

Complementary Uses of Patents, Copyrights and Trademarks by Software Firms: Evidence from Litigation

Stuart Graham* and Deepak Somaya**

Corresponding author: stuart.graham@dupree.gatech.edu
The Business School at Georgia Tech
800 West Peachtree Street NW, Atlanta, GA 30332 USA
Tel: 404.385.5107 Fax: 404.894.6030

March 2004

Abstract:

This paper explores a fundamental question of innovation strategy: Are IP protections complements or substitutes? We employ litigation data on patents, copyrights, and trademarks to study the concurrent and overlapping IP protections used by software firms. Despite the relative weakening of legal copyright protection in the 1990s, we find a surprisingly large and growing reliance on copyright enforcement by software firms. While prior research, as well as the policy debate, has tended to view different types of IP as substitutes, we propose conditions under which they can act as complements. We design an empirical test that uses a fixed-effects seemingly-unrelated-regression (SUR) model to estimate the occurrence of litigation in patents, copyrights, and trademarks, and find evidence of complementarity between these different types of IP used by software firms.

Keywords: Patents, Copyright, Trademark, Software, Litigation, Complements and Substitutes, Intellectual Property Strategy, Intellectual Property Enforcement.

JEL Classification:

Intellectual Property Rights: National and International Issues--Patent Copyright (O340)
Technological Change; Innovation; Research and Development: General (6210)

* College of Management, Georgia Institute of Technology.

** Robert H. Smith School of Business, University of Maryland. Excellent research assistance was provided by Kenneth Liang, Deepak Iyengar, Mark Liu, Onur Tekinturhan and Brad Way. Somaya gratefully acknowledges research funding provided by the OECD under contract # JA00016602.

1.1 INTRODUCTION

Since Teece (1986), we have understood that competitive advantage in the knowledge economy is driven by the appropriability conditions that firms face. But in knowledge industries, where intellectual property (IP) protections are often crucial to firm success, we have had scant evidence on the role that IP protections play in capturing value, particularly when different forms of IP are used by firms concurrently. This paper explores a fundamental question of innovation strategy: Are IP protections complements or substitutes? An answer to this question is critical to our understanding of how firms can effectively implement strategies to capture value from innovation.

We approach this question by recognizing that the role IP plays in firm appropriability strategies has undergone considerable change over the last two decades. Since the October 1982 creation in the United States of a single appellate jurisdiction for patents in the Court of Appeals for the Federal Circuit, rates of patenting and patent litigation have grown rapidly in the U.S. Simultaneously, the overall legal and political environment in the U.S. is also believed to have become much more “patent friendly” (Merges, 1996; Merges and Nelson, 1994; Scotchmer, 1996; Kortum and Lerner, 1999). One manifestation of this patent-friendly institutional environment is the effective extension of patent protection to new “subject matter” areas, notably living organisms, computer programs, and business methods.

In the software industry, a mainstay of the knowledge-based economy, the extension of patent protection to computer programs has been controversial. In the early 1990s, spurred by court decisions and a Department of Commerce study, software

patenting acquired sudden legitimacy and experienced a dramatic surge (Graham and Mowery, 2003). This watershed event generated substantial academic and policy debate about the merits and potential pitfalls of the new property right (Samuelson, Denber and Glushko, 1992; Samuelson, Davis, Kapor and Reichman, 1994). As the influence of software patents grows in the Internet economy, in such areas as business methods and finance, new strategic opportunities are created for patentees and fresh policy concerns are raised (Lerner, 2000). The free and open-source software community has also voiced opposition to software patents. This community sees the open-source development model as an alternative to the property-rights model, and because patents play a prominent role in this latter model, the open-source community views patents as a threat to the success of the open source movement.

While much of the academic discussion has focused on policy questions concerning the type of intellectual property (IP) protection best suited to software, relatively little attention has been paid to the ways in which software firms use different types of intellectual property in practice. Graham and Mowery (2003) is an exception in that it analyzed both patenting and copyrighting activity in software, uncovering a declining trend in the propensity of firms to seek copyright registrations in the 1990s, while concurrently these same firms were increasing their propensity to patent. These findings have, however, been subject to criticism arising out of the inherent limitations of the copyright registration data. This paper uses intellectual property litigation data to overcome some of these limitations and finds that both patent and copyright litigation have grown at a very rapid pace in the 1990s. Because we use patent, copyright, and trademark litigation data

together, the analysis is able to redress, to an extent, the oft-criticized and excessive focus on patents in intellectual property research.

