%	5640	5%
1993	109890	23251	21%	6750	6%	6353	6%	6500	6%
1994	113704	22490	20%	6154	5%	7305	6%	7669	7%
1995	113955	23087	20%	6809	6%	8024	7%	8670	8%
1996	121805	24872	20%	8367	7%	9739	8%	10922	9%
1997	124147	28728	23%	11031	9%	10359	8%	11731	9%
1998	163204	35748	22%	13705	8%	16572	10%	18754	11%
1999	169145	36468	22%	14136	8%	16700	10%	19955	12%
2000	176082	34690	20%	12817	7%	17113	10%	21196	12%
2001	184045	36418	20%	14046	8%	18721	10%	23565	13%
2002	184418	35928	19%	13800	7%	19732	11%	25019	14%
2003	187047	34970	19%	12762	7%	21967	12%	27839	15%
2004	181318	29039	16%	10273	6%	24485	14%	30551	17%
2005	157741	24724	16%	9019	6%	23372	15%	29208	19%
2006	196437	29769	15%	11497	6%	33527	17%	41279	21%
2007	182928	28346	15%	10993	6%	30110	16%	38728	21%
2008	185244	26316	14%	10390	6%	33009	18%	42421	23%
2009	191933	28621	15%	11012	6%	36615	19%	48144	25%
2010	244358	39852	16%	15054	6%	49706	20%	65158	27%
2011	247728	41016	17%	15184	6%	51977	21%	69829	28%
2012	276796	46678	17%	17061	6%	65192	24%	85057	31%

Figure 1: Patent Issues from USPTO.gov (Not Excluding Reissues or Non-utility Patents).



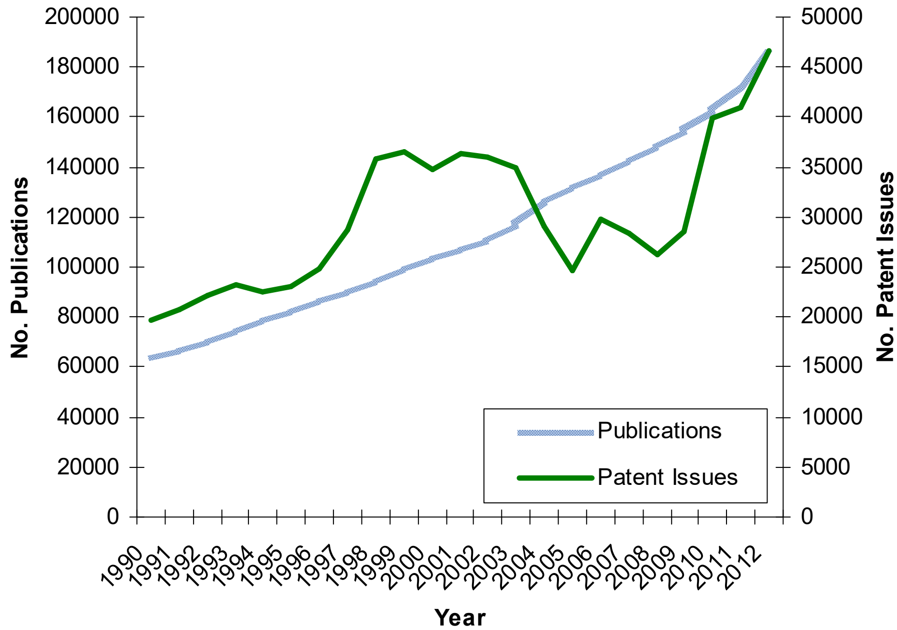
A. Biotechnology Publications

The number of biotechnology publications in PubMed and Web of Science both increased over the 1990–2012 time frame. As can be seen in Table 3, while the number of biotechnology publications increased, the relative percentage of biotechnology papers in the PubMed database only grew in the early 1990s and has remained constant since. However, Figure 2 shows that the growth in publications followed the same basic profile as the growth in patents.

Table 3: Number of Biotechnology Publications in PubMed.

Year	PubMed All	PTO Extended	% of Total	PTO Short	% of Total
1990	406754	63661	16%	51471	13%
1991	408147	66674	16%	54045	13%
1992	413439	70556	17%	57689	14%
1993	421845	74343	18%	60436	14%
1994	432674	78479	18%	64007	15%
1995	443856	82314	19%	67426	15%
1996	453795	86625	19%	70405	16%
1997	453001	89769	20%	72647	16%
1998	470700	94382	20%	76464	16%
1999	490354	99050	20%	80159	16%
2000	527998	103717	20%	83989	16%
2001	540492	106951	20%	86828	16%
2002	555776	110780	20%	89704	16%
2003	581622	116780	20%	94552	16%
2004	618667	126328	20%	102479	17%
2005	654769	132027	20%	106295	16%
2006	680824	136738	20%	109681	16%
2007	705740	142769	20%	114424	16%
2008	745128	148576	20%	118691	16%
2009	777687	154453	20%	122507	16%
2010	814821	162490	20%	129027	16%
2011	863373	172151	20%	136114	16%
2012	927493	185202	20%	145946	16%

Figure 2: Number of Biotechnology Patents Versus Biotechnology Publications in PubMed for PTO Extended Search Terms.

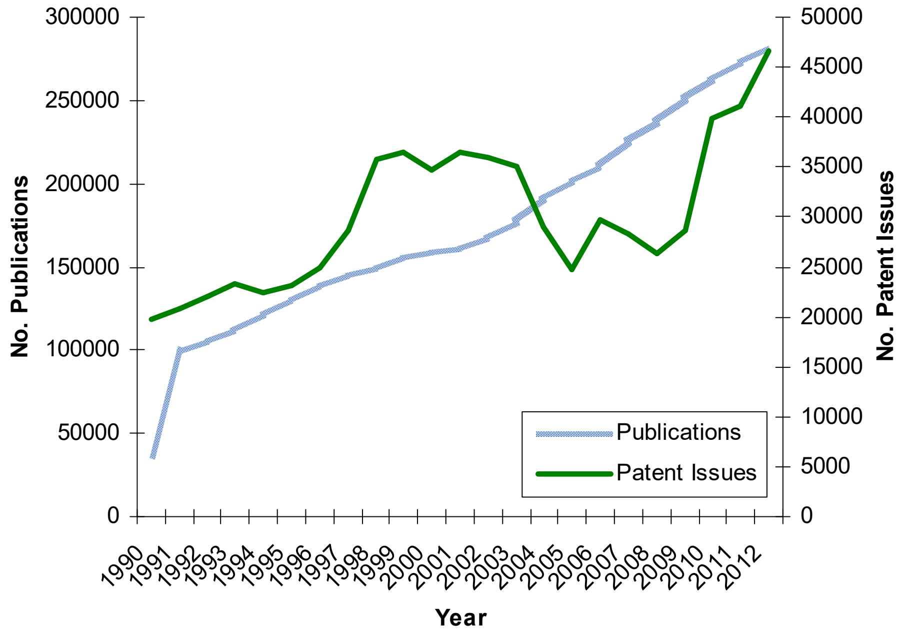


Web of Science data confirmed the same overall trends. As shown in Table 4, the number of biotechnology publications increased, but the relative percentage of biotechnology publications compared to all published papers in Web of Science has been mostly flat since the mid-1990s. Figure 3 again shows that this growth profile matched the growth of biotechnology patent issues.

Table 4: Number of Biotechnology Publications in Web of Science (WoS).

Year	WoS All	PTO Extended	% of Total	PTO Short	% of Total
1990	1006516	35933	4%	32277	3%
1991	1045357	99252	9%	88594	8%
1992	1060277	105352	10%	94060	9%
1993	1101863	112513	10%	100275	9%
1994	1160430	121573	10%	108184	9%
1995	1211401	129829	11%	115032	9%
1996	1269727	138418	11%	121572	10%
1997	1303341	144749	11%	126427	10%
1998	1315041	149696	11%	130415	10%
1999	1303426	155829	12%	135237	10%
2000	1347786	158615	12%	138142	10%
2001	1325805	161370	12%	140786	11%
2002	1372170	167640	12%	146127	11%
2003	1436869	176787	12%	154273	11%
2004	1532001	191179	12%	166581	11%
2005	1654100	201945	12%	175340	11%
2006	1739724	209985	12%	181961	10%
2007	1888946	225640	12%	193297	10%
2008	1999751	236623	12%	201762	10%
2009	2105906	250363	12%	211805	10%
2010	2051355	262329	13%	221300	11%
2011	2116602	273148	13%	230440	11%
2012	2140145	281500	13%	237230	11%

Figure 3: Number of Biotechnology Patents Versus Biotechnology Publications in Web of Science for PTO Extended Search Terms.



B. Software Publications

The number of software publications in Web of Science increased dramatically from 1990 to 2012, whether measured by PTO classification keywords or by Bessen and Hunt's software keywords. Table 5 compares these results to both the total number of publications in Web of Science and Microsoft's top one hundred software journals list.[42]

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[42] MICROSOFT ACADEMIC SEARCH, http://academic.research.microsoft.com/RankList?entitytype=4&topDomainID=2&subDomainID=0&last=0&start=1&end=100 [http://perma.cc/ML5C-VQ2Q] (last visited Nov. 25, 2015).

Table 5: Number of Software Publications in Web of Science (WoS).

