THE UNIVERSITY OF TEXAS SCHOOL OF LAW

Law and Economics Research Paper No. 97
March 2007

The Disputed Quality of Software Patents

John R. Allison
The University of Texas McCombs School of Business
&

Ronald J. Mann
The University of Texas School of Law

THE DISPUTED QUALITY OF SOFTWARE PATENTS

John R. Allison & Ronald J. Mann[*]

TABLE OF CONTENTS

TABLES AND FIGURES

---

[*] Allison is the Spence Centennial Professor in the McCombs School of Business, University of Texas at Austin. Mann is a Visiting Professor of Law at Columbia Law School and the Ben H. & Kitty King Powell Chair in Business and Commercial Law at the University of Texas School of Law. We thank Abe Dunn and An-Shih Liu for statistical analysis.

DRAFT: DO NOT CITE OR QUOTE WITHOUT PERMISSION

ABSTRACT

We analyze the characteristics of the patents held by firms in the software industry. Unlike prior researchers, we rely on examination of the individual patents to determine which patents involve software inventions. This method of identifying the relevant patents is more laborious than the methods that previous scholars have used, but it produces a dataset from which we can learn more about the role of patents in the software industry. In general, we find that the patents computer technology firms obtain on software inventions have more prior art references, claims, and forward citations than the patents the same firms obtain on non-software inventions. We also find that the patents that software firms obtain on software inventions also have more prior art references, claims, and forward citations than the software patents obtained by the firms that derive revenues from other product lines. Finally, we conclude that the patents of the largest firms are no better (or worse) than the patents of the smallest firms, belying the idea that large firms are plagued by challenges based on the worthless patents of their smaller competitors.

The paper closes with a brief discussion of the implications of our empirical analysis. The findings undermine the strongest criticisms about the low quality of software patents. It is simply not accurate to say that software patents as a class have remarkably low numbers of prior art references and forward citations. Thus, they cut against technology-based patent reforms designed to make it more difficult to obtain software patents. On the other hand, the evidence that small firms are no less capable than large firms at producing quality patents vitiates concerns that higher hurdles at the early stage of the patenting process would disadvantage smaller inventors in particular.

THE DISPUTED QUALITY OF SOFTWARE PATENTS

I.   INTRODUCTION

As the use of patents has become commonplace in the software industry, concerns about their propriety have remained surprisingly strong. It is easy to understand why those who were late to develop effective patenting strategies would oppose software patents in the mid-1990's, when patenting began to spread broadly through the industry.[1] Despite the widespread use of patenting in the modern software industry, however, the concerns about software patents have continued. For example, the FTC's October 2003 report *To Promote Innovation* summarizes hearings in which "[m]any panelists and participants expressed the view that software and Internet patents are impeding innovation."[2] As knowledgeable a technologist as Hal Varian proclaims "a steady reduction in patent quality, with patents of dubious novelty being granted routinely."[3] Similarly, the National Research Council decries events that are "degrading the quality of" new patents, especially in high technology industries.[4] Large firms in particular have complained about the poor quality of the patents being asserted against them in litigation.[5] Most

---

[1] See John R. Allison, Abe Dunn & Ronald J. Mann, *Software Patents, Incumbents, and Entry*, 85 TEXAS L. REV. (forthcoming 2007).

[2] Federal Trade Commission, To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy 56 (2003).

[3] Hal R. Varian, Economic Scene: A Patent That Protects a Better Mousetrap Spurs Innovation. But What About One for a New Way to Amuse a Cat?, N.Y. Times, Oct. 21, 2004.

[4] National Research Council of the National Academies, *A Patent System for the 21st Century* 1, 46-51 (2004). A scholarly volume that accompanies that report emphasizes concerns that "a weakening of the standards of novelty and non-obviousness [has] undermin[ed] the purpose of patents to provide an incentive to those who innovate in a genuine way." Patents in the Knowledge-Based Economy 2 (Wesley M. Cohen & Stephen A. Merrill eds. 2003).

[5] *E.g.*, Testimony of Richard J. Lutton, Jr., Chief Patent Counsel, Apple, on behalf of the Business Software Alliance, Hearing on Patent Quality and Improvement before the Subcommittee on Courts, the Internet and Intellectual Property, House Judiciary Committee (Apr. 20, 2005) ("The current

recently, a 2006 Brookings Institution Report authored by Doug Lichtman identifies problems in

ensuring patent quality as one of the principal justifications for a proposal to abandon the

presumption of validity.[6]

Although a good deal of the public criticism can be dismissed as self-serving efforts to

promote the interests of particular sectors of the industry,[7] two distinct variants of the criticism

are substantial. The first is the idea that software patents impede innovation because they hinder

entry by new firms.[8] The second is closely related to the first, but reflects a distinct concern

about the craft and effort reflected in the patents themselves, rather than the competitive structure

of the industry in which they are deployed.[9] Indeed, the seriousness of this concern is

---

patent system has given rise to too many low quality patents being issued, and a growing pattern of assertions of weak patents that threaten to damage productive companies and stifle innovation."); Intellectual Property Owners Association, *IPO Survey: Corporate Patent Quality Perceptions in the U.S.* (Sept. 20, 2005) (reporting survey in which most respondents believe patent quality is unsatisfactory or poor, more believe that patent quality will continue to deteriorate than expect it to improve, and the overwhelming majority believe that litigation costs will increase in the next three years).

[6] Doug Lichtman, Aligning Patent Presumptions with the Reality of Patent Review: A Proposal for Patent Reform (Hamilton Project Discussion Paper December 2006).

[7] See, e.g., Matthew Broersma, *Stallman: OSDL Patent Project "Worse Than Nothing*," News.com (Sept. 19, 2006) (discussing the view of Free Software Foundation founder Richard Stallman that all software patents are inappropriate). For a thorough discussion of the relation between patent strategy and policy perspectives of software firms, see Allison et al., supra note 1.

[8] See, e.g., Patents in the Knowledge-Based Economy 2 (Wesley M. Cohen & Stephen A. Merrill eds. 2003).

[9] See, e.g., James Bessen & Eric Maskin, Sequential Innovation, Patents, and Imitation 20 (Jan. 2000 manuscript) (arguing that "software patents have been too broad and too obvious"); Mark H. Webbink, *A New Paradigm for Intellectual Property Rights in Software*, DUKE L. & TECHNOLOGY REV. ¶¶ 5-8 (2005) (complaining about trivial and invalid software patents); John Kasdan, Obviousness and New Technologies (Columbia Law and Economics Working Paper No. 146) (March 1999 draft); David Evans and Anne Layne-Farrar, *Software Patents and Open Source: The Battle over Intellectual Property Rights*, 9 VA. J.L. & TECH. No. 10 ¶ 25 (2004) (summarizing complaints about "trivial" software patents); see also John H. Barton, *Reforming the Patent System*, 287 SCIENCE 1933 (2000) (criticizing bad patents as a problem that pervades all of the high-technology sectors); Glynn S. Lunney, Jr., *E-Obviousness*, 7 MICH. TELECOMMUNICATIONS & TECH. L. REV. 363 (2001) (criticizing the "potential monopoly costs of unjustified patents" because of a general decline in the doctrine of obviousness).

underscored by the central role of the software industry in the Community Patent Review Initiative[10] and in such initiatives as IBM's effort to develop a "Patent Quality Index."[11]

There has been a great deal of writing on the first subject, including some sophisticated econometric analysis of the relation between patenting, on the one hand, and innovation and competition in the software industry, on the other.[12] There has been much less writing about the second subject. Given the concern that an unduly lax standard for issuing patents will have an adverse effect on economic growth,[13] and given the importance of the software sector to our economy, questions about the quality of such a rapidly growing class of patents are important. Thus, although Stuart Graham and David Mowery's work includes a preliminary assessment of

---

[10] See Beth Simone Noveck, "Peer to Patent": Collective Intelligence, Open Review and Patent Reform, 20 HARV. J.L. & TECH. 123 (2006).

[11] See Jennifer LaClaire, *IBM Teams with OSDL, USPTO on Patent Quality Initiative*, ECommerceTimes, January 10, 2006. IBM's senior vice president of technology and IP explained IBM's motivation as follows: "Raising the quality of patents will encourage continued investment in research and development by individual inventors, small businesses, corporations and academic institutions while helping to prevent over-protection that works against innovation and the public interest."

[12] For a selection of the most recent papers of interest, see Iain M. Cockburn & Megan MacGarvie, Entry, Exit and Patenting in the Software Industry (NBER Working Paper 12563) (October 2006 draft) (analyzing the effects of patenting rates on entry and exit into sectors of the software industry); Bronwyn H. Hall & Megan MacGarvie, The Private Value of Software Patents (NBER Working Paper 12195) (April 2006 draft) (analyzing the effect of software patents on the value of the firms that hold them); Michael Noel and Mark Schankerman, Strategic Patenting and Software Innovation (June 2006) (analyzing whether patenting by software firms has positive or negative spillovers). One of us also has written about this subject, providing a mix of qualitative interviews and empirical analysis of patenting practices. See Ronald J. Mann, *Do Patents Facilitate Financing in the Software Industry?*, 83 TEXAS L. REV. 961 (2005) [hereinafter Mann, Software Patents]; Ronald J. Mann & Thomas W. Sager, *Patents, Venture Capital, and Software Startups*, 36 RESEARCH POL'Y 193 (2007).

[13] Nancy Gallini & Suzanne Scotchmer, Intellectual Property: When Is It the Best Incentive System?; Bronwyn H. Hall, Business Method Patents, Innovation, and Policy (NBER Working Paper No. 9717).

the frequency with which subsequent patentees cite the patents owned by large software firms,[14]

there is much more to be done.

The problem gains in urgency as policymakers in all three branches seriously consider

reforms to the patent system that are justified for the most part by anecdotal complaints about the

system rather than actual analysis of software patents as a class.   For example, the 109th

Congress considered a series of bills proposing major changes to patent procedures designed to

respond to a perceived problem with quality.[15]   The PTO has its own "Strategic Plan 2007-

2012," which advocates a major reallocation of priorities and resources to satisfy the primary

goal to "optimize patent quality and timeliness."[16]   Finally, and most visibly, the Supreme Court

---

[14] Stuart J.H. Graham & David C. Mowery, Software Patents: Good News or Bad News? (May 2004 draft). For careful case studies analyzing the quality of particular software patents, see Martin Campbell-Kelly, *Not All Bad: An Historical Perspective on Software Patents*, 11 MICH. TELECOMM. & TECH. L. REV. 191, 214-15 (2005); Martin Campbell-Kelly & Patrick Valduriez, A Technical Critique of Fifty Software Patents (Jan. 2005 draft).

[15] E.g., Proposed Patent Reform Act of 2005, H.R. 2795, 109th Cong., 1st Sess. §§ 9-10 (altering post-grant procedures and easing rules for pre-grant third-party submissions, both to respond to perceived quality problems); Proposed Patent Reform Act of 2006, S. 3818, 109th Cong., 2nd Sess. §§ 6, 7 (same). The concerns about quality are most evident at the hearings on those bills. See, e.g., Hearing Before the Courts, the Internet, and Intellectual Property Subcommittee of the House Judiciary Committee 7 (Sept. 15, 2005) (Serial No. 109-53) (Testimony of Emery Simon, Business Software Alliance) (contending that "the IT industry, like so many others, is encountering the enormous costs of dealing with patents of questionably quality" and offering as evidence the fact that "hundreds of patent infringement suits are pending against computer software and hardware companies, costing the industry hundreds of millions of dollars each year"); Hearing Before the Courts, the Internet, and Intellectual Property Subcommittee of the House Judiciary Committee, at 13 (June 9, 2005) (comments of Mr. Griswold, Chief Intellectual Property Counsel, 3M Innovative Properties Co.) ("[O]ur solution is to start with the major problem. The problem is patents of low quality.").