This juxtaposition of the use of patent, copyright and trademark by software firms suggests a potentially fruitful avenue for academic inquiry: examining the relationships among different types of intellectual property in the appropriability strategies of firms. In particular, it would be valuable to understand when and how different forms of IP protection act as substitutes or complements to each other. The theoretical literature has typically failed to consider the relationship between different forms of intellectual property, or when considering the relationship, such as in the case of the patent-secrecy tradeoff, has generally adopted the view that different forms of intellectual property protections are substitutes. Prior empirical research has also addressed this question to some extent through the analysis of survey data (Levin, Klevorick, Nelson and Winter, 1987; Cohen, et al., 2002), but the evidence appears to be mixed.

This paper seeks to examine the complementarity-substitution dichotomy in more depth, and thus fill an important lacuna. The software industry affords a unique opportunity to examine the research question due to the relevance of patent, copyright, and trademark protection to the same products and technologies. Moreover, this study can take advantage of the shift in the intellectual property regime in favor of patents for software as an exogenous shock that allows an examination of how changes in litigation are correlated between different types of intellectual property.

While patenting has played an increasingly prominent role in the software industry during the 1990s, relatively little is known about precisely how patents are used. It is

natural to assume that like other systems products industries, defensive patenting may be commonplace in the software arts, leading to cross licensing of patent portfolios, and counter-suits in litigation (Grindley and Teece, 1996; Hall and Ziedonis, 2001; Somaya, 2003a). Our paper evaluates the many roles that patents play in the software industry, and their relative importance when compared with similar industries. We find that using declaratory judgment suits—defensive suits that enable infringers to proactively have a patent declared invalid—is a disproportionately popular strategy in litigation involving packaged-software intellectual property.

The rest of this paper is organized as follows. Section two presents a brief background discussion of the software industry and the use of intellectual property by software firms. Section three provides an in-depth look at the enforcement of patents, copyrights, and trademarks in software, and compares various descriptive data relating to software intellectual property litigation with those in other industries. Section four examines the determinants of patent litigation in software technologies across a range of industries in which these technologies are used. Section five examines complementarity and substitution among patents, copyrights, and trademarks in software, using data on IP litigation for a defined set of packaged software firms. Section six discusses the significance and limitations of the findings, and concludes.

1.2 BACKGROUND: SOFTWARE AND INTELLECTUAL PROPERTY

While patent protection for software has generated controversy, its expansion over time reflects an overall trend towards stronger and more widespread patent protection in the United States (Merges and Nelson, 1994; Scotchmer, 1996). Throughout the 1990s, patent

filings in the U.S. grew dramatically, and software patenting grew at an even faster pace (Kortum and Lerner, 1999; Graham and Mowery, 2003). At the same time, court decisions circumscribing the use of copyright, such as the Supreme Court's decision to limit so called "look and feel" protections in *Lotus Development v. Borland International*,¹ appear to have been a factor in the relative decline in the strength of copyright protection as compared to patents. Trademark protection remained limited in scope until the late 1990s, when trademark concerns expanded with the growth of the world-wide-web and the increasing commercial importance of domain names.

1.2.1 Software: A Description

The software industry, which by 2001 had topped \$185 billion in worldwide revenues,² had its genesis in the unbundling of software from hardware led by International Business Machine (IBM) in the late 1960s. Early mainframe computers did not have separable operating instructions, being instead hard-wired to accomplish required tasks: Unbundling had the effect of separating the instructions (software) from the machine (hardware). Subsequent to IBM's unbundling, an increasing number of independent software vendors (ISVs) began to enter the market, and this entry was further spurred by the introduction of the desktop computer in the late 1970s. This rapid entry of ISVs paralleled the introduction of more user-friendly input and output devices, the switches and tubes of early mainframes being replaced by keyboards, mouses, and screen displays with "graphical user interfaces" (GUI).

¹ 49 F.3d 807 (1st Cir. 1995), aff'd 116 S.Ct. 804 (1996).

² International Data Corp. (online: <http://www.siiia.net/divisions/research/growth.asp>). This estimate is for packaged software only, and thus underestimates global revenues because it is missing important elements such as embedded software. The packaged personal computer-based software market in the United States alone is estimated at nearly \$30 billion.