Year	WoS All	PTO Terms	% of Total	Key words	% of Total	Top 100 (MSFT)[1]	% of Total
1990	1006516	3015	0%	43	0.00%	13113	1.3%
1991	1045357	14434	1%	267	0.03%	13569	1.3%
1992	1060277	16738	2%	343	0.03%	14302	1.3%
1993	1101863	17975	2%	345	0.03%	15062	1.4%
1994	1160430	20714	2%	342	0.03%	16610	1.4%
1995	1211401	22255	2%	352	0.03%	16569	1.4%
1996	1269727	27732	2%	449	0.04%	17558	1.4%
1997	1303341	34694	3%	579	0.04%	17025	1.3%
1998	1315041	37182	3%	563	0.04%	18016	1.4%
1999	1303426	36300	3%	478	0.04%	17983	1.4%
2000	1347786	40567	3%	476	0.04%	16634	1.2%
2001	1325805	41809	3%	441	0.03%	16297	1.2%
2002	1372170	45067	3%	463	0.03%	16715	1.2%
2003	1436869	51003	4%	478	0.03%	18198	1.3%
2004	1532001	56087	4%	539	0.04%	18165	1.2%
2005	1654100	62125	4%	498	0.03%	20721	1.3%
2006	1739724	68408	4%	581	0.03%	21811	1.3%
2007	1888946	76620	4%	639	0.03%	22608	1.2%
2008	1999751	82816	4%	665	0.03%	26771	1.3%
2009	2105906	91093	4%	674	0.03%	23462	1.1%
2010	2051355	87993	4%	700	0.03%	28060	1.4%
2011	2116602	93365	4%	682	0.03%	25175	1.2%
2012	2140145	99791	5%	641	0.03%	- N/A -	- N/A -

[1] Note: The Web of Science database does not actually carry all of these articles listed by Microsoft as having been published.

Figures 4–6 compare each of these measures of software publications to the growth of software patents. While the growth profiles differ slightly, each graph shows that the number of software publications has risen along with the number of software patents.

Figure 4: Number of Software Patents Versus Software Publications in Web of Science (WoS) Based on PTO Classification Terms.

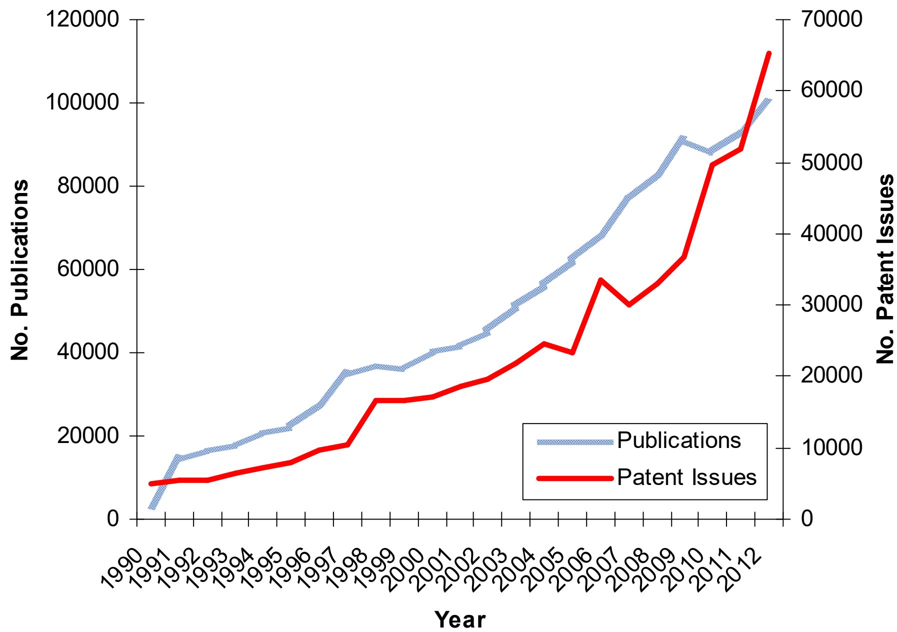


Figure 5: Number of Software Patents Versus Software Publications in Web of Science (WoS) Based on Software Keywords.

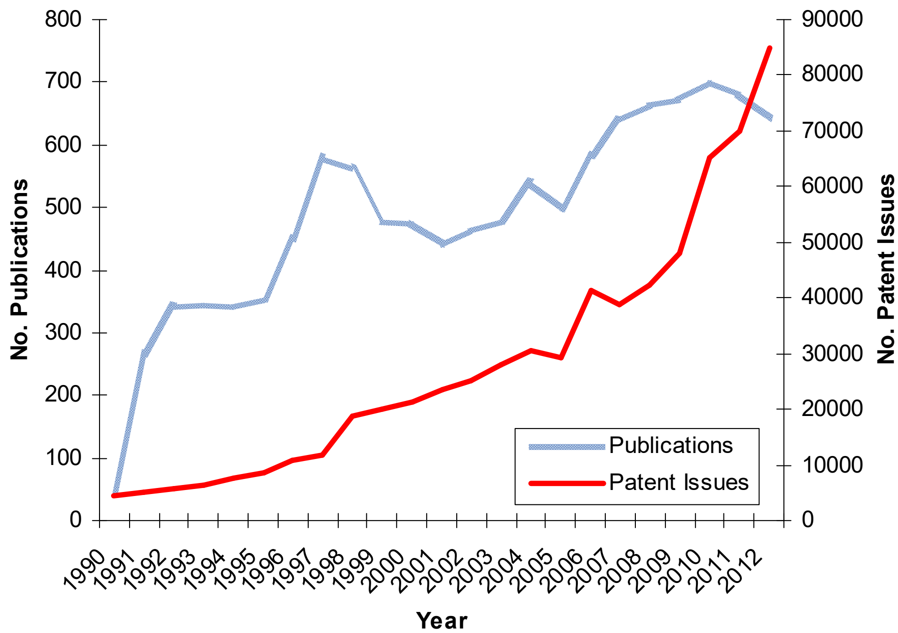
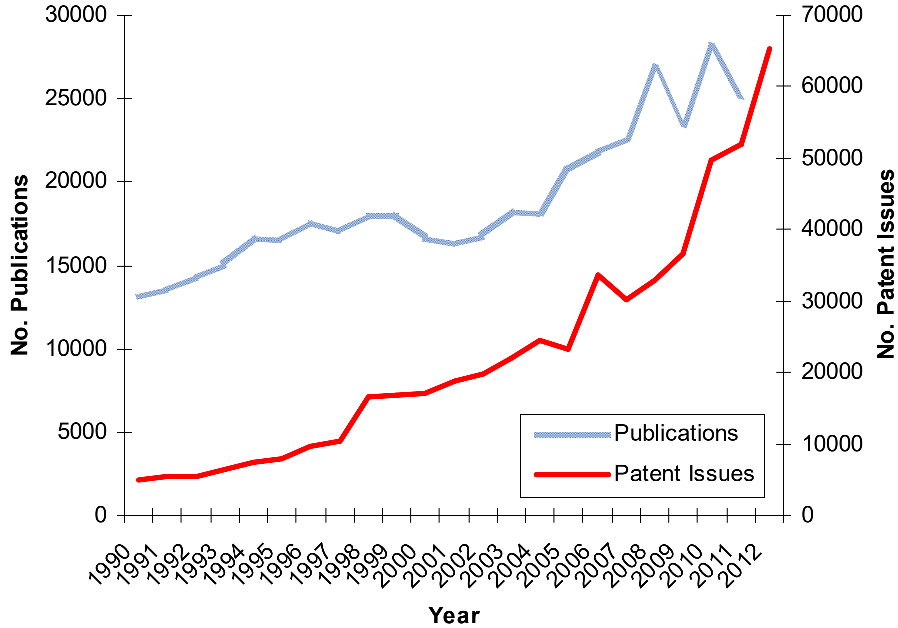


Figure 6: Number of Software Patents Based on PTO Classification Terms Versus the Number of Software Publications in Microsoft's Top 100 List.



It is possible that the number of publications available for online search in the PubMed and Web of Science databases also increased over the same time period that I searched. This could mean that the number of publications carried in the database rose but that the actual number of publications did not. More importantly, the increase in publications alongside the increase in patents does not itself reveal what would have happened in the absence of patents. I address the question of what effect patents have on publications in the next section by comparing subject matter areas where patents were invalidated to areas where patents were upheld as valid through final judgments at the Federal Circuit.

IV. COURT DECISIONS' EFFECTS ON PUBLICATIONS

Following the methodology explained in Section II.B, I found fifty-seven Federal Circuit decisions on patent validity in the area of biotechnology and fifteen in the area of software in the four years between 2003 and 2006, after excluding any cases that did not make a patent validity holding or where the patent validity holdings were reviewed later at the Supreme Court of the United States. I analyzed the patents at issue in those cases for subject matter keywords and then grouped any common subjects together. I then filtered out any subject matter areas where the keywords returned a total of either zero or one publication. The data sets are summarized in Table 6.

Table 6: The Number of Federal Circuit Decisions That Made a Patent Validity Holding, the Number of Patents at Issue in Those Cases, and the Number of Subject Matter Areas After Grouping and Filtering.

	Biotechnology	**Software**
Federal Circuit decisions	57	15
Subject matter areas (after filtering and grouping)	46 PubMed / 45 WoS[1]	12
Patents at issue (after filtering and grouping)	75 PubMed / 73 WoS[1]	26

[1] Web of Science (WoS) results differed slightly from PubMed.

A. Biotechnology Subject Matter Areas

Biotechnology is typically viewed as a capital-intensive field dependent on the productivity of highly risky research and development efforts. This section investigates the effects of patent validity on innovation as measured by research publications.

1. PubMed Results

Table 7 displays the total number of publications in the subject matter areas held valid versus those held invalid at the Federal Circuit, averaged over the six years previous to and subsequent to the Federal Circuit decision.[43] The years previous to the Federal Circuit decision represent the time period when both sets of patents were valid. The years subsequent to the Federal Circuit decision represent potential divergence in publication behavior in the subject matter areas where the patents had been invalidated or upheld as valid. It can be seen that the number of publications for subject matter areas upheld as valid grew at a slightly higher pace than for those held invalid. The difference was 35% (upheld) to 31% (invalidated). But this small difference was not statistically significant given the high standard deviations.

Table 7: PubMed Publications Averages and Standard Deviations for 2003–2006 for Aggregated Biotechnology Subject Matter Areas.

Year	**Decision**	**Avg. before**	**Avg. after**	**% Change**
2003	Valid	5063	7778	+ 54%
	Invalid	1136	1580	+ 39%
2004	Valid	59	83	+ 41%
	Invalid	426	613	+ 44%
2005	Valid	544	603	+ 11%
	Invalid	2693	2786	+ 3%
2006	Valid	2354	3197	+ 36%
	Invalid	6226	8584	+ 38%
		Totals	**Valid Avg. (Std. dev.)**	**+ 35% (±18%)**
			Invalid Avg. (Std. dev.)	**+ 31% (±19%)**
			Z-test p-value	**0.38**

[43] *See infra* app. tbls. 3–6 (providing disaggregated data).