[16] The draft plan is available at www.uspto.gov/web/offices/com/strat2007. A central concern in the plan is to improve the quality of patent applications because of the PTO's view that "[b]etter application input contributes directly to more efficient processing and to quality, thereby benefiting both the examiner and the applicant."   Statement of the Honorable Jon W. Dudas, Under Secretary of Commerce for Intellectual Property and Director of the United States Patent and Trademark Office, Hearing on Patent Quality Enhancement in the Information-Based Economy, Subcommittee on Courts, the Internet, and Intellectual Property of the House Committee on the Judiciary (Apr. 5, 2006). For empirical evidence assessing the extent of that problem, see John L. King, Patent Examination Procedures and Patent Quality, in Patents in the Knowledge-Based Economy 54 (Wesley M. Cohen and Stephen A. Merrill eds. 2003).

in the last few years has granted review in an unusually large number of patent cases, apparently motivated in part by concerns that excessive numbers of low-quality patents may be stifling innovation.[17]

This paper responds to that gap in the literature by providing detailed empirical analysis of the patents held by software firms. Specifically, we examine the roughly 34,000 patents held by the firms listed in a leading industry periodical during the five-year period from 1998-2002. We started by collecting a list of the firms from *Software Magazine's* Software 500. Relying on questionnaires disseminated by the magazine, that list indicates the top 500 firms in the software industry each year by revenue from software and services. Based on industry interviews, we believe that the response rate is quite high. The list appears to be widely regarded as authoritative within the industry. Martin Campbell-Kelly, for example, uses the list pervasively in his comprehensive history of the industry.[18] It is, by way of comparison, considerably more comprehensive than the Softletter 100 that Graham and Mowery use, which is limited to prepackaged software providers. Because of considerable turnover in the industry, that list

---

[17] This concern is most evident in Justice Kennedy's concurring opinion in eBay v. MercExchange, LLP, 126 S. Ct. 1837, 1842-43 (2006) (while concurring in decision that injunctions in patent infringement cases should not be automatic, but based on traditional principles of equity, noting his impressionistic belief that too many ill-advised patents had been granted on software-implemented business methods), but also appears to underlie the grants in cases such as Laboratory Corp. of America Holdings v. Metabolite Laboratories, Inc., 126 S. Ct. 601 (2005) (granting certiorari on question whether method for detecting a deficiency of cobalamin or folate by observing correlation with elevated level of total homocysteine is patentable subject matter) & 126 S. Ct. 2921 (2006) (dismissing writ as improvidently granted after oral argument), and in KSR Int'l Co. v. Teleflex, Inc. (No. 04-1350), 129 S. Ct. 2965 (2006) (granting writ of certiorari on the question of the standard for combining prior art references to determine whether a patent is invalid for obviousness) (argued Nov. 28, 2006). See also Microsoft v. AT&T Corporation (No. 05-1056), 127 S. Ct. 467 (2006) (granting certiorari to review whether software can be a "component" of a patented invention supplied from the United States to a foreign country and, if so, whether *copying* the software in the foreign country amounts to "combining" it with other components to make an infringing invention in violation of 35 U.S.C. §271(f)) (argued Feb. 21, 2007).

includes about 1100 firms for the five years.[19] Of importance for our project, it extends from the

largest firms in the industry (IBM and Microsoft were first and second throughout the five-year

period) to much smaller firms (iCIMS, Inc. was the smallest firm in 2002, with annual revenues

of only $400,000). We then collected from Delphion a complete set of all of the 34,000 patents

issued between January 1, 1998 and December 31, 2002 to each of the listed firms.

Our analysis proceeds in three steps. Part II addresses the threshold question of exactly

what should count as a software patent. Unlike prior researchers, we rely on examination of the

individual patents to determine which patents involve software inventions. This method of

identifying the relevant patents is more labor-intensive than the methods on which previous

scholars have relied, but it produces a dataset with a far lower error rate.

Part III considers what it means to discuss patent "quality" and "value."

We build on a substantial literature that connects the value and quality of patents to objective

features of the patents: the number of claims in the patents, the number of prior art references in

the patents, and the number of forward citations (citations to a patent received in later patents).[20]

---

[18] Martin Campbell-Kelly, From Airline Reservations to Sonic the Hedgehog: A History of the Software Industry (2003).

[19] Because the purpose of our study is to focus on firms that fairly can be characterized as software firms, we excluded the 18 firms that did not derive at least 20% of their total revenues from software in any of the five years for which we collected data. The excluded firms are Cisco, Hitachi, Intel, NEC, Raytheon, Valassis, PreVision Marketing, VCON, Adaptec, Alstom ESCA, Amdahl, Brooktrout, Infolmage, International Network Services, Kasten Chase, MessageQuest, Template Software, and TYX.

[20] There may be other indicators of effort on the part of the applicant, but these characteristics have been most prominent in the existing literature, in large part because they are readily accessible in an automated way from existing databases of patent information. Other indicators that might be probative (such as the number of references added by the examiner or adequate correspondence between the specification and claims) are not as easily assessed in a replicable and automated way. On Jan. 1, 2001, the PTO began identifying examiner-added prior art references on the face of the patent, but 60% of the patents in our data set were issued prior to that time.

We compare software patents to the non-software patents obtained by the same firms not only because our data set contains large numbers of both, but also because we believe that such a comparison may provide more direct insight into questions of relative quality and value than a comparison of software patents to a sample from the general population of patents. In general, we find that the patents firms obtain on their software inventions have more claims, cite more references, and are more frequently cited as prior art by later patents ("forward citations") than the patents the same firms obtain on their non-software inventions. We explain below the relationship of patent characteristics such as number of claims, prior art references, and forward citations to the concepts of patent quality and value. We also consider the possibility noted in the existing literature that the patents obtained by pure software firms would differ from the quality and value of patents obtained by less specialized firms, and conclude that our dataset supports that hypothesis.

Finally, Part IV closes with a brief discussion of the implications of our empirical analysis. First, we believe that the findings undermine the strongest criticisms about the low quality of software patents. Whatever one might glean from subjective analyses of the nature of the inventions disclosed by each patent, it is simply wrong to assert, for example, that software patents as a class fail in any notable way to mention the relevant prior art. Second, the findings suggest, contrary to the idea that large firms are plagued by a mass of low-quality patents obtained by smaller firms, there is no substantial difference between the patents obtained by the largest and most experienced patentees and those obtained by their less well-capitalized competitors. Collectively, we argue, those findings have important ramifications for patent reform, because they cut decisively against reforms focused on a particular area of technology. At the same time, to the extent they suggest that lack of resources is not a constraint on patent

quality, they undermine the concern that reforms that raise the bar for patent filings will operate

to the particular detriment of smaller inventors.

II.   WHAT IS A SOFTWARE PATENT?

Identifying a data set of software patents is a difficult task – what Professors Graham and

Mowery have called the "thorniest" task for a scholar in this area.[21]   This is so for several

reasons. First, there is no universally accepted definition of what a software patent is. Second,

neither the U.S. Patent and Trademark Office (PTO) classification system nor the International

Patent Classification (IPC) system was designed for that purpose.   Both systems focus on

functionality at a low level of abstraction and are unsuitable for defining any technology area at a

conceptual level.   Third, even if these systems were suitable for identifying for defining a

technology area, software is a critical element of inventions in so many disparate fields that it

presents an unusual challenge for any categorical classification system.[22]

The existing literature includes three separate efforts to identify a large data set of

software patents.[23]   The first was by Graham and Mowery. They have not attempted to define

---

[21] Graham & Mowery, supra note 14.

[22] With respect to the USPTO classification system, part of the problem reflects the changes over time of the relevant United States patent classes most commonly used for software-related inventions. For a careful discussion of that development, see GREGORY A. STOBBS, SOFTWARE PATENTS ¶ 5.10[D], at 43-50 (2006 cumulative supplement) (discussing the replacement of the old class 395 by a new set of classes in the 700 series).

[23] For a previous discussion and comparison of efforts to define software patents, see Anne Layne-Farrar, *Defining Software Patents: A Research Field Guide* (2005, on file with the authors). One caveat about the Layne-Farrar study is in order. She compared the results of the Bessen-Hunt study, the Graham-Mowery studies, and an earlier study by John Allison and a colleague. See John R. Allison & Emerson H. Tiller, *The Business Method Patent Myth*, 18 BERKELEY TECH. L.J. 987 (2003). Layne-Farrar reports that when software experts read a random sample of patents from an earlier set identified by Allison, she found that only 5% represented Type II errors (underinclusiveness). Her experts were not able to identify Type I errors (overinclusiveness). But the Allison-Tiller data set that she examined was not an appropriate dataset for testing the methodology that we apply here. That dataset did not purport to be a complete or even representative set of software patents; rather, it included all patents in PTO classes

the term "software patent," but rather have used first the IPC system and more recently the

USPTO class system, in an effort to develop a class-based data set of software patents owned by

pre-packaged software firms.[24]   Specifically, they first identified pre-packaged software firms,

using the Softletter 100, an industry publication that identifies the 100 largest prepackaged

software firms.[25]   Then, they identified the classes of the patents assigned to those firms. Using

those classes, they ran additional searches to compile a dataset of software patents.[26]   Generally,

they analyze those datasets to assess the relation between patenting and R&D and find no strong

evidence that strategic patenting is impeding innovation.[27]   As a definitional matter, their

methodology does produce large concentrations of patents on software inventions, but as we

discuss below, it omits several classes that contain large numbers of software patents obtained by

software firms that are not prepackaged software firms.

705, 707, and 709 issued through the end of 1999 that addressed Internet applications. See Layne-Farrar, *supra*, at 11. Although Internet-related business method patents are a subset of software patents, the objective of the Allison-Tiller study was to identify that subset of patents, not software patents in general.

[24] See Stewart J.H. Graham & David C. Mowery, *Intellectual Property Protection in the U.S. Software Industry*, in PATENTS IN THE KNOWLEDGE-BASED ECONOMY 219 (Wesley M. Cohen & Stephen A. Merrill eds., 2003) (IPC-based definition); Graham & Mowery, *supra* note 14 (definition based on United States patent classes).

[25] As the discussion below should make clear, our project uses a considerably broader conception of the software industry, based on *Software Magazine*'s Software 500, which covers many sectors excluded from the prepackaged software sector with which Graham & Mowery work.

[26] The IPC-based definition uses G06F 3/ 5/ 7/ 9/ 11/ 12/ 13/ & 15/; G06K 9/ & 15/; and H04L 9/ to develop a dataset of patents held by the top 15 firms in the 1995 *Softletter 100*. Graham & Mowery, *supra* note 24. The definition based on United States classes uses classes 345, 358, 382, 704, 707, 709-11, 713-15, and 717 to develop a dataset of all patents issued in those classes from 1987-2003. Graham & Mowery, *supra* note 14.

[27] Graham & Mowery, *supra* note 14, at 19-22.

The second significant effort to identify a large set of software patents appears in an unpublished paper by Jim Bessen and Bob Hunt.[28] Eschewing a class-based definition, Bessen and Hunt instead develop a keyword search algorithm. Their technique starts with a definition of the term "software patent" that includes, as we do, [29] patents on inventions in which the data processing algorithms are carried out by code either stored on a magnetic storage medium or embedded in chips ("firmware").[30] In applying the definition, however, Bessen and Hunt rely on

---

[28] James Bessen & Robert M. Hunt, An Empirical Look at Software Patents 7-9 (Fed. Res. Bank of Philadelphia Working Paper No. 03-17).

[29] As Bessen and Hunt note, *id*. at 9, one of the current authors, John Allison, earlier employed a definition of software patent that excluded firmware, including only inventions in which the code implementing the data processing algorithms are stored on a magnetic storage medium. See John R. Allison & Mark A. Lemley, *Who's Patenting What? An Empirical Exploration of Patent Prosecution*, 53 VAND. L. REV. 2099, 2110-11 (2000); John R. Allison & Mark A. Lemley, *The Growing Complexity of the U.S. Patent System*, 82 B.U. L. REV. 77, 89 (2002); Allison & Tiller, supra note 23, at 1029. The reasons for using this definition were a combination of initial doubt and compromise with a coauthor, followed by a need for consistency. Each of those articles made use of the same data set of 1,000 randomly selected patents-in-general issued between mid-1996 and mid-1998. After a great deal more experience gained from closely reading thousands of computer-related patents, Allison became firmly convinced that the definition should include firmware. When he used the same set of 1,000 randomly selected patents in a subsequent article, he studied each patent again and reclassified them using a definition that included firmware. See John R. Allison, Mark A. Lemley, Kimberly A. Moore, & R. Derek Trunkey, *Valuable Patents*, 92 GEO. L.J. 435 (2004) (definition not explicitly provided in article). Allison used this more inclusive definition not only in that paper and in this one, but also in an extensive empirical study of more than 7,600 university-owned patents. See Arti K. Rai, John R. Allison, Bhaven Sampat & Colin Crossman, *Technology Transfer or Business as Usual? The Determinants and Consequences of University Software Ownership* (Jan. 2007, on file with authors). Thus, when we say that identifying a large set of software patents is daunting, we speak from rich experience.