Swift adoption of the desktop PC created a fast-growing market for operating and applications software during the 1980s. New entrants like Microsoft and Adobe Systems filled much of the growing demand for PC software, while incumbents, such as International Business Machine and Texas Instruments, played a more limited role. Through the 1990s, the increasing importance of network solutions, including ultimately the Internet, provided further opportunities for new products and entry.

Software programs produced by packaged software firms are generally separated into three types: Operating systems, applications, and tools.³ Operating systems manage the internal functions of the computer, serving as an interface between the hardware, application software, and the user. Applications process data for the user, accomplishing such tasks as word processing, bookkeeping, and gaming. Tools allow programmers to complete specific tasks associated with creating the software, and include cross-compilers, debuggers, and testing tools among others. In order to be of value, individual applications (and tools) must be written to be compatible with the operating system that directs the hardware on which the application is expected to run.

The programming of both operating systems and applications is supported by two different types of code: Object code and source code. *Object code* is the software that operates the computer, and as such is comprised of a series of binary “0” or “1” codes which operate the “on” and “off” circuits of the machine. This machine language is difficult if not impossible for human programmers to decipher and manipulate, and so software is written in source code. *Source code* is comprised of arithmetic and near-

³ Firmware, software that directs certain functions of the hardware and substitutes for hardwiring, is often distinguished as an independent type of software.

human-language statements, which can be both learned and read by humans. Because source code cannot be directly used by the hardware, a third type of code, assembler language, provides a mechanism for translating source code into machine-usable object code. In the marketplace, difficult-to-read object code finds its way into the hands of consumers, while the readable source code remains proprietary and in the hands of the programmer.

These language characteristics of software suggest potential challenges for, as well as providing a solution for, the public goods problem (Nordhaus, 1969) in innovation. In the case of software, the ease of copying in digital form—and the fact that quality does not markedly degrade with copying—exacerbates this problem, and increases the likelihood that the market will undersupply the good. Limiting customer access to only the object code (through source code secrecy) provides software firms with one mechanism to prevent copying of the product, and copyright protection over the written source code provides another.⁴ Patents and trademarks provide additional layers of exclusivity, for the technological ideas and brand name, respectively.

Network externalities and the economics of standardization introduce systematic distortions in software competition. The value to an adopter of software is enhanced by the number of other adopters, both due to the ability to communicate and exchange files, and the transferability of learned skills. Thus the likelihood that a single product may emerge as a standard is increased by positive consumption externalities as more users

⁴ Denying customer access to the source code is also likely less costly for the firm. Not only is the firm insulated from suffering the costs of having to support technical changes that the customer may make, but to the extent that customer changes might open the authoring firm to liability for the unintended but foreseeable changes of customers, the object code limitation insulates from liability as well.

adopt the product (Katz and Shapiro, 1985), suggesting substantial advantages from lead-time and early market entry. Intellectual property protection is particularly valuable in such markets, both because it may impede competition for a proprietary standard and because it may extend, and present barriers, to new entrants challenging the standard.⁵

1.2.2 Intellectual Property Protection in Software

Due to the economic characteristics of software, the role of intellectual property has captured a central place in both firm strategy formulation and, by necessity, the policy process. The development of intellectual property protections since the 1970s can be seen as an endogenous process in which the growth and increasing economic influence of the sector translated into an expansion of the quality and quantity of property rights. While secrecy and lead-time are no doubt important appropriability mechanisms in software (Leibeskind, 2000), we focus intentionally on the affirmative legal property rights granted under the federal patent, copyright, and trademark laws.

1.2.2.1 Copyright

Significant policy uncertainty attended the development of the new technology of software in the 1970s, with the government first putting its imprimatur upon copyright as the most effective protection mechanism for software. Due in part to an early Supreme Court decision openly hostile to software patenting,⁶ the commission charged by Congress (the Commission on New Technological Uses or CONTU) with recommending an appropriate mechanism chose copyright in 1979 (Samuelson, 1984). “Computer program” was subsequently explicitly adopted by Congress as copyrightable subject matter in the

⁵ See R. Merges, P. Menell, M. Lemley and T. Jorde (1997). Intellectual Property in the New Technological Age, Aspen.

⁶ *Gottschalk v. Benson*, 409 U.S. 63 (1972).

Copyright Act amendments of 1980. As writings, computer programs are protected by copyright upon the moment of authorship. While federal copyright registration is available and affords important rights and presumptions, registration is not technically necessary to enjoy protection.