Figures 7–10 display the publication data for each individual year previous and subsequent to the Federal Circuit decision.

Figure 7: PubMed Publications in Biotechnology Subject Matter Areas for 2003 Federal Circuit Decisions.

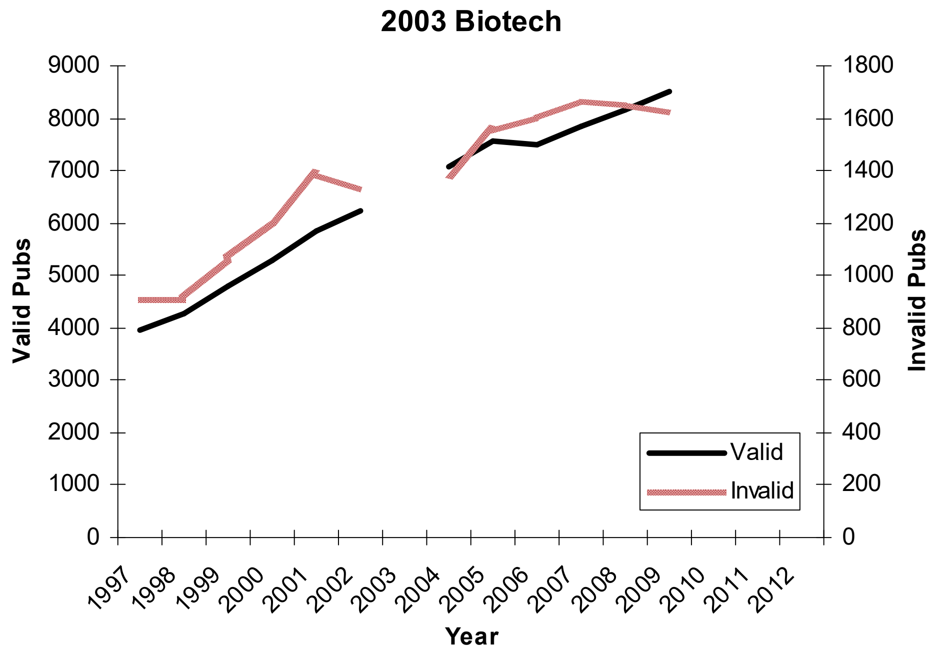


Figure 8: PubMed Publications in Biotechnology Subject Matter Areas for 2004 Federal Circuit Decisions.

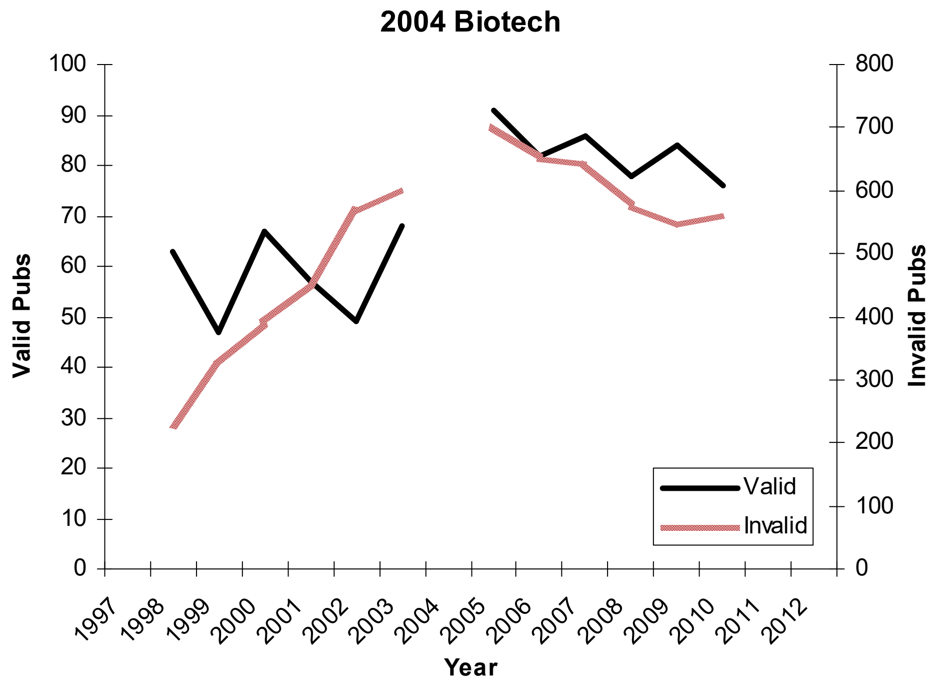


Figure 9: PubMed Publications in Biotechnology Subject Matter Areas for 2005 Federal Circuit Decisions.

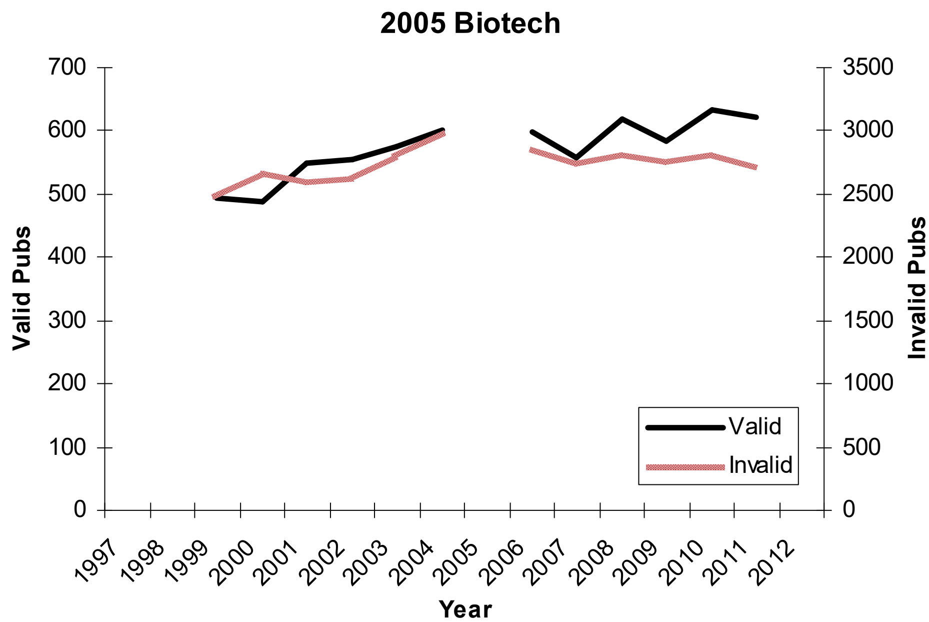
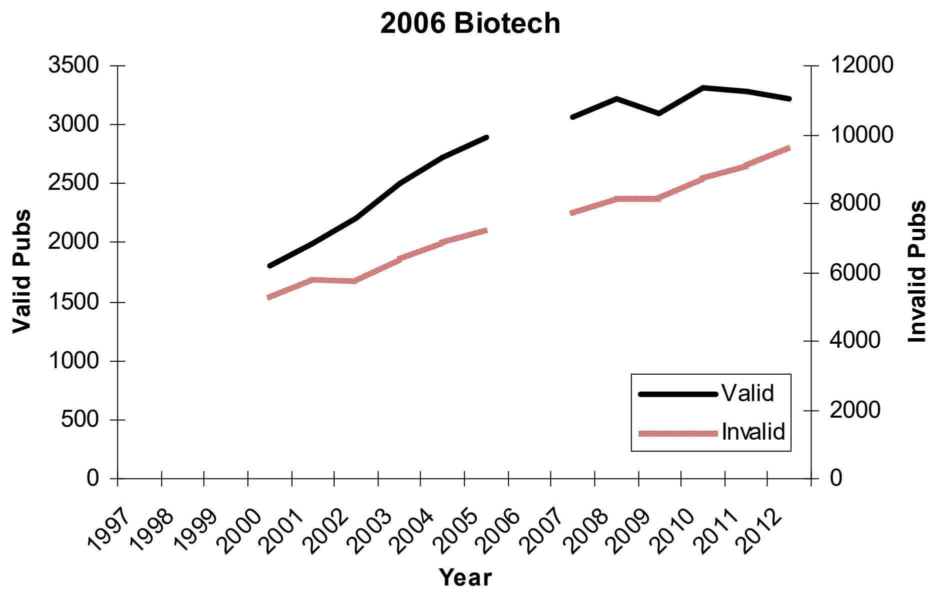


Figure 10: PubMed Publications in Biotechnology Subject Matter Areas for 2006 Federal Circuit Decisions.



Analyzing the changes in publication behavior for each subject matter, individually rather than in aggregate, produced similar results. Publications in the subject matter areas invalidated grew at a slower pace than in areas upheld as valid, but the results were still not statistically significant. The number of publications in subject matter areas upheld as valid increased by 37% while the number of publications in subject matter areas invalidated increased by only 20%. This data is provided in Table 8.

Table 8: PubMed Publications Averages and Standard Deviations for 2003–2006 for Individual Biotechnology Subject Matter Areas.

Year	Decision	Change Average	Change Std. Dev.
2003	Valid	+ 29%	± 40%
	Invalid	+ 23%	± 68%
2004	Valid	+ 44%	± 63%
	Invalid	+ 85%	± 116%
2005	Valid	+ 19%	± 25%
	Invalid	+ 11%	± 48%
2006	Valid	+ 61%	± 91%
	Invalid	- 1%	± 40%
Totals	**Valid**	**+ 37%**	**± 57%**
	Invalid	**+ 20%**	**± 64%**
	Z-test p-value	**0.17**	

2. Web of Science Results

Because Web of Science carried a different set of journals, the filtered subject matter areas differed slightly.[44] The publication counts also differed and produced more drastic results. As shown in Table 9, publications in subject matter areas upheld by the Federal Circuit grew by 51% after being upheld while publications in subject areas invalidated by the Federal Circuit actually shrank by 1% after being invalidated. Unlike the PubMed results, these results were statistically significant, as shown in Table 9.