[30] We note one other, possibly minor, difference between the basic definition that Bessen and Hunt start with and the definition we use in this study, but the effects of those differences is difficult to gauge. The Bessen & Hunt definition of a software patent includes patents on inventions that "use" software as part of the invention, but excludes those that "use" off-the-shelf software:

> Our concept of software patent involves a logic algorithm for processing data that is implemented via stored instructions; that is, the logic is not "hard-wired." These instructions could reside on a disk or other storage medium or they could be stored in "firmware," that is, a read-only memory, as is typical of embedded software. But we want to exclude inventions that involve only off-the-shelf software — that is, the software must be at least novel in the sense of needing to be custom-coded, if not actually meeting the patent office standard for novelty.

Bessen & Hunt, supra note 28, at 8.

automated word searches of the specifications (written descriptions) of patents in their sample. Specifically, Bessen and Hunt start by examining a random sample of patents, which they classify according to their definition and use as the basis for a keyword search algorithm that they can then apply en masse to classify patents more broadly.[31] Like Graham & Mowery, Bessen and Hunt focus their statistical analysis on the relation between patenting and R&D. Their conclusion, however, is much more pessimistic: that the increase in patent propensity during the 1990's reflects a patent "arms race" that undermines incentives to innovate.[32] As a definitional matter, they report in their paper that a test of their algorithm on a random sample indicates a false positive rate of 16% and a false negative rate of 22%.[33] Given those error rates, previous scholars have criticized their definition for including excessive numbers of patents that are not fairly regarded as software patents.[34] As we discuss below, their definition also omits broad classes of patents that plainly cover software inventions.

The third notable effort, in a recent working paper by Bronwyn Hall and Megan MacGarvie,[35] combines those approaches. Hall and MacGarvie first develop their own set of patent classes, looking to classes commonly used in patents assigned to fifteen large software firms. Then, they combine the patents in those classes with the patents in the IPC-class definition developed in the first Graham & Mowery paper. Finally, they apply the Bessen &

---

[31] The relevant query searches for (("software" in specification) or ("computer" AND "program" in specification)) AND (utility patent excluding reissues) ANDNOT ("chip" OR "semiconductor" OR "bus" OR "circuit" OR "circuitry" in title) ANDNOT ("antigen" OR "antigenic" OR "chromatography" in specification).

[32] Bessen & Hunt, supra note 28, at 26-38.

[33] *Id*. at 9.

[34] See Robert W. Hahn & Scott Wallsten, A Review of Bessen and Hunt's Analysis of Software Patents (Nov. 2003 draft); Layne-Farrar, supra note 23; Graham & Mowery, supra note 14.

[35] Hall & MacGarvie, supra note 12.

Hunt textual search to the patents in the combined set of classes and exclude the patents that do

not satisfy the search criteria. The object of their analysis is to consider whether the arguable

reduction of patentability restrictions in the 1990's increased or decreased the value of firms in

the industry. They generally conclude that the initial extension of patentability decreased the

value of firms in the industry, but that market values have increased substantially in the

subsequent years.[36]

Although each of the three previous definitions has the benefit of objectivity and easy

replicability, and thus can be applied automatically to large datasets, those definitions sacrifice a

great deal of accuracy. The class system does not closely match the variety of patents obtained

on software, and keyword searches produce at best a crude match to software patenting. On that

point, Allison's studies of thousands of computer-related patents convince us that different patent

owners make highly idiosyncratic uses of language in the titles, abstracts, written descriptions,

and claims of patents, even in those dealing with the same area of technology. Moreover,

software is a critical part of inventions in such far-flung fields that reliance on particular search

terms will produce a data set that is substantially overinclusive and underinclusive at the same

time.[37]

---

[36] Hall & MacGarvie, supra note 12, at 18-30.

[37] To illustrate the problem, consider a few examples of overinclusiveness. Among the patents that satisfy the Bessen and Hunt algorithm are the following:

• Genetic Control of Flowering, U.S. Patent No. 6,265,637 (filed Jan. 11, 1999). The patent claims involve genetic engineering methods and products. Although the claimed invention did not involve data processing, the Bessen and Hunt algorithm identified the patent as software because the inventors employed an existing software program in their research to predict the probability of a genomic sequence, and the word "software" thus appeared twice in the patent specification.

• Frozen Food Product, U.S. Patent No. 6,096,867 (filed July 22, 1997). The patent covers a frozen dessert product with a specified composition. The Bessen and Hunt algorithm identified the patent as software because the inventors used the word "software" in the specification when they described how

Because of the problems with the earlier definitions, our work rests on a different approach, a careful patent-by-patent examination of the nature of the invention. As we discuss below, we have attempted to make our classification process as objective as possible. We start with the following definition of a software patent:

> *a patent in which at least one claim element consists of data processing, regardless of whether the code carrying out that data processing is on a magnetic storage medium or embedded in a chip.*

Based on Allison's experience, study, and thought, we believe that this definition is both appropriately inclusive and susceptible of principled consistent application. It also is important that our definition captures the realities of claim drafting. It is common for most of the elements of a patent claim to describe the prior art, with one or two elements describing the purportedly novel and nonobvious advance. For example, claims in the patents of computer hardware manufacturers often begin with a description of a generic router, printer, magnetic resonance imaging machine, or other hardware, describing the only purported novelty in a single element

---

they employed an existing software program in their research for imaging and measuring the size of ice crystals.

- Hammer Device, U.S. Patent No. 5,305,841 (filed Oct. 9, 1992). This invention consists of a rock-crushing device. The algorithm identified the patent as software because the inventors used the phrase "computer program" in the specification when they described their use of an existing software program for simulation purposes while designing the mechanical device.

- Thermoplastic polypropylene blends with mixtures of ethylene/butene and ethylene/octene copolymer elastomers, U.S. Patent No. 5,985,971 (filed Oct. 29, 1997). This invention consists of certain groups of chemical compositions claimed to have superior adherence for coating materials such as automotive paints. The algorithm identified the patent as software because the specification used the term "computer program" to describe the inventor's use of a commercially available software program for simulating molding conditions in which the claimed compositions would be useful.

- Storage case for compact discs, U.S. Patent No. 5,954,197 (filed Dec. 16, 1996). This invention consists of a mechanical storage and shipping container for CDs. The algorithm identified the patent as software because the phrase "personal computers" appeared in the specification when the inventors noted that CDs in jewel cases were easier to load into the CD drive of a computer than CDs stored in older types of cases.

consisting of a function carried out by algorithms.   A claim covers the entire invention, and in a

case like this, the entire invention is not just the new algorithms in isolation but instead is a piece

of hardware that allegedly does something different because of the new algorithms

Applying that methodology, we examined each of the 20,000 patents issued to firms

other than IBM to determine whether it was a patent on a software invention. For the 14,000

IBM patents, we read a random sample of about 300 patents and extrapolated from that sample.

Using that methodology, about 68% (13,500) of the non-IBM patents qualified as software

patents and about 55% of the IBM patents (extrapolating from the sample that we examined), for

a blended total of about 62% (21,200) software patents. Table 1 summarizes the major classes of

software patents using both the IPC and USPTO classification systems.

TABLE 1: LEADING SOFTWARE PATENT CLASSES

IPC CLASS	S/W PATENTS IN CLASS	% OF ALL S/W PATENTS	CUM. % OF S/W PATENTS	USPTO CLASS	S/W PATENTS IN CLASS	% OF ALL S/W PATENTS	CUM. % OF S/W PATENTS
G06F	8875	63.2	63.2	707	1551	11.0	11.0
H04L	583	4.2	67.4	345	1434	10.2	21.2
G06K	502	3.6	71.0	709	1264	9.0	30.2
G06T	438	3.1	74.1	711	890	6.3	36.5
H04N	329	2.3	76.4	710	753	5.4	41.9
H04B	317	2.3	78.7	714	730	5.2	47.1
G09G	262	1.9	80.6	717	664	4.7	51.8
G10L	241	1.7	82.3	713	637	4.5	56.3
B41J	227	1.6	83.9	370	598	4.3	60.6
H04J	206	1.5	85.4	382	420	3.0	63.6

The most obvious problem with our methodology is that it requires reading every patent,

an extraordinarily slow and laborious process. Although the appropriate treatment of many

patents is obvious under this definition, a substantial percentage must be studied with care.[38]

Claims are often obtuse, and in the computer field they are frequently broad, necessitating a

close reading of not only independent but also dependent claims and frequent resort to the

written description for help in interpreting claim language.[39]

In the end, we acknowledge an irreducible element of subjectivity that undermines the

ease of replication of our determinations. At the same time, however, it seems clear that our

determinations will be more accurate than the comparatively crude determinations made under

the automated class-based or keyword search methodologies discussed above. For example,

although the Graham & Mowery class-based searches are not significantly overinclusive because

they limit their data set to patents owned by prepackaged software firms, they are significantly

underinclusive. They exclude seven of the ten largest classes of software patents, including

several classes that are dominated by software patents in our data collection, such as G06T

(image data processing or generation)[40] and H04J (multiplex communication).[41] A similar

problem afflicts their more recent definition based on national classes, where they exclude

several classes that in our dataset are dominated by software patents, such as classes 455

---

[38] Because patents from firms in computer-related industries are more likely to include patents
that are close to the line, the percentage requiring careful scrutiny is far higher for a project like this one
than it is for a project (like Allison's previous projects) studying a population of patents across a broad
array of fields.

[39] See Phillips v. AWH Corp., 415 F.3d 1303 (Fed. Cir. 2005) (en banc).

[40] 438 of the 444 patents in this class are software patents.

[41] 206 of the 225 patents in this class are software patents.

(telecommunications),[42] 712 (processing architectures and instruction processing for electrical

computers),[43] and 719 (interprogram or interprocess communication for electrical computers).[44]

Similarly, the Bessen and Hunt word search algorithm suffers not only from the problem

of overinclusiveness discussed above and in the existing literature, but also from

underinclusiveness, because a great many software patents do not include the terms "software"

or from "computer program" in their specifications. The relevance of computerized data

processing to the invention is often so clearly understood to the inventors and to other experts in

a given field that it is not mentioned in the patent specification.[45] Moreover, the exclusion of

---

[42] 281 of the 332 patents in this class are software patents.

[43] 327 of the 331 patents in this class are software patents.

[44] All of the 271 patents in this class are software patents.

[45] Rai et al., supra note 29, analyzes a sample 7600 patents, all patents issued in 1982, 1987, 1992, 1997, and 2002 to universities identified by the Carnegie Commission on Higher Education as research and doctoral universities. Allison coded these patents as software or non-software by manual examination applying the same protocol as this paper.

To analyze differences between the Allison method and the Bessen and Hunt keyword search algorithm, Bhaven Sampat (one of the co-authors of Rai, et al., supra note 29, applied the Bessen-Hunt algorithm to the 2,942 university-owned patents issued during 2002 and compared the results to Allison's assessment of those patents. Sampat identified large numbers of patents that were treated differently, including many software patents that were not identified with the Bessen-Hunt algorithm, illustrating significant underinclusiveness. Of the 2,942 patents the Bessen-Hunt keyword search identified 221 patents as software that were not (overinlusiveness), and 198 as non-software patents that did in fact cover software inventions (underinclusiveness). For a few examples of underinclusiveness, Allison identified 21 of the first 214 patents in the list of 2,942 as software patents; the Bessen-Hunt search missed 10 of those 21. To illustrate our view that these patents should qualify as software patents, we provide here descriptions of the first five of those ten:

(1) Variable resolution imaging system, U.S. Patent No. 6,335,957 (filed Jan. 12, 1999). The patent claims an imaging system for medical and industrial purposes including software algorithms that purportedly improve the resolution of images. Software is at the heart of the invention, but the Bessen and Hunt keyword search did not identify it as software because the terms "software" and "computer program" do not appear in the specification.

(2) Apparatus and method for improving vision and retinal imaging, U.S. Patent No. 6,338,559 (filed Apr. 28, 2000). The patent claims a method and optical device for improving human vision, which includes in the claims software for generating high-resolution images of the retina. The claims include the term "computer means," and the specification twice includes the term "computer," but the specification does not explicitly refer to "software" or a "computer program."

patents with terms such as "circuit," "chip," "circuitry," "bus," and "semiconductor" in the title

removes many software patents, given the frequency with which the title of a patent will fail to

reflect the true nature of the claimed invention.[46]

III.   WHAT IS THE "QUALITY" AND "VALUE" OF SOFTWARE PATENTS?

A.   Defining Patent "Quality" and "Value"

1.   Different Meanings

Just as the rapid pace of innovation and the heterogeneous nature of software make it

difficult to develop a definitive classification of "software" patents, the vagueness of common

criticisms of software patents makes it difficult to be sure what it would mean for a patent to

---

(3) Genomics via optical mapping with ordered restriction maps, U.S. Patent No. 6,340,567 (filed Oct. 3, 2000). The patent claims "A method of producing high-resolution, high-accuracy ordered restriction maps based on data created from the images of populations of individual DNA molecules (clones) digested by restriction enzymes. Detailed modeling and a statistical algorithm, along with an interactive algorithm based on dynamic programming and a heuristic method employing branch-and-bound procedures, are used to find the most likely true restriction map." In Rai et al, supra note 29, Allison categorizes this as one of a set of "pure" software patents that consist of nothing but algorithms. The Bessen and Hunt keyword search did not retrieve the patent because the specification did not refer to "software" or a "computer program."