Despite its legislative beginnings, the development of the software copy-“right” was, in reality, largely court-made. Litigation offered judges the opportunity to define *ex post* the right granted by Congress in 1980, and thus the development of the software property right has been attended with substantial uncertainty. Early cases demonstrated clearly that the literal copying of an incumbent’s code was a violation of the Copyright Act,⁷ but the copying of non-literal elements, such as the “look and feel” of the user interface, invited uncertainty about the scope of the copy-“right.”

While appellate decisions in influential federal circuits extended a reasonably broad copyright protection to software’s non-literal elements,⁸ the Court of Appeals for the Second Circuit in 1992 decided *Computer Associates Int’l v. Altai*,⁹ a watershed decision that trimmed the broad protection of non-literal elements of program code. The logic and method announced in *Altai* has been widely adopted, and supported in subsequent landmark cases such as *Lotus Development v. Borland International*¹⁰ in which the firm Borland International was permitted to use elements of Lotus’ 1-2-3 menu organization in its spreadsheet products.

1.2.2.2 Trademark

⁷ Apple Computers v. Franklin Computer, 714 F.2d 1240 (3rd Cir. 1983).

⁸ Whelan Assoc. v. Jaslow Dental, 797 F.2d 1222 (3rd Cir. 1986).

⁹ 982 F.2d 693 (2nd Cir. 1992).

¹⁰ 49 F.3d 807 (1st Cir. 1995), aff’d 116 S.Ct. 804 (1996).

Trademark law has traditionally sought to protect the consumer and is not a property right for the owner *per se*, although this view of trademark has been undergoing a transformation that maps, in time, to the development of the software industry. Federal trademark protection extends to any word, name, symbol, or device used to identify goods or services in commerce, and thus does not literally apply to the written computer code covered by copyright. To the extent, however, that quickly identifiable logos and symbols may assist a software producer in developing a “bandwagon” effect leading to *de facto* standardization of an operating system or application, trademark protection may be quite valuable. Furthermore, a species of trademark protection—“trade dress”—protects the non-functional appearance of a product, and thus may offer the software producer protection over the non-literal “look and feel” elements of a computer program, thus overlapping the thorny issues with which judges hearing copyright suits have grappled during the last two decades.¹¹

1.2.2.3 Patent Protection

While both the U.S. Patent and Trademark Office (PTO or USPTO) and the U.S. Supreme Court had opposed extending patent protection to software throughout the 1970s,¹² this opposition has been subsequently replaced by sponsorship. By the mid-1980s, software was legally considered patentable subject matter, supported by both the

¹¹ An example from competition in computer hardware highlights this issue. In a trademark suit brought in 1984 against rival C. Itoh and Co., Digital Equipment Corp. (DEC) claimed that its rival’s CIT-220+ video display terminal was manufactured with aesthetic non-functional characteristics (essentially, the “look and feel”) of the keyboard and terminal setup copied from DEC’s terminal model VT220. While the federal district court found that DEC’s terminal setup had been aesthetic in its early design phase, elements had become “functional” in the marketplace, and thus could not support a trademark infringement action. *Digital Equipment Corp. v. C. Itoh and Co.*, 229 U.S.P.Q. 598 (D.N.J. 1985).

¹² The U.S. Supreme Court’s *Gottschalk versus Benson* decision (409 U.S. 63 (1972)) highlights the reluctance of both the Patent Office and the Court to extend patent rights to software.

administrative and judicial branches. Changes in the institutional structure of the courts—i.e. the founding of the Court of Appeals for the Federal Circuit (CAFC) in 1982 to hear all patent appeals—and changes in legal doctrine over time first permitted and then strengthened patent protection for software.

This increasingly permissive attitude as regards software patenting has been linked to an overall strengthening of the “patent right” since the early-1980s, thus making the software patent right more valuable (Merges, 1996). After the Supreme Court allowed the patenting of software embedded in a machine in the 1981 cases of *Diamond v. Diehr*¹³ and *Diamond v. Bradley*,¹⁴ a steady stream of cases from the CAFC has supported the patentability of software. Even as software patent applications at the USPTO began to rise in the early 1990s, a study commissioned by the Department of Commerce¹⁵ concluded that the patentability of software was long established in law, and should continue. While the policy debate has since softened in the U.S., it has resurfaced internationally (particularly in Europe), in the open source community, and in the extension of software patenting to business methods and financial innovations.