[44] *See infra* app. tbls.7–10 (providing disaggregated data).

Table 9: Web of Science Publications Averages and Standard Deviations for 2003–2006 for Aggregated Biotechnology Subject Matter Areas.

Year	**Decision**	**Avg. before**	**Avg. after**	**% Change**
2003	Valid	2336	3253	+ 39%
	Invalid	759	641	- 16%
2004	Valid	14	29	+ 107%
	Invalid	187	133	- 29%
2005	Valid	225	317	+ 41%
	Invalid	1255	1464	+ 17%
2006	Valid	1905	2239	+ 18%
	Invalid	7645	9416	+ 23%
		Totals	**Valid Avg. (Std. dev.)**	**+ 51% (±39%)**
			Invalid Avg. (Std. dev.)	**- 1% (±25%)**
			Z-test p-value	**0.01**

Figures 11–14 display the publication data for each individual year previous and subsequent to the Federal Circuit decision.

Figure 11: Web of Science Publications in Biotechnology Subject Matter Areas for 2003 Federal Circuit Decisions.

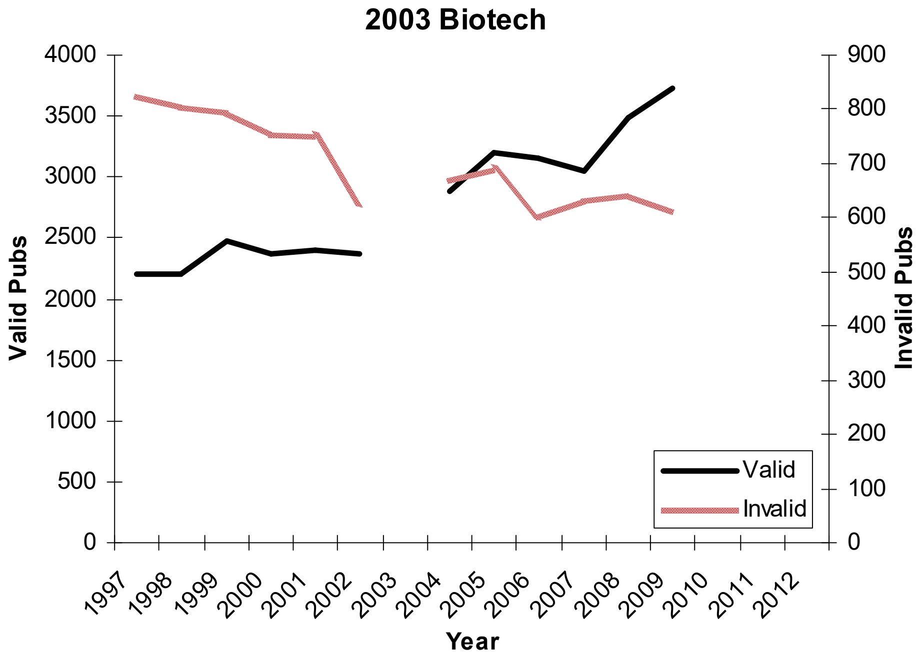


Figure 12: Web of Science Publications in Biotechnology Subject Matter Areas for 2004 Federal Circuit Decisions.

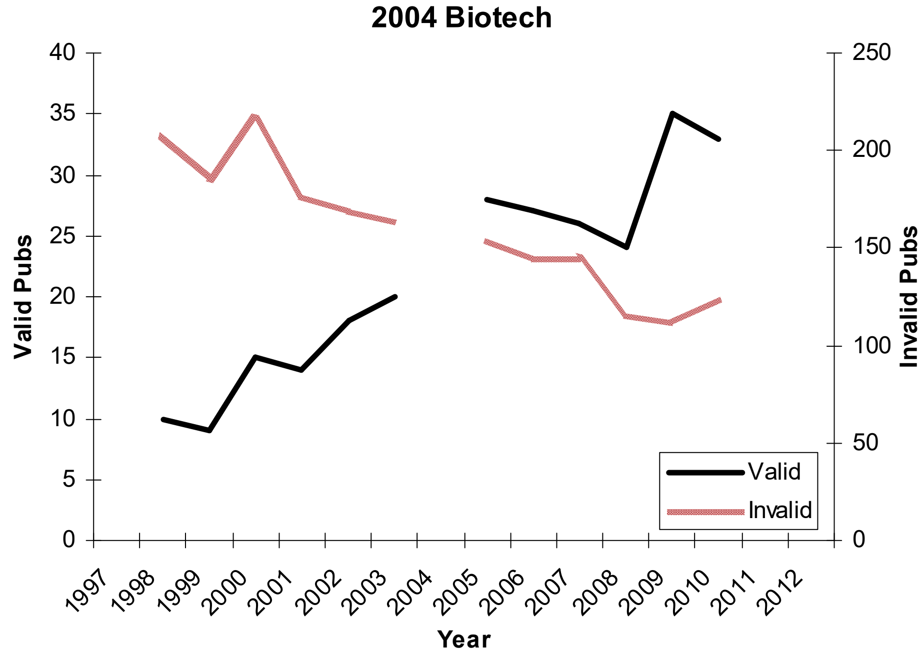


Figure 13: Web of Science Publications in Biotechnology Subject Matter Areas for 2005 Federal Circuit Decisions.

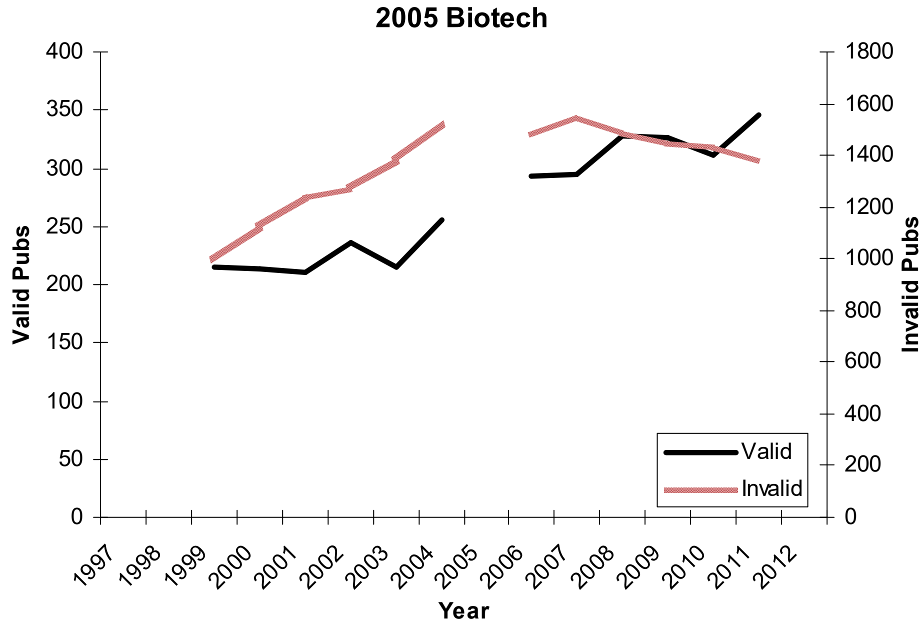
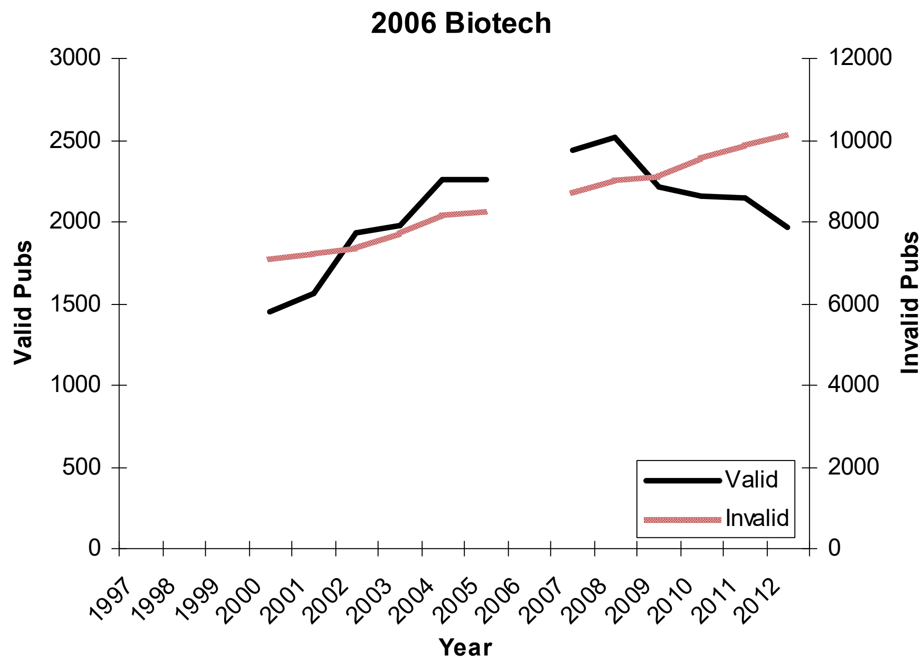


Figure 14: Web of Science Publications in Biotechnology Subject Matter Areas for 2006 Federal Circuit Decisions.



The changes in publication behavior were also evaluated for each of the subject matter areas individually. Publications in subject matter areas upheld by the Federal Circuit grew by 63% after being upheld while publications in areas invalidated by the Federal Circuit shrank by 5% after being invalidated. These results were of high statistical significance. Data are provided in Table 10.

Table 10: Web of Science Publications Averages and Standard Deviations for 2003–2006 for Individual Biotechnology Subject Matter Areas.