(4) Method for determining storm predictability, U.S. Patent No. 6,340,946 (filed Aug. 3, 2000). The patent claims a method for determining the predictability of elements in a weather radar image, more specifically, a method for generating a predictability score indicative of the predictability for a pixel in the weather radar image. Allison coded this patent as not only software, but also "pure" software, because the entire invention consisted of software. Although the specification referred to a "computer system," it did not refer to "software" or a "computer program."

(5) Methods for analysis and sorting of polynucleotides, U.S. Patent No. 6,344,325 (filed Feb. 8, 2000). The patent claims a software-implemented method for analyzing fluorescence signals to isolate polynucleotide molecules based on size. Although the patent plainly claims data processing techniques, and the specification refers three times to a "computer," it does not refer to "software" or a "computer program."

[46] See, e.g., Universal serial bus controlled connect and disconnect, U.S. Patent No. 6,415,342 (filed July 27, 1999). The invention in this patent covers a USB device and software for communications between the device and the computer to which it is connected and disconnected. The specification includes the word "software" once, but the Bessen and Hunt word search would exclude this patent because of the word "bus" in the title.

have the "quality" that would deflect criticism. The simplest possibility would be to view quality

as a function of the four legal criteria for patentability. From that perspective, the patents of the

lowest quality are those most likely to be held invalid in an infringement action or on

reexamination. The best evidence of low quality, then, would be high rates of invalidity.[47]

Research focused on that metric would examine validity decisions of the Federal Circuit (or

perhaps the results of PTO reexamination proceedings). There are, however, some obvious

difficulties with that project. For one thing, if we are concerned about the possibility of

regulatory capture – that the Federal Circuit's case law on validity is a major part of the

problem[48] – then analysis of Federal Circuit decisions is of questionable value. Such work also

must confront the likelihood that larger companies may spend more on litigation and thus may be

more likely to defend a weaker patent. Moreover, it will shed no light on the characteristics of

unlitigated patents.

In any event, this paper for the most part examines the input of the drafter and the patent

office, attempting to determine the extent to which software patents are likely to withstand

challenges to their validity. From that perspective, we could think of quality in two distinct

ways. One possibility – captured in complaints that software patents are too broad or fail to

account adequately for prior art – is that quality refers to the accuracy and completeness with

which the patent defines an invention and distinguishes it from prior art. Thus, this concept of

---

[47] For concerns about validity of that sort, see, *e.g.*, Iain M. Cockburn, Are All Patent Examiners Equal? Examiners, Patent Characteristics, and Litigation Outcomes, in Patents in the Knowledge-Based Economy 19 (Wesley M. Cohen & Stephen A. Merrill eds. 2003); *U.S. Patent Quality Questioned in Industry Poll*, PRNewsire, Sept. 13, 2006 ("High quality patents are usually thought of as those that will hold up if challenged in court.").

[48] This is a central claim in Adam B. Jaffe & Josh Lerner, Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What to Do About It (2004). For

quality is one of craft, focusing on the efforts of the patentee and the examiner to produce an

appropriate description of the invention and to determine that the invention satisfies the statutory

standards of novelty and nonobviousness. One common concern here is that current incentives

motivate software firms to patent too quickly, seeking patent protection without investing the

appropriate effort to reduce an abstract idea to a useful product.[49] Related to that point is the

problem that patent examiners unfamiliar with a cutting-edge technology like software might be

less capable of assessing the quality of the disclosure or of the innovation than they are in

technological areas with which they are more familiar. This raises the question whether the

patented invention in fact represented a novel and nonobvious advance over what had been done

before.[50]

A second possibility – captured in complaints that software patents are trivial or too easy

to obtain – is that quality refers to the economic value of the patent.[51] This conception of quality

overlaps with the first, because a patent granted without adequate consideration to the prior art is

more likely to be held invalid and one in which the invention is inadequately claimed may fail to

---

an insightful review, see Rochelle Dreyfuss, *Pathological Patenting: The PTO As Cause or Cure*, 104 Mich. L. Rev. 1559 (2006).

[49] This idea is voiced frequently in Mann's interviews with venture capitalists and investors in software firms, who worry that a focus on rapid-fire patenting distracts from a focus on successful product design.

[50] The requirement that an invention be novel (that there be no single piece of prior art disclosing an identical invention) appears in 35 U.S.C. § 102 (2006). The more onerous requirement that an invention be "nonobvious" (that the patent claim something more than an obvious advance over the prior art as a whole) appears in 35 U.S.C. § 103 (2006). In the statutory phrasing, the nonobviousness determination depends on the perspective of a "PHOSITA," a hypothetical "person having ordinary skill in the art." *Id.*

[51] We refer here to "private value"—the value of a patent to its owner—and not to "social value"—the value of a patent to society. Moreover, like most others, we refer to the value of a stand-alone patent and not to the value that a patent may contribute to a patent portfolio. At least in theory, a patent might have little value by itself but have value in its contribution to a company's portfolio of

to capture all of the infringing activity that it could have. Yet this conception of value is only

partly dependent on quality, because it also encompasses the value of the markets and products

with which the patent is concerned: the economic value of a patent relates directly to the value of

the commerce over which the patent grants a right to exclude. Thus, value in its broadest

conception is not, strictly speaking, relevant to the question on which we focus here – how well

the system is functioning to distinguish "good" and "bad" patents.

Both of those conceptions of quality have important policy implications. The first

conception of quality (the ex ante conception) is important in efforts to improve the processes by

which the PTO considers and issues patents. The second (the post hoc conception) is important

in efforts to improve the system by which patents are licensed and enforced, to ensure an

appropriate balance of access to technology and incentive to invent. As we emphasize above,

however, this paper focuses on the former "ex ante" conception of quality.

2.   *Indicators of Quality*

The academic literature has been much more successful in efforts to identify objective

indicators of the post hoc conception of value than it has been in identifying objective indicators

of the ex ante conception of quality. Generally, the strategy has been to identify some objective

characteristic of a patent or an event in the life of a patent that provides an indication that the

patent has value, and to search for notable patterns in the characteristics of the affected patents.

For a single patent, or a small number of patents, a reasonable test of quality would be to

have a person having ordinary skill in the art conduct a thorough search of the prior art and

evaluate the likelihood that a patent discloses a novel and nonobvious invention. Such an

---

patents in which the whole is greater than the sum of its parts. See, e.g., Gideon Parchomovsky & R.

approach clearly is not feasible for data sets that contain a large enough number of patents for statistical analysis and, in any event, the results often would still be subject to doubt—this is what is done in patent infringement litigation, and there are frequently genuine issues of disputed fact pertaining to patent validity.

Prior Art. Putting that impractical "first best" solution to one side, it is reasonable to conclude that the best proxy we have for patent quality[52] is the number of prior art references together with (to the extent practicable) some assessment of the types and informational content of those references and their sources.[53] Prior art is the objective evidence of what previously has been done. It is intuitively appealing to view the quantity and, to the extent we can measure it, the quality of prior art cited in patents as indicators of patent quality. Both should correlate with the seriousness of the patent applicant's effort to identify previous inventions and distinguish the new inventions from those inventions, and with the rigor and thoroughness of the PTO's

---

Polk Wagner, *Patent Portfolios*, 154 U. Pa. L. Rev. 1 (2005).

[52] We note that the quantity of prior art well may relate not only to quality, but also to value. For example, if a thorough search of prior art is expensive, a greater quantity of prior art suggests that the patent applicant perceived that its invention was important enough to make this investment. In addition, we know from prior work that patents involved in infringement litigation have significantly more prior art references than non-litigated patents. Allison et al., supra note 29. This makes sense because, all other things being equal, litigated patents should be more valuable to their owners than the general population of patents. Factors other than the size of the stakes also affect the propensity to litigate patents, however. See, e.g., Jean O. Lanjouw & Josh Lerner, *The Enforcement of Intellectual Property Rights: A Survey of the Empirical Literature*, 49/50 ANNALES D'ECONOMIE ET DE STATISTIQUE 223-246 (1998) (surveying empirical studies in economics on intellectual property litigation, including the relationship between patent litigation and patent value); Jean O. Lanjouw & Mark Schankerman, *Enforcing Intellectual Property Rights*, NAT'L BUREAU OF ECON. RES. WORKING PAPER NO. 8656 (2001) (finding that the fact, but not the outcome, of litigation correlates with patent value).

[53] See Allison & Tiller, supra note 23, at 1045-52; John R. Allison & Starling D. Hunter, *On the Feasibility of Improving Patent Quality One Technology at a Time: The Case of Business Methods*, 21 BERKELEY TECH. L.J. 729, 751-57 (2006); Deepak Hegde & Bhaven N. Sampat, *Examiner Citations, Applicant Citations, and the Private Value of Patents* (Dec. 2006, on file with authors).

examination.[54]   Furthermore, the most common basis for judicial invalidation of patents is omitted prior art.[55]

That is not to say that the number and quality of references is a perfect indicator of patent quality. For example, some drafters load up patents with very large numbers of references, in an apparent effort to distract attention from the most important prior art references. Yet over a large group of patents in a substantial dataset, it is reasonable to think that patents that disclose more prior art reflect a higher level of effort on the part of the applicant and examiner than those that disclose less prior art.

Although other objective indicators might seem at first to be more relevant to "value" than to "quality" we believe that they are important as well. First, given the imperfection of inferences drawn from prior art, additional information about patent value buttresses those inferences. For example, suppose, as seems likely, that patent owners (patentees) care more about quality when they expect their patents to be valuable. Patentees' *ex ante* perceptions about value should have some reliability because patentees at the time of filing and prosecution have a considerable amount of value-relevant information about the market in which they will deploy the claimed invention.

---

[54] Regarding the thoroughness of both the applicant's prior art search and the examination process, patent and nonpatent prior art references may be provided by either the applicant or the examiner. Intuitive arguments suggest that patent applicants should be responsible for more prior art references than examiners. See Allison & Tiller, *supra* note 23, at 1037-38 n.167. Recent empirical work by Bhaven Sampat quantifies the accuracy of this intuition. See Bhaven N. Sampat, *When Do Applicants Search for Prior Art? A Window on Patent Quality* (Nov. 2006, on file with authors) (concluding that applicants provided 59% of references to prior patents and 90% of references to NPPA, with examiners adding 41% and 10%, respectively).

[55] See John R. Allison & Mark A. Lemley, *Empirical Evidence on the Validity of Litigated Patents*, 26 AM. INTELL. PROP. ASS'N Q.J. 185, 231-34, 251 (1998) (examining the population of litigated patents leading to final written decisions on validity or invalidity during 1989-96). The "challenger" to a

Claims. Like the number of prior art references, the number of claims in a patent relates

intuitively to patent value. Following the detailed written description of the invention in a

patent,[56] claims identify the invention with linguistic precision. Patent claims define the patent

owner's property interest.[57] Having a patent attorney draft more claims necessarily costs more

money.[58] Moreover, increasing the number of claims in a patent increases the universe of

potential infringers and the likelihood that the patent will be held to extend to competing

products. This seems particularly true with respect to independent claims.[59] Empirical research

has validated that intuition with respect to the total number of claims, illustrating that litigated

patents have significantly more claims than non-litigated ones.[60] At the same time, as with prior

art references, the relation between the number of claims and the quality of the patent is more

---

patent's validity is usually the defendant in a patent infringement suit, but may be a plaintiff in a
declaratory judgment action.

[56] 35 U.S.C. § 112 ¶ 1 (2006).

[57] 35 U.S.C. § 112 ¶ 2 (2006).

[58] More claims in a patent application also modestly increases PTO examination fees. See 37
C.F.R. § 1.116(h), (i) (2007).

[59] Patent claims are either independent or dependent. As the term implies, an independent claim
stands by itself. Each dependent claim adds more specificity to one of the independent claims, narrowing
its technological reach. The advantage to the patent drafter of the dependent claim is that a narrower
dependent claim might be held valid even if the broader independent claim is held invalid. Conversely,
patent drafters often write multiple independent claims that cover the same invention, using different
verbal formats to increase the odds that a later product that is substantively identical or similar to the
disclosed invention will not "slip through the cracks." Consequently, we should expect a positive
correlation between the number of independent claims and patent value. One recent example illustrating
the private value of using multiple independent claims is the notorious case of NTP, Inc. v. Research in
Motion, Ltd., 418 F.3d 1282 (Fed. Cir. 2005), in which NTP successfully sued RIM, the maker of the
"Blackberry" personal communication device for infringement of several NTP patents. The Federal
Circuit concluded that the function of the Blackberry functioned did not violate the "method" (i.e.,
process) claim of the NTP patent, id. at 1317-18, but that it did infringe the NTP patent's "system" claim,
id. at 1317.

[60] See Allison et al., supra note 29, at 451-52; Jean O. Lanjouw & Mark Schankerman,
Characteristics of Patent Litigation: A Window on Competition, 32 RAND J. ECON. 129 (2001).

ambiguous. A patent with a large number of claims often might include broad and ill-confined descriptions of technology already in use at the time the applicant filed the application.

Forward Citations. Another intuitive and empirically validated indicator of patent value is the number of times a patent that later patents cite a patent as prior art, often referred to as "forward citations." Logically, it is reasonable to expect a correlation between the number of those forward citations and the relevance of the patent to continuing developments in the applicable technological field. The number of forward citations similarly relates to the likelihood that the patent disclosed a fundamental development in the particular technology field, thus giving the patent owner a valuable head start. Moreover, later citations to a patent by the owner of the earlier patent ("self-citations") suggest that the patent owner is building a group of patents on closely related technological advancements, which suggests a greater likelihood of commercial exploitation of the patent.

Hence, it is no surprise that empirical studies have found significant positive correlations between number of forward citations and value. One study, for example, concluded that forward citations relate to the market value of the firms that own the underlying patents.[61] Other research shows that litigated patents have significantly more forward citations than unlitigated patents.[62]

There are, of course, many reasons unrelated to technological import that later applications might, or might not, cite a particular patent. Some applications might avoid citing a

---

[61] Bronwyn H. Hall et al., *Market Value and Patent Citations*, 36 RAND J. ECON. 16 (2005); Dietmar Harhoff et al., *Citation Frequency and the Value of Patented Inventions*, 81 REV. ECON. STAT. 511 (1999); Manuel Trajtenberg, *A Penny for Your Quotes: Patent Citations and the Value of Innovations*, 21 RAND J. Econ. 172 (1990).

[62] See Allison et al., supra note 29, at 454-55; Lanjouw & Schankerman, supra note 60. Interestingly, the number of self-citations—citations in later patents granted to the same patent owner— correlates even more significantly with litigation propensity than the number of forward citations by others. Allison et al., supra note 29, at 454.

patent in an effort to undermine perceptions of the patent's quality. This is particularly true in the milieu of biotech startups, where the details of patent applications are a topic of interest to both investors and competitors. It seems a much less important concern in the startup sector of the software industry, in which it is considerably less customary for competitors or investors to study the details of patent applications.[63] Thus, we believe that forward citations are a plausible indicator of the post hoc value, and thus an indirect confirmation of the ex ante quality.

Maintenance Fees. Another possible indicator of value is maintenance fees. Intuitively, the willingness of patent owners to keep their patents alive by paying maintenance fees should relate to the value of the patent to its owner.[64] The failure of the owners of most patents to pay the relatively modest "maintenance fees" necessary to keep their patents in force suggests that more than half of all patents are not worth even a few thousand dollars a few years after they are issued.[65] That intuition is buttressed by empirical research identifying strong positive correlations between the indicators of value discussed above and maintenance fee payments. Specifically, Kimberly Moore concluded that patents with more claims and forward citations are more likely to be maintained.[66] Although the recency of patents in our dataset precludes us from

---

[63] See Mann, supra note 12, at ??.

[64] Such fees are due in increasing amounts at 3½ years ($900), 7½ years ($2,300), and 11½ years ($3,800) after the patent issues. 37 C.F.R. §§ 1.20(e)-(g) (2006). Those fees are halved for small entities. *Id.*

[65] See Jean O. Lanjouw, et al., *How to Count Patents and Value Intellectual Property*, 46 J. INDUS. ECON. 405 (1998); Mark A. Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1495, 1504 tbl. 3 (2001).

[66] Kimberly A. Moore, *Worthless Patents*, 20 BERKELEY TECH. L.J. 1521, 1530 (2005). Moore's bivariate analysis found significant positive relationships between the payment of maintenance fees and the number of claims, number of prior art references, and number of forward citations. *Id.* In her multivariate logistic regression, however, the number of prior art references lost its significance. *Id.* at 1537-38. This loss of significance for number of references in the multivariate analysis is almost certainly caused by the interaction between numbers of prior art references and numbers of claims. For discussion of the correlation between the number of claims and number of prior art references, see Allison

using maintenance fees as an indicator of value in our work, the relation between maintenance fees and the indicators on which we rely buttresses the premise of this study.

Patent Families. The last important indicator of value used in the existing literature is the number of countries in which the owner has obtained patent protection on the same invention (often referred to as a "patent family"). This makes sense because of the large expense of patenting in a number of different countries. For example, Jean Lanjouw and Mark Schankerman have developed a patent quality index that relies on the number of claims in the patent, prior art references in the patent, the number of forward citations to the patent, and the number of countries in which the patentee sought protection for the invention.[67] Although the number of countries in which an applicant seeks patents on the same invention is almost certainly a valid value indicator, it would have little if any meaning in our study because innovation and patenting in the software industry is dominated so completely by the United States.

3.   *Our Approach*

Writing against the backdrop of that literature, we decided for our assessment of the quality of software patents to focus on the three data points that dominate the existing empirical literature: the number of claims in the patent, the number of prior art references in the patent, and the number of forward citations to the patent. In an effort to obtain more nuanced information about the nature of patenting in the industry, we broke down two of those three principal variables into sub-categories. First, we analyzed not only total claims, but also independent

---

& Tiller, *supra* note 23, at 1055 (showing high correlation between number of claims and number of prior art references).

claims.[68] Second, we broke down total prior art references in the patent into three categories: U.S. patent, foreign patent, and non-patent prior art ("NPPA").[69] Given the wide disparity in the informational value of NPPA, we also make a rough estimate of the informational quality of the NPPA, categorizing those references to provide rough measure of the likely objectivity, accuracy, and reliability of the references. We thought this breakdown would be particularly useful given the limited role of foreign patent references and the relatively high value of non-patent references.

In total, this produced seven different data points that we could use to describe the patents: the numbers of total claims, independent claims, total references, U.S. patent references, foreign patent references, non-patent references, and forward citations.[70] Table 2 sets forth some

---

[67] Jean O. Lanjouw & Mark Schankerman, Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators, 114 ECON. J. 441 (2004).

[68] The only previous analysis of independent claims separately from total (independent plus dependent) claims appears in Allison et al., *supra* note 29, at 451-52, 478-79. The large population study reported in that paper analyzed only the number of total claims and, using a multivariate logistic regression, found a highly significant relationship between number of total claims and litigation (litigated patents being viewed as a subset of valuable patents) (p = <0.0001). *Id*. at 478. The smaller, more finely graded sample study reported in that paper analyzed the number of independent and dependent claims separately. Bivariate analysis showed highly significant relationships between number of both independent and dependent claims and the fact that the patents were litigated (p = 0.0011 for independent claims and 0.0044 for dependent claims). *Id*. at 452 n.68. When using a multivariate logistic regression for the sample study, the positive relationship between number of independent claims and litigation remained highly significant (p = 0.006), but the relationship between number of dependent claims and litigation ceased to be significant at the .05 level although significant at the .10 level (p = .08). *Id*. at 452 n.68, 479.

[69] Delphion shows both the references themselves and the number of references for U.S. and foreign patents. For non-patent references, however, Delphion only shows the references themselves and does not report a count. Moreover, these references are run together as lines in a text file. We developed a computer program to count the number of non-patent references.

[70] Because some of the patents issued quite recently, there is a substantial amount of truncation in the forward citations. Accordingly, although Table 2 reports a simple descriptive statistic for the entire dataset, our statistical analysis follows Jaffe & Trajtenberg in analyzing for each patent the number of forward citations divided by the average number of citations for a patent applied for in the same year. See ADAM B. JAFFE ET AL., PATENTS, CITATIONS, AND INNOVATIONS: A WINDOW ON THE KNOWLEDGE ECONOMY 438 (2005).

simple descriptive statistics for those variables for the entire dataset, including both software and

non-software patents.

TABLE 2: DESCRIPTIVE STATISTICS

VARIABLE	MEAN	MEDIAN	MIN	MAX	SD	MEDIAN (BOTTOM DECILE)	MEDIAN (LEAST CITED)
TOT. CLAIMS	20.1	18	1	318	13.8	4	16
IND. CLAIMS	3.7	3	1	92	2.7	1	3
TOT. REFS	16.0	11	0	470	22.9	3	9
U.S. PAT. REFS	11.8	9	0	352	14.3	2	8
FOR. PAT. REFS	0.9	0	0	88	2.5	0	0
NON-PAT. REFS	3.3	1	0	396	12.8	0	0
FORWARD CITATIONS	6.7	3	0	291	10.3	0	--

As the large standard deviations suggest, there is a great variety among our patents in the potential indicators of quality. To quantify that variation, the last two columns in Table 2 describe the worst of the patents by two separate metrics: the median of the bottom decile of each characteristic, and the median on each characteristic of the bottom decile of patents by forward citations. As those columns show, a substantial number of patents fare poorly on the metrics we examine. Most notably, one in twenty of the patents have three references or fewer, a strikingly low number for any field of search. Thus, although the data do undermine the idea that software patents *as a class* are notable for their poor quality, they suggest at the same time that a meaningful number have poor quality.

B. Software and Non-Software Patents

The central question is whether information about the characteristics of software patents on the data points summarized in Table 1 suggests that software patents are "better" or "worse" in some objective way than other patents. The problem in answering that question lies in selecting an appropriate baseline. If we were to match the patents to randomly selected patents issued on the same dates, we might determine how software patents differ on the selected

characteristics from typical patents. However, we ultimately concluded that the most informative way to evaluate these patents was to compare the software patents in the dataset to the non-software patents. This provides a sample of patents obtained by the same set of firms during the same periods, with the only difference being between the particular types of technology covered by the patents.

Using that metric, we compared the software and non-software patents among the 20,000 patents issued to firms other than IBM (about 68% of which are software patents). As Table 3 illustrates, the software patents (SWP) had significantly more total prior art references, claims, independent claims, and forward citations than the non-software patents (NSWP). All of those differences are significant at least at the 99% level (that is, $p = 0.01$ or less).[71] For comparative purposes, we include parallel data on the number of claims and references from the roughly contemporaneous sample of 1,000 randomly selected patents that John Allison and his co-authors analyzed in *Valuable Patents*.[72] Because the general patents for the most part have even lower indicators of quality than the non-software patents in our dataset, that comparison further buttresses our result.

---

[71] We analyze the differences in Table 3 with a two-sample t test with equal variances. As the Statistical Appendix discusses, we investigated the robustness of those differences with a variety of controls and multivariate regression models, which buttress the results discussed in the text.

[72] Allison et al., supra note 29.

TABLE 3: SOFTWARE AND NON-SOFTWARE PATENTS

	MEAN	MEDIAN	SD	N
TOT. CLAIMS				
SWP	22.9	20	15.4	14,044
NSWP	17.8	17	12.4	5,804
GENERAL	14.9	12	11.5	1,000
IND. CLAIMS				
SWP	4.2	3	2.9	13,266
NSWP	3.4	3	2.5	5,694
ADJ. FORWARD CITATIONS				
SWP	1.1	.64	1.46	14,042
NSWP	1.0	.49	1.24	5,799
TOTAL REFERENCES				
SWP	18.5	11	30.5	14,044
NSWP	14.1	10	16.6	5,804
GENERAL	15.2	10	16.3	1,000
U.S. PATENT REFERENCES				
SWP	12.7	8	18.3	14,044
NSWP	11.1	8	13.4	5,804
FOREIGN PATENT REFERENCES				
SWP	.84	0	2.82	14,044
NSWP	1.3	0	2.8	5,804
NON-PATENT REFERENCES				
SWP	5.0	1	17.9	14,044
NSWP	1.6	0	4.9	5,804

Generally, those results suggest a sanguine picture of the quality of software patents. To be sure, as we discuss in Part IV, it is likely that the differences between software patents and non-software patents depend at least in part on aspects of software patent drafting and software

technology. The data do cast doubt, however, on broad assertions and anecdotal suggestions that software patents as a class are of lower quality than patents in other areas of technology. Given the academic literature discussed in the preceding section that links the indicators in Table 3 to various indicators of the post-hoc value of the patent, the evidence we present here suggests that any problems with quality are at a much more subjective (and difficult to detect) level.