Year	Decision	Change Average	Change Std. Dev.
2003	Valid	+ 33%	± 49%
	Invalid	- 22%	± 45%
2004	Valid	+ 139%	± 111%
	Invalid	- 41%	± 31%
2005	Valid	+ 38%	± 35%
	Invalid	+ 25%	± 66%
2006	Valid	+ 83%	± 113%
	Invalid	- 6%	± 22%
Totals	**Valid**	**+ 63%**	**± 82%**
	Invalid	**- 5%**	**± 45%**
	Z-test p-value	**< 0.001**	

As described in Section I, corporate decisions are influenced by litigation outcomes because bottom lines are directly affected. Once corporations realize that patents no longer protect a particular subject matter area, they lose the incentive to disclose innovation in the field. They may well lose the incentive to innovate at all, or they may continue to innovate in secret if the end product or service is profitable. This not only has the negative effect of causing corporations to duplicate research, but non-corporate entities additionally lose disclosure benefits from corporate advancements. The data in Tables 11–12 of corporate authorship confirm this hypothesized mechanism. Corporations publish less overall in subject matter areas that have been invalidated than in areas that have been upheld as valid by the Federal Circuit. This is true whether the data are viewed in aggregate or by individual subject matter areas.

Table 11: Web of Science Publications Averages and Standard Deviations for 2003–2006 for Aggregated Biotechnology Subject Matter Areas Authored by Corporations.

Year	Decision	Avg. before	Avg. after	% Change	% Corp. before	% Corp. after	Change in % Corp.
2003	Valid	187	139	- 26%	8%	5%	- 3%
	Invalid	58	39	- 33%	7%	5%	- 2%
2004	Valid	7	7	+ 0%	19%	9%	- 10%
	Invalid	16	6	- 63%	6%	4%	- 2%
2005	Valid	39	35	- 10%	9%	7%	- 2%
	Invalid	85	61	- 28%	6%	4%	- 2%
2006	Valid	261	223	- 15%	14%	10%	- 4%
	Invalid	232	152	- 34%	4%	2%	- 2%
	Totals	**Valid Avg. (Std. dev.)**		**- 13% (±11%)**	**Valid Avg. (Std. dev.)**		**- 5% (±4%)**
		Invalid Avg. (Std. dev.)		**- 39% (±16%)**	**Invalid Avg. (Std. dev.)**		**- 2% (±0%)**
		Z-test p-value		**< 0.004**	**Z-test p-value**		**0.07**

Corporations publish about 13% less in subject matter areas after they were upheld as valid but about 39% less in areas after they were invalidated. When subject matter areas were analyzed individually in Table 12, the results were even more drastic: a 44% increase compared to a 21% decrease. Both of these results are statistically significant. However, the percentage of papers authored by corporations decreased for the subject matter areas that were upheld as valid as compared to the areas that were invalidated when the data are viewed in aggregate. The percentage held constant when the data are viewed by individual subject matter areas. One would expect that if corporations decreased their publication counts after patents were invalidated then the percentage of corporate authorship would decrease significantly as compared to the case where patents were validated. However, I found that the difference was not statistically significant. In fact, at a non-significant level, there is an opposite effect. This means that non-corporate entities actually follow corporate publication behavior and publish less in subject matter areas after patents are invalidated. One possible explanation is that non-corporate research derives significant value from the progress made and disclosed by corporations. After subject matter areas are invalidated by the Federal Circuit, corporations may stop disclosing information either through their own publications or through other types of communications, collaborations, and disclosures. While corporate publications are a smaller percentage of the total disclosures, they may nonetheless contain important information (for example, because corporations are much closer to the immediate needs of the market). Thus, non-corporate entities may publish less when they are deprived of the flow of important information from corporations' valid patents. This would also suggest that non-corporate research does not fill the research gaps created by corporate non-disclosure. Rather, the entire field of research gains or suffers together based on the total number of contributors.

Table 12: Web of Science Publications Averages and Standard Deviations for 2003–2006 for Individual Biotechnology Subject Matter Areas Authored by Corporations.

Year	Decision	Change Avg.	Change Std. Dev.	Change in % Corp. Average	Change in % Corp. Std. Dev.
2003	Valid	+ 12%	± 96%	+ 0%	± 7%
	Invalid	- 27%	± 51%	- 4%	± 8%
2004	Valid	+ 90%	± 210%	- 11%	± 15%
	Invalid	- 64%	± 28%	- 3%	± 2%
2005	Valid	- 9%	± 50%	- 3%	± 8%
	Invalid	+ 5%	± 60%	+ 0%	± 3%
2006	Valid	+ 120%	± 229%	- 1%	± 4%
	Invalid	- 24%	± 36%	- 3%	± 3%
Totals	**Valid**	**+ 44%**	**± 148%**	**- 3%**	**± 9%**
	Invalid	**- 21%**	**± 49%**	**- 3%**	**± 5%**
	p-value	**< 0.03**	**p-value**	**0.50**	

These results are consistent with the theory that patents encourage innovation. While the results are only statistically significant for the Web of Science data, the PubMed data demonstrate similar trends. At the very least, it seems apparent that patents did not have a negative effect on innovation. Although, an alternative explanation might be that patents tend to be validated in subject matter areas where truly novel advances are made and tend to be invalidated in areas where minor, trivial advances are made. Areas where truly novel advances are made might have been more "fertile" for new discovery and thus resulted in more publications. This could mean that patent law is well aligned to encourage truly novel advances. But if this is true, we should expect to see a higher total number of publications in valid subject matter areas than in invalid subject matter areas. However, in both the PubMed and Web of Science data, the opposite is true. As can be seen in Tables 7 and 9, there are more publications in the areas that were eventually invalidated than in the areas that were upheld as valid during the time period when both sets of patents were valid. It is hard to believe that the Court's validity decisions on average occurred right at the inflection point of an invalid subject matter area's research productivity. Rather, this data is more consistent with the notion that the Court's determination of validity influences a subject matter area's productivity but does not predict it. The relative decrease of publications in invalid subject matter areas combined with the relatively higher total number of publications is also consistent with the theory that innovation occurs even without patents but to a lesser degree than with patents.

But as mentioned earlier, biotechnology is typically viewed as an area where patents are likely to be more important to incentivize the highly risky research and development efforts upon which the industry relies. The next section investigates an area thought to be on the other side of the spectrum.

B. Software Subject Matter Areas

Software is considered by many to be an area that does not need patents to stimulate innovation. In this section, I present the analogous data collection and analysis similar to Section IV.A. Unfortunately, there are significantly fewer validity decisions made by the Federal Circuit between 2003 and 2006. Table 13 summarizes these publication data.[45]

Table 13: Web of Science Publications Averages and Standard Deviations for 2003–2006 for Aggregated Software Subject Matter Areas.

Year	Decision	Average pubs. before	Average pubs. after	% Change
2003	Valid	38	69	+ 82%
	Invalid	0.83	0.17	- 80%
2004	Valid	0.5	1.0	+ 100%
	Invalid	No data	No data	No data
2005	Valid	32	66	+ 106%
	Invalid	587	1169	+ 99%
2006	Valid	5.7	11	+ 83%
	Invalid	41	99	+ 141%
		Totals	**Valid**	**+ 93% (±12%)**
			Invalid	**+ 54% (±117%)**
			Z-test p-value	**0.28**

Publications in subject matter areas upheld by the Federal Circuit grew by 93% after being upheld while publications in subject areas invalidated by the Federal Circuit grew by 54% after being invalidated. So, while the publications increased in both cases, publications increased

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[45] *See infra* app. tbls.11–14 (providing disaggregated data).

more for subject matter areas with validated patents. However, these results were not statistically significant.

Figures 15–18 display the annual publication data prior and subsequent to Federal Circuit decisions.

Figure 15: Web of Science Publications in Software Subject Matter Areas for 2003 Federal Circuit Decisions.

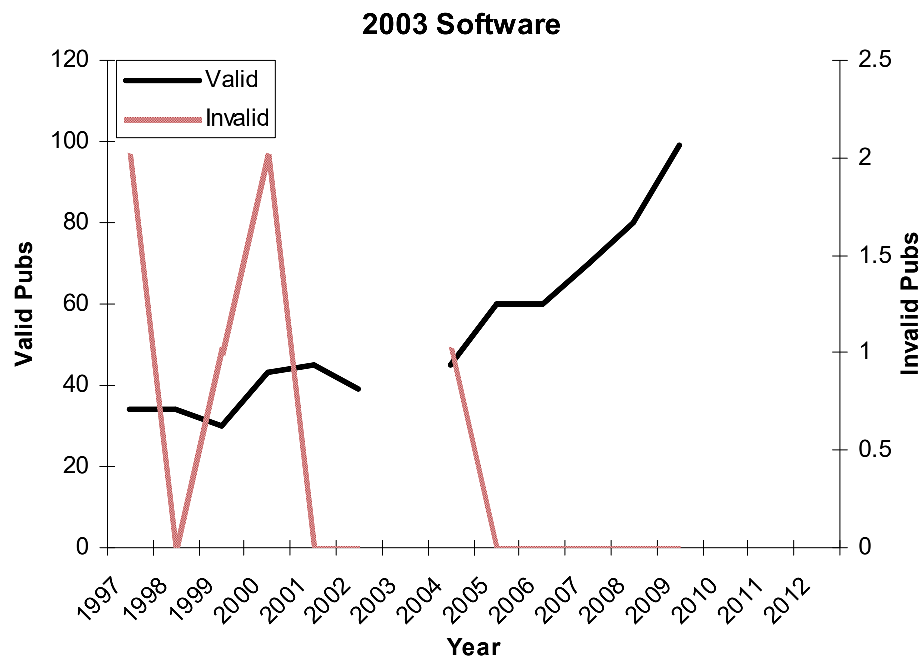


Figure 16: Web of Science Publications in Software Subject Matter Areas for 2004 Federal Circuit Decisions.

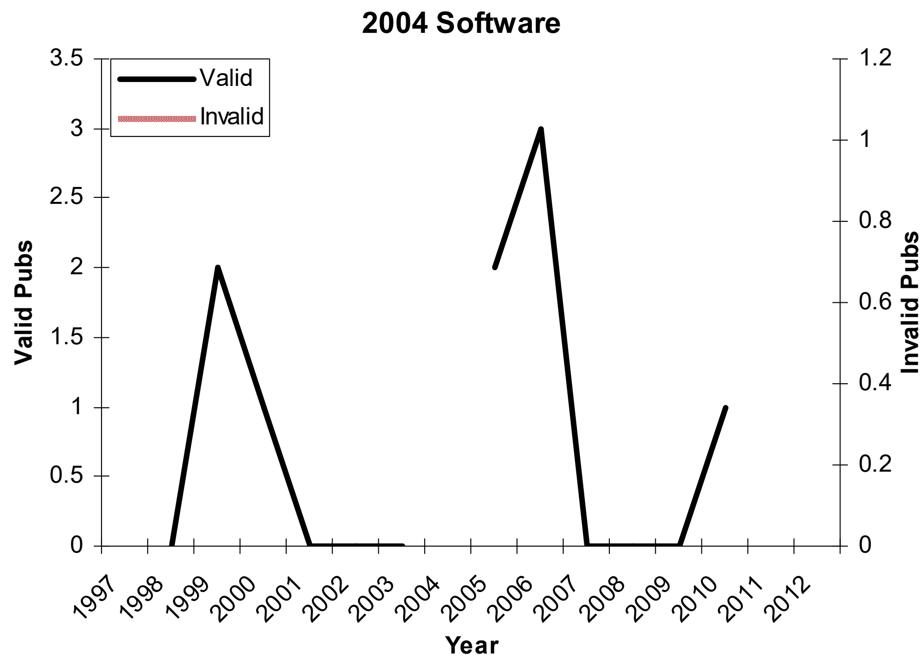


Figure 17: Web of Science Publications in Software Subject Matter Areas for 2005 Federal Circuit Decisions.

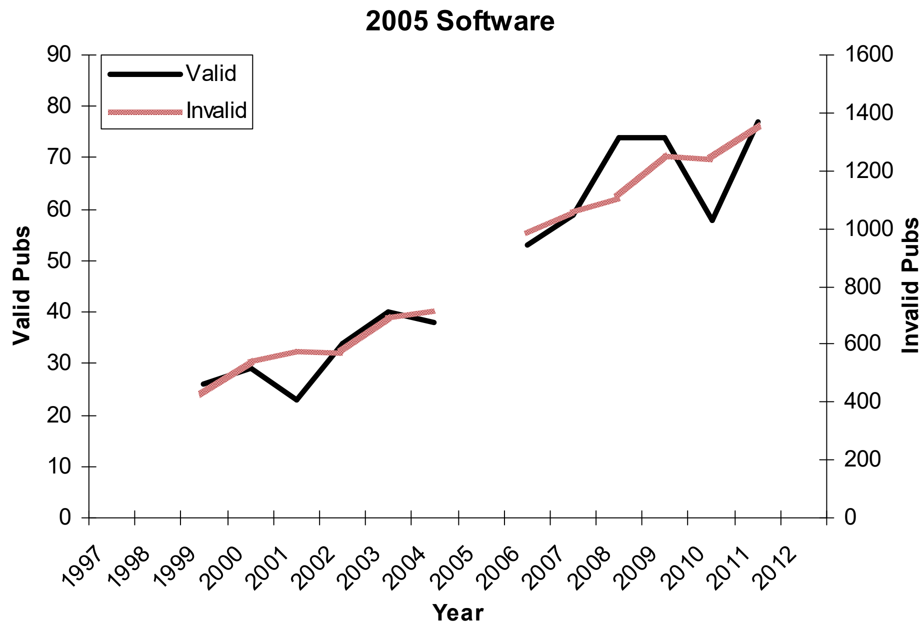
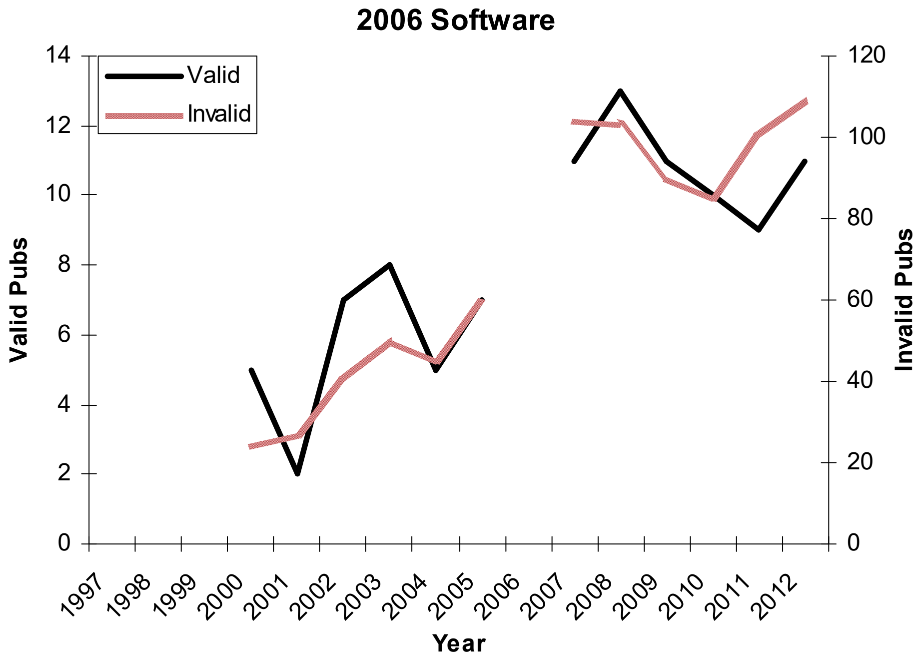


Figure 18: Web of Science Publications in Software Subject Matter Areas for 2006 Federal Circuit Decisions.



Changes in publication behavior were also evaluated for each subject matter area individually. The average differences were about the same and the standard deviations remained high. Publications in subject matter areas upheld by the Federal Circuit grew by 82% after being upheld while publications in areas invalidated by the Federal Circuit grew by 59% after being invalidated. However, there were too few data points to determine any statistically significant result given the high standard deviations. This data is provided in Table 14.

Table 14: Web of Science Publications Averages and Standard Deviations for 2003–2006 for Individual Software Subject Matter Areas.

Year	Decision	Change Average	Change Std. Dev.
2003	Valid	+ 43%	± 73%
	Invalid	- 80%	Only 1 data point
2004	Valid	+ 100%	Only 1 data point
	Invalid	No data	No data
2005	Valid	+ 107%	± 13%
	Invalid	+ 73%	± 50%
2006	Valid	+ 91%	Only 1 data point
	Invalid	- 141%	Only 1 data point
Totals	**Valid**	**+ 82%**	**± 45%**
	Invalid	**+ 59%**	**± 83%**
	Z-test p-value	**0.27**	

Again, I looked at the behavior of corporate research authorship. The data in Tables 15–16 for corporate authorship seem to confirm that corporations publish less overall in subject matter areas that have been invalidated than in areas that have been upheld as valid by the Federal Circuit. This is true whether the data was viewed in aggregate or by individual subject matter areas. Unfortunately, due to the small data set relative to the standard deviations, these results again lacked statistical significance.

Table 14: Web of Science Publications Averages and Standard Deviations for 2003–2006 for Aggregated Software Subject Matter Areas Authored by Corporations.

Year	Decision	Avg. pubs. before	Avg. pubs. After	% Change	% Corp. before	% Corp. after	Change in % Corp.
2003	Valid	7.7	5.5	- 25%	16%	6%	- 10%
	Invalid	0.2	0	- 100%	9%	0%	- 9%
2004	Valid	0.2	0.7	+ 250%	67%	25%	- 42%
	Invalid	No data	No data	No data	No data	No data	No data
2005	Valid	4.2	6.2	+ 50%	8%	5%	- 3%
	Invalid	19	11	- 42%	4%	1%	- 3%
2006	Valid	2.2	1.5	- 32%	26%	9%	- 17%
	Invalid	9	12	+ 33%	15%	9%	- 6%
	Totals	**Valid**		**61% (±131%)**	**Valid Avg. (Std. dev.)**		**- 18% (±17%)**
		Invalid		**- 36% (±67%)**	**Invalid Avg. (Std. dev.)**		**-6% (±3%)**
		Z-test p-value		**0.09**	**Z-test p-value**		**0.08**

As was the case in biotechnology, the percentage of papers authored by corporations actually decreased more for the subject matter areas that were upheld as valid compared to the areas that were invalidated. This is true whether the data are viewed in aggregate or by individual subject matter areas. These results are even more pronounced than in the case of biotechnology when they are analyzed by individual subject matter areas that were statistically significant. As before, it is unexpected that non-corporate entities follow corporate publication behavior. There are also less publications in subject matter areas where patents were invalidated. It appears that, even more so than in the field of biotechnology, fewer corporate disclosures and publications slowed the research and progress of non-corporate software advancements. Again, it would seem that non-corporate research publications do not fill the gap left by corporate non-disclosure. More interestingly, when patents are held valid, the percentage of corporate authorship decreases more than when patents are held invalid. This is a statistically significant result when analyzed by individual subject matter areas; non-corporate entities publish more in subject matter areas where patents are upheld as valid. This again suggests that the entire field of research gains or suffers together.

Table 15: Web of Science Publications Averages and Standard Deviations for 2003–2006 for Individual Software Subject Matter Areas Authored by Corporations.

Year	Decision	Change Avg.	Change Std. Dev.	Change in % Corp. Avg.	Change in % Corp. Std. Dev.
2003	Valid	- 47%	± 44%	- 16%	± 14%
	Invalid	- 100%	Only 1 data point	- 9%	Only 1 data point
2004	Valid	+ 0%	Only 1 data point	- 42%	Only 1 data point
	Invalid	No data	No data	No data	No data
2005	Valid	+ 65%	± 67%	- 3%	± 4%
	Invalid	+ 4%	± 89%	0%	± 5%
2006	Valid	- 31%	Only 1 data point	- 17%	Only 1 data point
	Invalid	+ 28%	Only 1 data point	- 12%	Only 1 data point
Totals	**Valid**	**+ 1%**	**± 64%**	**- 16%**	**± 16%**
	Invalid	**- 10%**	**± 82%**	**- 3%**	**± 5%**
	Z-test p-value	**0.40**	**Z-test p-value**	**< 0.03**	

As discussed earlier, an alternative explanation might be that patents tend to be validated in subject matter areas where truly novel advances are made and tend to be invalidated in areas where minor, trivial advances are made. However, if this is true, we should expect to see more publications in valid subject matter areas than in invalid subject matter areas. Again, as can be seen in Table 13, there are more publications in subject matter areas that are invalidated than in subject matter areas that are upheld as valid during the time period when both sets of patents remained valid. There is no statistically significant (or even statistically insignificant) data to suggest anything contrary to the conventional theory that innovation occurs with or without patents, but to a lesser degree without patents.