The data on types of prior art references is particularly reassuring, because the differences between software and non-software patents display a pattern that is consistent with the reality of software patent drafting. First, the subcategory of foreign patent references is the only one of our seven data points that appears in software patents with a lower frequency than in non-software patents. However, the relative paucity of software patents in other countries[73] and the centrality of the United States to software innovation make the infrequency of foreign references entirely predictable.

Similarly, the recent rise of software patenting suggests that software patents would have many more non-patent references than non-software patents. The difference between software and non-software patents in the number of non-patent prior art (NPPA) references is stronger than the difference on any other data point. To provide a better understanding of the nature of the prior art, we examined the NPPA in a random sample of 200 software and 200 non-software patents from our dataset.[74]

---

[73] See, e.g., FLORIAN MUELLER, NOT LOBBYISTS AS SUCH (2005) (discussing failure of efforts to authorize software patents in the EU).

[74] We also analyzed the NPPA references in a random sample of 50 IBM patents, 33 of which turned out to be software and 17 non-software. The amount of NPPA in these patents was so small that we have not reported it in table form. Only 12 out of the 33 IBM software patents, and 7 out of 17 non-software patents cited any NPPA at all. One notable fact about the NPPA in the 50 IBM patents, however, is that, in the 12 out of 33 software patents that cited at least some NPPA, 35 out of 46 total NPPA references (76%) were cites to academic literature. In the 7 out of 17 non-software patents that

For a large set of patents, there is no practicable way to make quality distinctions among the *patents* referred to therein as prior art, that is, there are no feasible means to assess the informational value of such references in a large data set. NPPA references are, however, susceptible to such quality distinctions because they can be classified in various ways to roughly reflect the probable accuracy, reliability, and objectivity of information contained in them. Any typology of the many kinds of printed publications (NPPA) is necessarily subject to some subjectivity and uncertainty, but it is possible to categorize NPPA to provide some assessment of relative informational value. The appendix describes our typology of NPPA, developed by one of the authors and his coauthors for two previous research projects.[75]

Table 4 shows the results of our study of the NPPA references in a random sample of 200 software patents and 200 non-software patents. Although our purpose here is to assess the NPPA qualitatively, the differences in the quantity of NPPA between the two samples are striking. Non-software patents cite less than 25% of the NPPA cited in software patents. Moreover, 63.5% of non-software patents cite no NPPA at all, while only 34.5% of software patents fail to cite any NPPA. On the other hand, our categorization of NPPA suggests that the NPPA that *is* cited in non-software patents is not qualitatively inferior to that cited in software patents. A significantly higher percentage of the NPPA found in non-software patents consists of academic

---

cited at least some NPPA, only 5 out of 15 total NPPA references (33%) were cites to Academic literature.

[75] See Allison & Tiller, supra note 23, at 1045-1052. This typology was created by carefully studying the NPPA references in over 100 randomly selected Internet-related business method patents and over 100 randomly selected patents-in-general, and defining categories based on the nature of the reference sources we found in those patents. Id. at 1046. The categories were slightly modified in the second article in which one of the authors and another coauthor analyzed the sources of NPPA references. See Allison & Hunter, supra note 53, at 741-742. In the first article, the typology combined academic and trade publications. Because of experience subsequently gained, in the second article we felt more confident in our ability to distinguish academic and practitioner-oriented trade journals and separated them into two categories. We separate them in the current study.

literature, although the gap closes considerably when we combine academic and trade publications. On the other hand, software patents include a substantial number of references to the popular press. But it is difficult to weigh the presence of those references heavily when we notice that, generally speaking, the amount of academic prior art in software patents is more than the total amount of non-patent prior art in non-software patents. Still, using our categories of NPPA as rough proxies for informational quality, non-software patents fare at least as well as software patents, and perhaps a bit better.

TABLE 4: NPPA IN SOFTWARE AND NON-SOFTWARE PATENTS

	Mean	Median	Std. Dev.	Min	Max	N	% of Total NPPA
Academic							
SW	2.60	0	0.43	0	40	519	37.45%
NSW	1.16	0	3.91	0	30	232	68.24%
Trade							
SW	1.75	0	1.01	0	200	349	25.18%
NSW	0.09	0	0.42	0	3	18	5.29%
University							
SW	0.23	0	0.08	0	14	45	3.25%
NSW	0.06	0	0.41	0	5	12	3.53%
Software							
SW	0.25	0	0.07	0	11	49	3.54%
NSW	0	0	0	0	0	0	0%
Patent Related							
SW	0.26	0	0.09	0	14	51	3.68%
NSW	0.11	0	0.51	0	4	21	6.18%
Govt Doc							
SW	0.13	0	0.06	0	10	26	1.88%
NSW	0.07	0	0.35	0	3	14	4.12%
Comp/Ind							
SW	0.92	0	0.17	0	19	183	13.20%
NSW	0.22	0	0.71	0	5	43	12.65%
Popular Press							
SW	0.82	0	0.77	0	154	163	11.76%
NSW	0	0	0	0	0	0	0%
Other							
SW	0	0	0	0	1	1	0%
NSW	0	0	0	0	0	0	0%
Total							
SW	6.93	1	28.7	0	384	1386	100%
NSW	1.7	0	4.44	0	31	340	100%

C.   Patent Quality and Firm Specialization

The next subject that we analyze is the difference in patenting among the types of firms in our dataset. We examine that question in two different ways: comparing firms that specialize in software to those that have more varied product lines, and considering a small set of very large firms to our broader dataset. Generally, we find that the patents of pure software firms are of higher quality than those of firms that are not pure software firms. That finding is not surprising, because it is consistent with the discussion above. More surprising, however, given the persistent criticisms large firms have leveled at the patents of small firms, is the finding that, broadly speaking, there are few notable differences between the patents of large firms and those of the industry as a whole.

1.   Patenting by Pure Software Firms

First, we consider the possibility that the patents that pure software firms obtain are "better" (or "worse") in some cognizable way than parallel patents obtained by firms that are not pure software firms. We are motivated to examine this question because of the apparent differences in culture and business strategy between pure software firms (like Microsoft, for example) and the large number of electronics firms that are important software developers and patentees in our dataset (IBM being the most obvious example).[76]

For these purposes, we decided (somewhat arbitrarily) to treat firms with 80% or more of their revenues from software as "pure" software firms and those with less than 80% of their revenues from software as mixed software firms. Under this definition, of the 294 firms in our data set to which patents were issued during the five-year period (70% of the firms obtaining no

---

[76] Allison et al, supra note 1, includes a detailed discussion of the differing exploitation strategies of incumbents, venture-backed startups, open-source developers, and independent developers.

patents during that period), 208 (71%) were pure software firms and 86 (29%) were mixed firms. One reason to think that this division should be important for patenting practices is that the patents of the software firms were almost exclusively software patents (3,948/4006 or 99%), while the patents of the mixed firms were only 64% software patents (10,092/15838).

Surprisingly, the software patents obtained by software firms differed significantly in all relevant respects from the software patents obtained by non-software firms.[77] As we report in Table 7 in the Statistical Appendix, the results are strikingly similar to the results in Table 3: strong relations for numbers of total claims, independent claims, foreign patent references (negative), and non-patent references, the only difference being a significant finding here for adjusted forward citations. The last finding, showing that later patents cite the software patents of pure software firms significantly more, suggests that the software patents of software firms are more rapidly integrated into future software innovation than the software patents of mixed software firms.

That finding parallels the recent finding of Graham & Mowery that the quality of patents (measured solely by number of forward citations) held by software firms is higher than the quality of patents held by electronics firms. They attribute this distinction to greater strategic patenting by electronics firms (that is, patenting for occupying general fields of technology rather than for protecting products of the patentee).[78] Our data make us skeptical of that explanation, primarily because the non-software patents held by pure software firms do not differ nearly so much from the non-software patents held by mixed software firms as do the respective sets of

---

[77] In a related paper using this same dataset, Allison et al., supra note 1, we find no significant relation between the share of a firm's revenue attributable to software sales and either the rate of patenting or propensity to patent.

[78] Graham & Mowery, supra note 14, at 24.

software patents. Of course, it is possible that there is more likely to be strategic patenting by

electronics firms use strategic patenting more aggressively in the software area than they do in

non-software areas. It seems more likely to us, however, that the differences reflect the

interaction of two distinct effects: software patents tend to have more substance (claims,

references, and citations) than non-software patents, and pure software firms are better able to

integrate their software patents into their subsequent development efforts.

2.   Patenting by Superpatentees

To get at the possibility of cultural differences in a different way, we also compared the

software patents of fifteen "superpatentee" firms to the software patents of other firms in our

dataset – the superpatentee firms being those firms that were in the dataset for each of the five

years and that have at least 50 total patents.[79] Here, as Table 8 summarizes, we found to our

surprise no significant differences between the software patents of the superpatentee firms and

the software patents of other firms in our dataset. Among other things, the data replicate the

large standard deviations that characterize the software patent data for our larger dataset: even

for the superpatentee firms a substantial number of the patents have strikingly few claims,

references, and forward citations.

Attempting to investigate the question more precisely, we then analyzed the software

patents of superpatentee firms on a sector-by-sector basis, grouping the firms into electronics

---

[79] The firms are Apple, EMC, HP, NCR, Qualcomm, Sun, Adobe, Autodesk, Computer Associates, Microsoft, Oracle, Sybase, Synopsys, EDS, Mentor Graphics, Novell, and Unisys. We exclude IBM from the list because (as explained above) we did not review IBM's patents to divide the software patents from the non-software patents.

firms, prepackaged software firms, and system design and processing firms.[80]   Generally, as Table 9 summarizes, our data buttress the discussion above, indicating that the distinctive software patents are most likely to be found among the relatively pure prepackaged software firms. Specifically, we find for those firms robust positive differences related to the numbers of total claims and independent claims, with marginally significant negative differences related to the number of U.S. patent references and foreign patent references.

But putting that narrow finding to one side, we are struck by our inability to find substantial differences in quality based purely on the size of the firms. As we discuss below, we think that has important implications for the course of patent reform.

D.   Patent Quality over Time

Our last inquiry into patent quality relates to the quality of the relevant patents over time. If the focus of the concern about quality is that the quality of software patents has been degrading rapidly since the legal environment became more conducive to them in the mid-1990's, a discussion of the quality of software patents must include some information about how their quality has changed over time.

Because the dataset described above is limited to patents issued between 1998 and 2002, we used for this analysis a separate dataset of all patents issued to the fifteen superpatentee firms discussed above, based on applications filed since 1990. This allows us to collect evidence about how our various indicators of patent quality changed during the 1990's for the largest firms in

---

[80] The firms are distinguished by three-digit NAICS codes: 334 for the electronics firms (Apple, EMC, HP, NCR, Qualcomm, and Sun), 511 for the prepackaged software firms (Adobe, Autodesk, Computer Associates, Microsoft, Oracle, Sybase, and Synopsys), and 541 for system design and processing (EDS, IBM, Mentor Graphics, Novell, and Unisys).

the three major sectors of large patentees discussed above.[81] To be sure, this data set is much less inclusive than the dataset we analyze above. Moreover, this set of data does not focus solely on software patents, because we did not individually separate software from non-software patents. Still, it is likely that most of these patents disclose software inventions because of our limitation to the group of software superpatentee firms. Thus, this data set does provide considerable evidence about trends in software patenting quality over time in the industry.

Generally, the data suggest that the quality of patents did not degrade substantially during the 1990's. For example, as Figure 1 shows, there has been a slow but steady increase in the number of independent claims for electronics and system design firms. By contrast, the number of independent claims in patents by prepackaged software firms rose much more rapidly until 1994, but fell since then to a level that approximates the level of the other sectors. It is apparent that events at the middle of the decade affected the patenting practices of prepackaged software firms (sector 2 in Figure 1) differently than the practices of the large firms in the other sectors. A possible explanation is that legal rules making it easier to patent software inventions more directly lessened the need for circuitous claim drafting and thus lowered the number of claims necessary for a sophisticated patentee to describe a particular invention. In any event, none of the three sectors had fewer independent claims in 2002 than in 1990.[82]

---

[81] Because of concerns about truncation because of as-yet-unissued patents, the analysis in this section ends with patents for which applications were filed in 2002.