So, despite the traditional thought that biotechnology and software reside on different ends of the spectrum as far as the importance of patents on innovation, the publication data suggest that both fields may be more characteristically similar than previously thought. While only statistically significant for about half of the biotechnology data, all of the results are consistent at a non-statistically significant level with the hypothesis that the amount of innovation disclosed through publication decreases in subject matter areas where patents are held invalid compared to areas where patents are upheld as valid.

V. CONCLUSIONS

Progress in science and the useful arts is best measured by the direct and immediate outcome of research and development: publication in a peer-reviewed journal. Not every research dollar of input will produce an output. Not every advancement will produce a product or service that can be commercialized. Nor will every advancement be worthy of a patent. But all of these advancements are sought to be encouraged by the patent system. A publication in a peer-reviewed journal ensures at a minimum that the advancement is sufficiently novel and innovative to warrant public disclosure. And public disclosure of innovation is the goal of the patent system.

In this paper, I present a method to assess the effects of patents on innovation by examining publication behavior over time in subject matter areas where patents are invalidated versus areas where patents are upheld as valid at the Federal Circuit. I researched this publication behavior in two fields where the role of patents has been hotly debated: biotechnology and software. As the number of patents grew in both of these areas over the past two decades, I found that publications in these two areas have grown at about the same rate. More importantly, I found that publications grew at a faster rate in subject matter areas after patents were upheld as valid by the Federal Circuit than in areas where patents were invalidated by the Federal Circuit. In biotechnology, the difference in publication behavior was as much as a 63% growth in subject matter areas after being held valid compared to a 5% reduction in subject matter areas after being held invalid. The results were statistically significant when based on Web of Science publications but were not statistically significant when based on PubMed publications. In software, the difference in publication behavior was as much as a 93% growth in subject matter areas after being held valid compared to a 54% growth in subject matter areas after being held invalid. However, these results based on Web of Science publications were not statistically significant. An important caveat is that publication behavior could also be affected by patents expiring or being licensed, but neither of these was considered here.

In both biotechnology and software, corporations published much more in subject matter areas upheld as valid compared to subject matter areas held as invalid. In biotechnology, this difference was as great as a 44% growth compared to a 21% reduction, which was statistically significant. In software, this difference was as great as a 61% growth compared to a 36% reduction, which was not statistically significant given the large standard deviations and small data set. In both biotechnology and software, non-corporate publications did not fill the gap left by reduced corporate publications. This would suggest that corporate secrecy decreased the information available for non-corporate researchers and thereby decreased the rate of progress for the entire field. Interestingly, and more salient in the field of software, non-corporate entities also seem to publish more in subject matter areas after patents are upheld as valid. This is a statistically significant and unexpected result that non-corporate research and corporate research are perhaps more closely linked than previously thought. But conceptually, it makes sense that progress in a field would be linked to the number of contributors to research and innovation.

My results contradict what past studies using citation rates have reported about the general effects of patents on innovation. But, since my results are based on actual measured progress in subject matter areas (rather than a mere proxy), they represent a more meaningful metric. But my results do not necessarily contradict studies that show a reduction of follow-on work, as my goal was to examine the aggregate of initial and follow-on innovation. I do not suggest that in all subject matter areas, patents always encourage net innovation. My results describe effects broadly across an entire field (e.g., biotechnology or software), but individual subject matter areas may diverge from the average. For future studies, larger data sets would provide more robust correlations. Also, testing the effects of varying breadth in the choice of subject matter keywords has potential as a valuable area of future study. Based on this research, patents appear to encourage rather than discourage innovation as measured by publications in both biotechnology and software. Even where the differences are not statistically significant, at the very least, patents have not decreased innovation in either biotechnology or software.

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APPENDIX

Table 1: Keywords Searches Based on PTO Classifications for Biotechnology.

(A) PubMed

(1) PTO Short list

(((((((drug[Title/Abstract]) OR bio-affecting[Title/Abstract]) OR body treating[Title/Abstract]) OR molecular biology[Title/Abstract]) OR microbiology[Title/Abstract]) OR peptide[Title/Abstract]) OR protein*[Title/Abstract]) OR multicellular living organisms[Title/Abstract]*

(2) PTO Extended list

((((((((((drug[Title/Abstract]) OR bio-affecting[Title/Abstract]) OR body treating[Title/Abstract]) OR molecular biology[Title/Abstract]) OR microbiology[Title/Abstract]) OR peptide[Title/Abstract]) OR protein*[Title/Abstract]) OR multicellular living organisms[Title/Abstract]) OR surgery[Title/Abstract]) OR peptide sequence[Title/Abstract]) OR protein sequence[Title/Abstract]*

(B) Web of Science

(1) PTO Short list

Topic=(drug) OR Topic=(bio-affecting) OR Topic=(body treating) OR Topic=(molecular biology) OR Topic=(microbiology) OR Topic=(peptide) OR Topic=(protein*) OR Topic=(multicellular living organisms)*

(2) PTO Extended list

Topic=(drug) OR Topic=(bio-affecting) OR Topic=(body treating) OR Topic=(molecular biology) OR Topic=(microbiology) OR Topic=(peptide) OR Topic=(protein*) OR Topic=(multicellular living organisms) OR Topic=(surgery) OR Topic=(peptide sequence) OR Topic=(protein sequence)*

Table 2: Keywords Searches for Software.

Web of Science

(1) PTO terms

Topic=(coded data generation) OR Topic=(computer graphics processing) OR Topic=(multiplex communications) OR Topic=(digital communications) OR Topic=(cryptography) OR Topic=(signal processing) OR Topic=(image analysis) OR Topic=(data processing) OR Topic=(computer aided design) OR Topic=(information security) OR Topic=(electronic funds transfer)

(2) Bessen and Hunt keywords

Topic=(software) AND Topic=(computer program) NOT Topic=(antigen*) NOT Topic=(chromatography) NOT Topic=(chip) NOT Topic=(semiconductor) NOT Topic=(bus) NOT Topic=(circuit*)

Table 3: PubMed Publications for Biotechnology Validity Decisions at the Federal Circuit from 2003.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
Swedish mutation, asparagine and leucine, transgenic rodents	3164	5374	70%	Valid	102	2
Arg-Gly-Asp, RGD peptide	178	249	40%	Valid	102	4

Keywords	**Pubs. Before[1]**	**Pubs. After[2]**	**Change**	**Decision**	**Issue[3]**	**No. Patents**
alendronic acid, alendronate salt, Fosamax, 4-amino-1-hydroxybutane-1,1-biphosphonic acid	143	257	80%	Valid	102	1
omeprazole, alkaline omeprazole, Prilosec	513	393	-23%	Valid	102, 103	2
cefpodoxime proxetil, Vantin, thiazolylacetamido cephalosporin	6.17	5.67	-8%	Valid	102, 103	1
paclitaxel, taxus brevifolia, Taxol	1045	1485	42%	Valid	ineq cond	1
hemodialysis shunts, measuring shunt blood flow	14.2	14.5	2%	Valid	ineq cond	1
descarbethoxylorati dine, DCL	15.7	38.3	145%	Invalid	102	1
loperamide OR simethicone	44.8	58.0	29%	Invalid	103	4
biologically active fibrinogen, transgenic animal producing fibrinogen, cDNA fibrinogen	23.2	21.8	-6%	Invalid	103	1
Taxol	1028	1445	40%	Invalid	ineq cond	2
computer graphics and stereotactic surgery	1.50	0.83	-44%	Invalid	102, 103, 112¶2 (part. point out)	2
dialysis recirculation	22.2	16.3	-26%	Invalid	102	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.

Table 4: PubMed Publications for Biotechnology Validity Decisions at the Federal Circuit from 2004.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
amorphous cefuroxime axetil, Ceftin	23.3	16.7	-29%	Valid	102, 103 112¶2 (indef)	2
controlled release naproxen, Naprelan	2.33	4.67	100%	Valid	102	1
transdermal administration of fentanyl, skin permeable fentanyl	30.2	58.5	94%	Valid	102, 103	1
hydrocodone and ibuprofen, Vicoprofen	2.67	3.00	13%	Valid	103	1
prostaglandin H synthase-2 inhibitor, PGHS-2 inhibitor	342	538	57%	Invalid	112¶1 (WD)	1
cytotoxic effect of tumor necrosis factor	83.0	70.7	-15%	Invalid	112¶1 (WD)	1
malignant tumor treatment with platinum coordination compounds	1.33	4.17	213%	Invalid	obvi-type double patenting	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.

Table 5: PubMed Publications for Biotechnology Validity Decisions at the Federal Circuit from 2005.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
antifungal capsule, antifungal bead core, itraconazole antifungal drug	309	336	9%	Valid	102	1
topical skin application of fatty acid ester of ascorbic acid, ascorbyl fatty acid ester	2.83	4.50	59%	Valid	102, obvi-type double patenting	2
fluoxetine treatment AND premenstrual syndrome, selective serotonin re-uptake inhibitors	45.2	42.7	-6%	Valid	103	1
topical glaucoma medication, "13,14-dihydro-15-keto-17-phenyl-18,19,20-trinot PGF2a isopropyl ester", Xalatan	136	148	9%	Valid	ineq cond	2
leuprolide in biodegradable polymer	0.50	0.50	0%	Valid	ineq cond	2
pulse oximeter	51.0	71.5	40%	Valid	102, 112¶2 (indef), ineq cond	4

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
angiotensin converting enzyme inhibitors with metal-containing stabilizer and saccharide, ACE inhibitors with metal-containing stabilizer and saccharide, Accupril, quinapril	39.0	23.0	-41%	Invalid	112¶1 (EN)	1
expressed sequence tags	647	681	5%	Invalid	101 (util), 112¶1 (EN)	1
biosynthetic human growth hormone, human growth hormone from recombinant DNA and E.Coli	1340	1237	-8%	Invalid	102, ineq cond	1
paroxetine hydrochloride hemihydrate	269	250	-7%	Invalid	102	1
vitamin B12 with folic acid, vitamin B12 with folic acid and vitamin B6	236	273	16%	Invalid	102	2
spine bone screws	161	323	100%	Invalid	103	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.