[82] Data on total claims shows a similar pattern.

FIGURE 1: INDEPENDENT CLAIMS OVER TIME
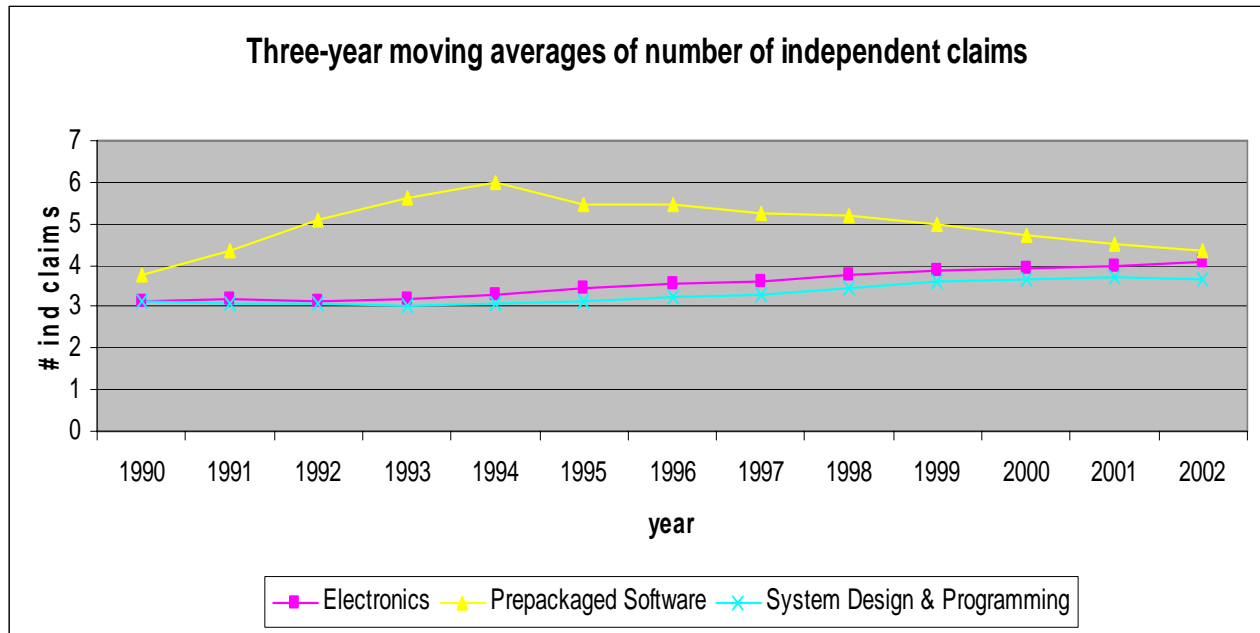
Figures 2 and 3 summarize parallel data on total prior art references and U.S. patent references, which show a steady rise throughout the 1990's, with the patents of prepackaged software firms trending upward substantially more rapidly than those of firms in the other sectors. Again, it is clear that the time pattern of the patents of prepackaged software firms is different from the pattern of patents of other firms, but the pattern suggests if anything that those patents gained in references even more rapidly than the patents of firms in other sectors. Presumably this is because of the rapid increase in innovation in that sector, which provided a steadily increase of relevant prior art appropriate for citation.

FIGURE 2: TOTAL REFERENCES OVER TIME
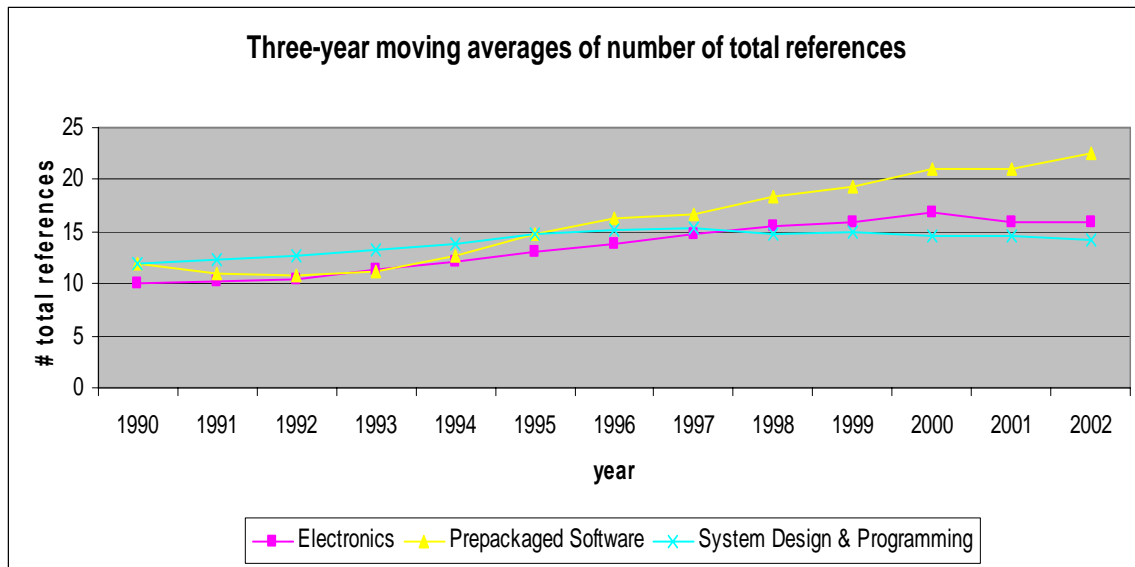
FIGURE 3: DOMESTIC REFERENCES OVER TIME
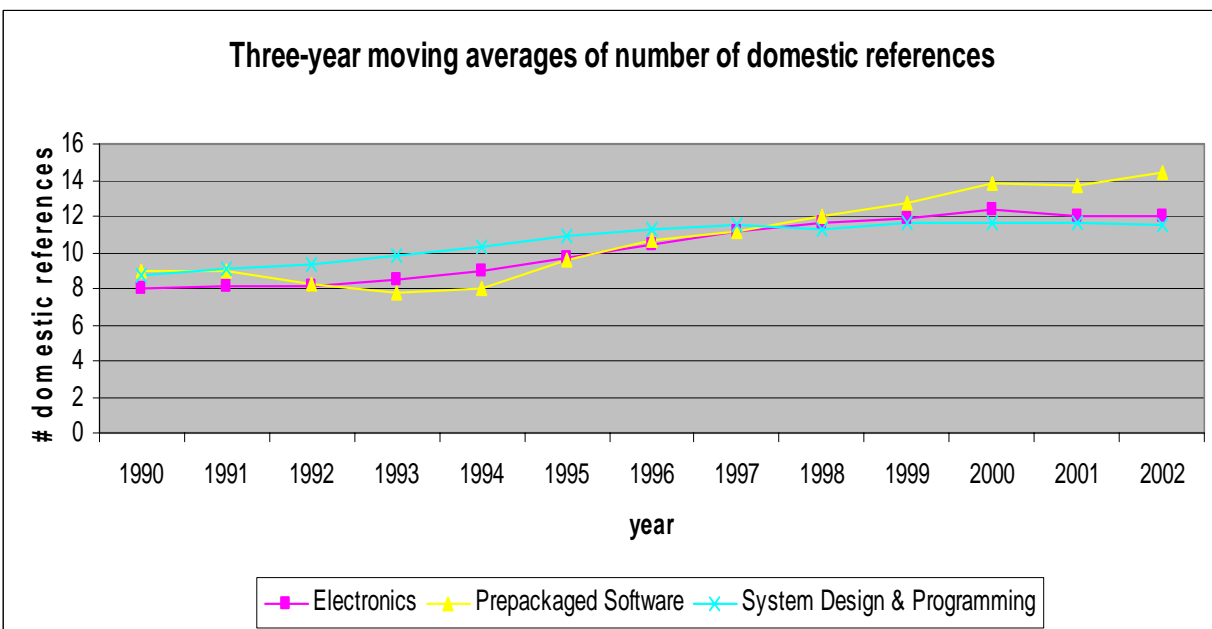
We emphasize that these time patterns do not prove that the patterns of prepackaged software firms were "better" than the patents of firms in the other sectors. They do make it

harder, however, to credit the common assertion that software patents declined rapidly in quality during that period.

IV.   IMPLICATIONS AND CONCLUSIONS

As the discussion above emphasizes, our work is suggestive. The complexity of the questions that we investigate makes definitive answers almost impossible. Thus, for example, although we believe that our definition and method of identifying a software patent is better than those used by others in the existing literature, we recognize that others may find other approaches more appealing, largely because of the huge opportunity costs associated with manual examination of large datasets of individual patents. However, the difficulty other scholars will find in using our definition makes this work all the more valuable, because we can provide an unparalleled examination of patents on software inventions based on a patent-by-patent review.

In our view, the data are important for two separate reasons. First, the data substantially undermine the traditional story that large firms in the software industry are plagued by a large number of low-quality patents obtained by the smaller firms in the industry. On the contrary, by objective standards, the software patents as a class compare quite favorably to patents that the same firms are obtaining at the same time on non-software inventions. Similarly, the patents obtained by small firms are no worse than the patents of the large firms.

Those findings have in our view twin implications for patent policy. The first is the simplest: they undercut the common suggestions that software patents should be prohibited entirely or should face special hurdles for examination designed to stem the alleged flood of low-quality patents. If in fact there is no flood of low-quality patents, then there is little reason to take aggressive action to respond. The second implication is more speculative, but rests on the

idea that the effort of the drafter does not depend substantially on the size or patenting experience of the drafter. To the extent that this is true, our findings undermine the concern that small firms will suffer disproportionately from reforms that raise the bar for patent grants, such as increased examination fees, special procedures for "gold-plated" patents, or additional opportunities for pre-grant opposition. If patent drafting is a routine exercise in which firms of all sizes do a better (or worse) job based on the incentives that the PTO's procedures present, then this presents a reasonable case for reforms designed to reward applicants that put more effort into their application or who are willing to provide more credible support for their application (as evidenced by a willingness to submit their application to a more onerous process).

In addition to their implications for policy, our findings provide a rare empirical illustration of the context of patent drafting. For example, the findings on prior art references seem to match up well with anecdotal understandings about the software industry indicating that until recently there were relatively few United States patents and very few foreign patent references available, but a relatively large amount of non-patent prior art. First, the centrality of U.S. firms to cutting-edge software innovation provides emphatic support for the finding that software patents cite relatively few foreign patent references. Similarly, the fact that we are still early in the era of routine software patenting suggests that, at least as compared to other fields of technology, the balance of patent and non-patent prior art should be weighted more heavily to non-patent prior art.

Second, our findings regarding the number of total and independent claims rest at least in part on techniques of software patent drafting. This is particularly true in the case of "pure" software patents, those covering inventions that consist solely of software rather than inventions in which software is merely a critical part. Allison's examination of tens of thousands of patents

over the last decade persuades him that software patent applicants are more likely than other patent applicants to claim software inventions in duplicative ways within a given patent. Therefore, for example, software patents often include separate sets of claims that characterize the invention as a method (or process), a machine or apparatus (or "device"), and a "system."[83]

We posit two possible explanations. First, it could depend on habits developed in earlier years, when doubt about the patentability of pure software suggested that it was important for the patent to show some "physical transformation." In that era, it was common for software patents to claim as machines or devices with terminology from the older mechanical and electronic arts, often describing a phantom physical structure in the specification and then claiming the invention as a "means" for performing certain functions.[84] Later, when it became clear that pure software was patentable, applicants began to claim software inventions directly as methods, systems, and so on, but often they still included the older claiming formats.[85] Moreover, even now, many modern software patents do cover inventions that have physical elements as well as software elements. In those cases, it is quite natural to use a number of different claim formats in the same patents.[86] To be sure, patents on other types of inventions often claim an invention using two or more claim formats, but the tendency is more pronounced for software patents, likely accounting for a portion of the finding that software patents have more total and independent claims. Second, by its nature, a software invention can be conceptualized in more different ways than many other types of invention. Unlike inventions in most other fields, it is

---

[83] See, e.g., U.S. Patent No. 5,886,634, Item removal system and method (filed May 5, 1997).

[84] See, e.g., U.S. Patent No. 5,440,676, Raster scan waveform display rasterizer with pixel intensity gradation (filed Jan. 29, 1988).

[85] See, e.g., U.S. Patent No. 6,418,443, Hot spot analysis of IMS databases (filed Feb. 1, 2000).