Table 6: PubMed Publications for Biotechnology Validity Decisions at the Federal Circuit from 2006.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
35S cauliflower mosaic virus promoter, CaMV 35S promoter	86.0	70.2	-18%	Valid	112¶1 (WD/EN)	4
olanzapine	399	450	13%	Valid	102, 103, ineq cond	1
clopidogrel bisulfate	280	873	212%	Valid	102, 103, obvi-type double patenting	1
erythropoietin, recombinant erythropoietin, erythropoietin glycoprotein	893	1052	18%	Valid [4]	102, 103	3
controlled release oxycodone	12.3	28.8	134%	Valid	ineq cond	3
low molecular weight herapin, Debrie LMWH	683	724	6%	Valid	ineq cond	2
making paroxetine	2.67	3.50	31%	Invalid	102	1

Keywords	**Pubs. Before[1]**	**Pubs. After[2]**	**Change**	**Decision**	**Issue[3]**	**No. Patents**
human parathyroid hormone binding, hPTH binding	91.8	83.5	-9%	Invalid	102	1
anesthetic sevoflurane, sevoflurane with water, sevoflurane with lewis acid inhibitor	286	311	9%	Invalid	102	1
riluzole, glutamate antagonist, antiglutamate for amyotrophic lateral sclerosis	2030	1895	-7%	Invalid	102	1
controlled release oxybutynin	8.83	5.67	-36%	Invalid	103	1
extended release clarithromycin, extended release erythromycin derivative	4.50	1.67	-63%	Invalid	103	1
screening protein inhibitor, screening protein activator	3676	6159	68%	Invalid	ineq cond	4
1-deamino-8-D-arginine vasopressin, DDAVP	127	126	-1%	Invalid	ineq cond	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.
[4] 3 patents were valid; 1 was invalid.

Table 7: Web of Science Publications for Biotechnology Validity Decisions at the Federal Circuit from 2003.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
Swedish mutation, asparagine and leucine, transgenic rodents	208	285	37%	Valid	102	2
Arg-Gly-Asp, RGD peptide	239	323	35%	Valid	102	4
alendronic acid, alendronate salt, Fosamax, 4-amino-1-hydroxybutane-1,1-biphosphonic acid	9.83	16.7	69%	Valid	102	1
omeprazole, alkaline omeprazole, Prilosec	613	448	-27%	Valid	102, 103	2
improved form 1 ranitidine	0.17	1.17	100%	Valid	103	1
cefpodoxime proxetil, Vantin, thiazolylacetamido cephalosporin	10.3	9.33	-10%	Valid	102, 103	1
paclitaxel, taxus brevifolia, Taxol	1177	2110	79%	Valid	ineq cond	1
hemodialysis shunts, measuring shunt blood flow	79.2	60.2	-24%	Valid	ineq cond	1
descarbethoxylorati dine, DCL	53.0	60.3	14%	Invalid	102	1
loperamide OR simethicone	46.3	59.3	28%	Invalid	103	4
biologically active fibrinogen, transgenic animal producing fibrinogen, cDNA fibrinogen	24.2	19.5	-19%	Invalid	103	1
taxol	615	489	-20%	Invalid	ineq cond	2

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
computer graphics and stereotactic surgery	1.00	0.00	-100%	Invalid	102, 103, 112¶2 (part. point out)	2
dialysis recirculation	20.2	13.2	-35%	Invalid	102	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.

Table 8: Web of Science Publications for Biotechnology Validity Decisions at the Federal Circuit from 2004.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
amorphous cefuroxime axetil, Ceftin	0.17	2.67	300%	Valid	102, 103 112¶2 (indef)	2
controlled release naproxen, Naprelan	2.67	5.83	119%	Valid	102	1
transdermal administration of fentanyl, skin permeable fentanyl	9.33	17.0	82%	Valid	102, 103	1
hydrocodone and ibuprofen, Vicoprofen	2.17	3.33	54%	Valid	103	1
prostaglandin H synthase-2 inhibitor, PGHS-2 inhibitor	42.8	16.2	-62%	Invalid	112¶1 (WD)	1
cytotoxic effect of tumor necrosis factor	144	117	-19%	Invalid	112¶1 (WD)	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.

Table 9: Web of Science Publications for Biotechnology Validity Decisions at the Federal Circuit from 2005.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
antifungal capsule, antifungal bead core, itraconazole antifungal drug	78.3	121	54%	Valid	102	1
topical skin application of fatty acid ester of ascorbic acid, ascorbyl fatty acid ester	1.67	2.83	70%	Valid	102, obvi-type double patenting	2
fluoxetine treatment AND premenstrual syndrome, selective serotonin re-uptake inhibitors	47.2	43.0	-9%	Valid	103	1
topical glaucoma medication, "13,14-dihydro-15-keto-17-phenyl-18,19,20-trinot PGF2a isopropyl ester", Xalatan	46.7	64.2	38%	Valid	ineq cond	2
leuprolide in biodegradable polymer	2.50	2.50	0%	Valid	ineq cond	2
pulse oximeter	48.2	83.2	73%	Valid	102, 112¶2 (indef), ineq cond	4

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
angiotensin converting enzyme inhibitors with metal-containing stabilizer and saccharide, ACE inhibitors with metal-containing stabilizer and saccharide, Accupril, quinapril	44.2	26.7	-40%	Invalid	112¶1 (EN)	1
expressed sequence tags	753	900	19%	Invalid	101 (util), 112¶1 (EN)	1
biosynthetic human growth hormone, human growth hormone from recombinant DNA and E.Coli	5.83	4.50	-23%	Invalid	102, ineq cond	1
paroxetine	360	356	-1%	Invalid	102	1
vitamin B12 with folic acid, vitamin B12 with folic acid and vitamin B6	36.3	78.2	115%	Invalid	102	2
spine bone screws	55.5	98.8	78%	Invalid	103	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.

Table 10: Web of Science Publications for Biotechnology Validity Decisions at the Federal Circuit from 2006.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue [3]	No. Patents
35S cauliflower mosaic virus promoter, CaMV 35S promoter	131	119	-9%	Valid	112¶1 (WD/EN)	4
Olanzapine	631	676	7%	Valid	102, 103, ineq cond	1
clopidogrel bisulfate	2.83	10.2	259%	Valid	102, 103, obvi-type double patenting	1
erythropoietin, recombinant erythropoietin, erythropoietin glycoprotein	1117	1379	23%	Valid [4]	102, 103	3
controlled release oxycodone	23.7	55.8	136%	Valid	ineq cond	3
making paroxetine	11.0	12.2	11%	Invalid	102	1
human parathyroid hormone binding, hPTH binding	44.0	32.5	-26%	Invalid	102	1
anesthetic sevoflurane, sevoflurane with water, sevoflurane with lewis acid inhibitor	208	239	15%	Invalid	102	1
riluzole, glutamate antagonist, antiglutamate for amyotrophic lateral sclerosis	939	842	-10%	Invalid	102	1
controlled release oxybutynin	16.3	12.8	-21%	Invalid	103	1

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue [3]	No. Patents
extended release clarithromycin, extended release erythromycin derivative	6.33	4.17	-34%	Invalid	103	1
screening protein inhibitor or activator	6351	8211	29%	Invalid	ineq cond	4
1-deamino-8-D-arginine vasopressin, DDAVP	70.7	62.7	-11%	Invalid	ineq cond	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.
[4] 3 patents were valid; 1 was invalid.

Table 11: Web of Science Publications for Software Validity Decisions at the Federal Circuit from 2003.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue [3]	No. Patents
load balancing at the DNS servers, load balancing and redirection	3.83	3.50	-9%	Valid	103	1
video recording software	33.7	65.5	95%	Valid	ineq cond	1
computerized securities trading system	0.83	0.17	-80%	Invalid	102	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.

Table 12: Web of Science Publications for Software Validity Decisions at the Federal Circuit from 2004.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
data flow diagrams by pointing and clicking with a mouse, data flow diagrams by graphical user interface	0.50	1.00	100%	Valid	102	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.

Table 13: Web of Science Publications for Software Validity Decisions at the Federal Circuit from 2005.

Keywords	Pubs. Before[1]	Pubs. After[2]	Change	Decision	Issue[3]	No. Patents
interactive data messaging	13.5	26.7	98%	Valid	112¶2 (indef)	1
selling goods through an electronic network, searching electronic markets	18.2	39.2	116%	Valid [4]	102, 103, 112¶1 (WD)	3
seamless wavelet based compression, discrete wavelet transformation, digital image compression	235	371	58%	Invalid	112¶1 (WD)	1
"RAID Squared",	17.5	33.8	93%	Invalid	102	1

Keywords	**Pubs. Before**[1]	**Pubs. After**[2]	**Change**	**Decision**	**Issue**[3]	**No. Patents**
redundant data storage						
embedded objects within hypermedia, interactive applications embedded in web pages	1.33	1.50	13%	Invalid	102, 103, ineq cond	1
On-line survey, electronic survey	333	763	129%	Invalid	103	1

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.
[4] 2 patents were valid; 1 was invalid.

Table 14: Web of Science Publications for Software Validity Decisions at the Federal Circuit from 2006.

Keywords	**Pubs. Before**[1]	**Pubs. After**[2]	**Change**	**Decision**	**Issue**[3]	**No. Patents**
electronic kiosk user interface, create custom user interface	5.67	10.8	91%	Valid [4]	102, 112¶2 (indef)	3
automatic transcription	40.8	98.5	141%	Invalid [5]	102, 112¶2 (indef)	11

[1] Average number of publications before the Federal Circuit decision.
[2] Average number of publications after the Federal Circuit decision.
[3] Patent statute(s) at issue in the cases.
[4] 2 patents were valid; 1 was invalid.
[5] 1 patent was valid; 10 were invalid.