[86] See, e.g., U.S. Patent No. 6,352,344, Scanned retinal display with exit pupil selected based on viewer's eye position (filed Feb. 14, 2001).

not unusual to simultaneously regard software as a method or process, a machine or device, a system, and a means for performing specified functions.

Third, the relatively high number of forward citations could partly reflect the fact that software is a hot area for innovation; it is likely that there will be more patents issued in technological areas related to software than in other technological areas. This phenomenon would lead, in due course, to a substantially greater number of forward citations for software patents than for non-software patents.

If those features of the software patenting environment lead directly to the relatively high quality indicators of the patents in our database, then scholars will need to proceed with care before adapting the existing "valuable patent" methodology – honed for the most part on economy-wide studies of large datasets – to studies of patent quality in particular industries. To make comparative judgments about patent quality in particular industries, it is necessary to develop quantitative measures of the environment for patenting, as it exists in each industry. In this context, however, the juxtaposition of findings persuades us that the best explanation of our data is the optimistic one. It is possible for the skeptic to explain away the significance of each of the separate quantitative findings about software patents – as the last few pages have attempted to do. But there comes a point where the need for so many complex explanations suggests that the simpler explanation is the better one: software patents as they have been issued in this country to software firms starting in the late 1990's in fact display impressive objective indications of quality.

A.   *Software and Non-Software Patents*

To test the robustness of the simple t-tests that we report in the text, we introduced a number of controls. Our analysis treats of our seven potential indicators of quality as alternative dependent variables. For each of those variables, we conducted a series of multivariate linear regressions that included several controls in addition to the software patent/non-software patent variable: year dummies (to account for the changes in the relevant characteristics over time),[87] industry sector dummies (to account for the differences in technology in different sectors of the software industry), and a pure-software firm dummy (that distinguishes between firms that obtain 80% or more of their revenue from software and those that have substantial non-software product lines). To control for problems of autocorrelation, we cluster the standard errors for each firm. *See* W.H. Rogers, *Regression Standard Errors in Clustered Samples*, 13 STATA TECHNICAL BULLETIN 19 (1993).

The first two columns of Table 5 report the results of those regressions (the coefficient on the SWP variable as an independent variable) for each of the different dependent variables. They confirm the central results in Table 3 with respect to claims, independent claims, foreign references and other references. The results for adjusted forward citations do not hold up as consistently in the various regression models, but we do not weigh that analysis heavily, because of the likelihood that the combination of the

truncation of those data and our Jaffe-Trajtenberg[88] adjustment have diluted the ability of

our data to provide information on that question. With respect to prior art references in

the patents, we note that the models discuss below suggest that the significance of the

number of total prior art references and U.S. patent references is unstable. Still, the

number of foreign patent references is significantly lower in software patents and the

number of non-patent references is significantly higher (both as in Table 3 and as

discussed in the text).[89]

TABLE 5: SOFTWARE PATENT REGRESSION MODELS

DEPENDENT VARIABLE	LINEAR COEFF.	LINEAR T-STAT.	XTREG FE COEFF.	XTGREG FE T-STAT
TOTAL CLAIMS	1.87	4.09	1.98	7.50
INDEPENDENT CLAIMS	0.38	3.24	.41	7.87
ADJ. FORWARD CITATIONS	.09	1.13	.06	2.18
TOTAL REFERENCES	2.31	2.81	2.69	5.41
U.S. PATENT REFERENCES	0.04	0.04	.21	0.68
FOREIGN PATENT REFERENCES	(.50)	(2.45)	(.49)	(10.35)
NON-PATENT REFERENCES	2.77	5.28	2.97	10.47

---

[87] We attempted to analyze the nature of the changes over time, but the coefficients and t-statistics on the dummies for the individual years were unstable and did not display any obvious pattern. Accordingly, we do not report that information here.

[88] See supra note 70 and accompanying text.

[89] We conducted similar regressions to consider whether IBM patents (almost half of our dataset) differ from patents held by other firms. Those regressions suggested that IBM patents generally have fewer claims, references, and forward citations. We do not weight those results heavily (and do not report them here) because they seem to reflect the fact that the share of IBM's

We next estimated a firm-level fixed effects model (using the xtreg function in Stata). This truncates our data considerably, because it analyzes only the patents of those firms that have both software and non-software patents). Nevertheless, as the third and fourth columns of Table 5 report, those regressions produced results quite similar to those from the simple linear regressions reported in the first two columns of Table 5. To control for skewness, we also conducted a parallel set of regressions using the log of the dependent variables and poisson regressions. {We use poisson regressions rather than logs for the data on adjusted forward citations because many of the datapoints are zero.} Table 6 reports those results, which are quite similar to the results in Table 5. Finally, although we do not report them here, we also estimated parallel models controlling for for both national and international patent classes. The results are similar to those in Tables 5 and 6.

---

patents that are software patents (55% by our estimate) is smaller than the share of the patents of other firms in our dataset that are software patents (68%).

TABLE 6: CONTROLS ON SOFTWARE PATENT REGRESSIONS

DEPENDENT VARIABLE	COEFF. (T) ON LOG OF DEPENDENT VARIABLE	XTREG FE COEFF. (T) ON LOG OF DEPENDENT VARIABLE	POISSON COEFF. (Z)	XTPOISSON FE COEFF. (Z)
TOTAL CLAIMS	.10 (4.33)	.11 (8.27)	--	--
INDEPENDENT CLAIMS	.13 (4.71)	.13 (11.32)	--	--
ADJ. FORWARD CITATIONS	--	--	.10 (1.15)	.05 (2.76)
TOTAL REFERENCES	.05 (0.58)	.07 (4.27)	--	--
U.S. PATENT REFERENCES	-.009 (-0.13)	-.002 (-.12)	--	--
FOREIGN PATENT REFERENCES	-.14 (-4.08)	-.13 (-4.79)	--	--
NON-PATENT REFERENCES	.23 (4.00)	.30 (9.48)	--	--

B.   *Non-Patent Prior Art (NPPA)*

When there was any doubt about how to categorize a particular reference, we searched the Internet as thoroughly as necessary to achieve a high degree of confidence about the appropriate classification. Our nine categories of NPPA are as follows:

(1) **Academic Publications:** This category represents publications of a type for which there is an *independent intermediating influence* such as one or more editors or referees to increase the probability of accuracy, reliability, and objectivity, and which are targeted primarily at an *academic, scholarly* audience. Academic books, book chapters, journal articles, and academic proceedings papers, which have been independently screened for accuracy and objectivity, are the primary components of this category.

(2) **Trade Publications:** This category includes trade books and chapters, trade journal articles, and similar items.   Trade publications are targeted primarily at a *practitioner* audience rather than an academic one, and *report on* developments in a field rather than create new knowledge in that field as academic works are more likely to do. Like academic publications, trade publications are a type of nonpatent prior art for which there is an *independent intermediating influence* such as one or more editors or referees to increase the probability of accuracy and objectivity. Although these publications are quite unlikely to be subject to the same degree of rigorous peer review as academic publications, they nevertheless constitute prior art of relatively high quality and are a good reflection of the state of the art at the time of publication.

(3)   **University Publications:**   This category includes publications from universities or consortia of universities, such as those from university research labs, departments (such as computer science, electrical engineering, information systems, business, etc.), individual faculty, and graduate student theses/dissertations.   Because these types of publications are developed in an environment of objective academic inquiry, they typically will be prior art of good quality although this quality is probably quite variable.

(4)   **Software:**   This category includes software programs and software documentation. These are separated from other company- or industry-sponsored publications because of their functional nature and obvious need for a high degree of accuracy and objectivity compared with less functionally motivated company-sponsored prior art.   Software and software documentation therefore represent prior art of comparatively high quality.

(5) **Patent-Related:** This category includes published patent applications and patent office search reports, such as PCT (Patent Cooperation Treaty) and EPO (European Patent Office) search reports. Such publications are likely to be of highly variable quality as prior art. Published patent applications are of uncertain quality as prior art because they have not yet been examined or otherwise tested. Published search reports are likely to be more objective and reliable than published applications because of the involvement of independent search authorities.

(6) **Government Documents:** This category includes documents published by U.S. and foreign governments and by international government organizations such as the World Intellectual Property Organization (WIPO), as well as web sites sponsored by such entities. The category does not include U.S. and foreign patent-related documents such as published patent applications and search reports, which are treated separately because of their special nature. The quality of government documents as prior art is likely to be extremely variable.

(7) **Company/Industry Publications:** This category includes press releases, web sites, advertisements, technical disclosure bulletins, and various other publications that were produced by individual companies or industry groups and published with *no independent intermediating influence* to increase the probability of accuracy and objectivity. It does not include software & software documentation, however, because the latter are sufficiently distinct from and inherently more reliable than other types of publications from companies or industry groups. After removing software and software documentation from the category, company- and industry-sponsored publications overall cannot be treated as high quality prior art.

(8) **Popular Press:** This category includes not only newspapers, magazines, & other publications of general interest, but also news publications aimed at general business and legal audiences. The relative quality of such publications varies greatly, but overall is relatively low.

(9) **Other:** Includes sundry items such as individual web pages, but most references placed in this category are those in which insufficient information was provided for determining what the item really was, even after we conducted a thorough Web search of key names & terms in the incomplete reference. One example is a reference to a partial title of an item, followed by "found on the web on x date."

C.   Pure and Mixed Software Firms

TABLE 7: PURE AND MIXED SOFTWARE FIRMS

DEPENDENT VARIABLE	SW_SWF COEFF. (T)	NONSW_SWF (T)
TOTAL CLAIMS	5.83 (5.30)	4.62 (2.88)
INDEPENDENT CLAIMS	.73 (2.17)	.334 (1.24)
ADJ. FORWARD CITATIONS	.16 (1.84)	.056 (0.25)
TOTAL REFERENCES	2.19 (1.34)	-.43 (-.26)
U.S. PATENT REFERENCES	.666 (0.47)	-1.68 (-1.27)
FOREIGN PATENT REFERENCES	-.07 (-0.38)	-.30 (-.64)
NON-PATENT REFERENCES	1.59 (3.04)	1.56 (2.51)

The results here reflect linear regressions on our seven dependent variables comparing software patents obtained by pure software firms to software patents obtained by mixed software firms, controlling, as in Tables 4 and 5, for year and sector and clustering on the individual firm. The first column compares software patents obtained by pure software firms (SW_SWF) to software patents obtained by mixed software firms.

The second column compares non-software patents obtained by pure software firms (NONSW-SWF) to non-software patents obtained by mixed software firms.

C.   Superpatentees and Other Software Firms

TABLE 8: SUPERPATENTEES AND OTHER SOFTWARE FIRMS

DEPENDENT VARIABLE	LINEAR COEFF. (T)	LOG COEFF. (T)	POISSON COEFF. (Z)
TOTAL CLAIMS	-1.21 (-0.65)	-.01 (-.08)	--
INDEPENDENT CLAIMS	.312 (1.12)	.081 (1.24)	--
ADJ. FORWARD CITATIONS	-.188 (-1.66)	--	-.163 (-1.68)
TOTAL REFERENCES	-4.24 (-1.49)	-.185 (-1.92)	--
U.S. PATENT REFERENCES	-3.65 (-1.73)	-.197 (-2.42)	--
FOREIGN PATENT REFERENCES	-.067 (-.33)	-.067 (-1.11)	--
NON-PATENT REFERENCES	-.529 (-.60)	-.120 (-1.09)	--

The results here reflect regressions on our seven dependent variables comparing software patents obtained by superpatentee firms to software patents obtained by other software firms, controlling for year and clustering on the individual firm. The first column reflects simple linear regressions. The second reflects regressions on the log of the dependent variable. As in Table 6, we use a poisson regression (reported in the third column) for adjusted forward citations, because of the large number of datapoints that are zero.

TABLE 9: PREPACKAGED SOFTWARE SUPERPATENTEES

DEPENDENT VARIABLE	LINEAR COEFF. (T)	LOG COEFF. (T)	POISSON COEFF. (Z)
TOTAL CLAIMS	3.34 (2.71)	.212 (4.14)	--
INDEPENDENT CLAIMS	1.01 (4.71)	.244 (5.12)	--
ADJ. FORWARD CITATIONS	-.064 (-0.61)	--	-.053 (-0.62)
TOTAL REFERENCES	-3.45 (-1.19)	-.065 (-0.76)	--
U.S. PATENT REFERENCES	-3.60 (-1.77)	-.152 (-2.19)	--
FOREIGN PATENT REFERENCES	-.34 (-2.00)	-.095 (-1.73)	--
NON-PATENT REFERENCES	-.49 (0.52)	.064 (0.77)	--