This changing intellectual property environment for software has been reflected in the patenting and copyright registration data of software firms. Graham and Mowery (2003) reports that patents issued per year to the top 15 packaged software firms (measured by 1997 revenues) grew rapidly through the 1990s, with over 200 patents issued to these firms in 1997 as compared to 0 in 1987. The paper also reports that copyright registrations

¹³ 450 U.S. 175 (1981).

¹⁴ 450 U.S. 381 (1981).

¹⁵ The Advisory Commission on Patent Law Reform, "A Report to the Secretary of Commerce," August 1992.

of the top 15 packaged software firms initially flattened and then decreased after 1991, after a rapid cumulative increase of over 200% from 1987-88. Reflecting this broad trend, Graham and Mowery finds that the software patenting propensity (patents obtained per R&D \$ spent) began to converge to the software copyright registration propensity (copyright registrations per R&D \$ spent) for this sample of large PC-only software firms.

However, a comparison of patenting and copyright registration data is subject to some valid criticism. Primarily, this is because copyright registration data are less reliable measures of copyright use than are the patent filing data of patent use. Since the copy-“right” accrues to the inventor by the mere act of “fixation” (writing the code in the case of software), U.S. federal copyright registration (an official act made to the administrative agency) is mainly useful in preparation or pursuit of litigation. Moreover, registration has very low direct costs (at most a few hundred dollars, as compared to about \$10,000 for an issued patent), so that the exercise of this option is not as clearly a conscious choice by firms, especially since the property right itself is not forfeited by foregoing registration of the copyright.

There are, however, substantial benefits that accrue to innovators when registering the copyright, particularly for those actors that intend, or foresee, a copyright enforcement action. While copyright protection is granted to the author upon the writing of a work—or in the case of software the typing of the code—regardless of whether or not the writing is registered with the Copyright Office,¹⁶ incentives are offered to the innovator for filing a

¹⁶ The 1976 Copyright Act, in accord with the international Berne Convention, gives copyright protection to authors regardless of registration status.

copyright registration. The U.S. registration procedure is both quick and inexpensive,¹⁷ and the legal strength of the resulting protection is greater for registered, as compared to unregistered, copyrights. Copyright registration within five years of the work's publication gives the copyright a presumption of validity under law.¹⁸

The act of registration also gives substantial benefits to those pursuing enforcement litigation. Copyright infringement suits cannot be filed in the U.S. courts until the copyright is registered, thus barring non-registered subject matter.¹⁹ Moreover, litigants are denied recovery of attorney fees and statutory damages, including the increased awards available for willful infringement, for any activities conducted by the infringer prior to the date of copyright registration. Ordinarily, the owner cannot collect these damages for the period between the time of publication and registration of the copyright, but the law offers an incentive for early registration: Damages are available from the date of publication *only* if the owner registers the copyright within three months of the work's publication.²⁰

As the rewards to copyrighting have shifted over time, it is reasonable to suggest that the incentives to registrants have changed accordingly. Because like a patent the copyright is a creature of the law, its value—whether registered or not—will rise and fall according to the favorability of court cases interpreting the strength, depth, and breadth of the copy-“right.” Lemley and O’Brien (1997) point to a series of court cases in the early 1990s that significantly weakened the copyright, leading innovators to substitute patent protection for software inventions. Their suggestion that copyright has become devalued,

¹⁷ Registration requires a two-page application form filing and a fee of \$30 US.

¹⁸ 17 U.S.C.A. §410 (2000).

¹⁹ 17 U.S.C.A. §411 (2000).

²⁰ 17 U.S.C.A. §412, 504, 505 (2000).

leading innovators to substitute other appropriability mechanisms for copyright, is one of the unsettled questions driving this research.

1.3 SOFTWARE INTELLECTUAL PROPERTY LITIGATION

In contrast to filing a patent and registering a copyright, decisions to litigate over patents and copyrights reflect similar costs and incentives, thus making litigation data more comparable across the two domains. In addition, trademark litigation data provide an additional reference point with which to compare trends in copyright and patent litigation. This paper uses two different datasets of software intellectual property litigation, which are described below.

1.3.1 Data Sources and Construction

The first dataset of software intellectual property litigation we generate is based on the Softletter100 list of (IBM) PC-based packaged software firms that have been compiled by a commercial firm (Softletter) for each year since 1985.²¹ These lists were combined and cleaned by accounting for name changes over time. Between 1985 and 1999, a total of 380 different firms were included in the Softletter100 list, which form the core of the “industry dataset.” While this sampling approach has some limitations, it has the advantage that it allows an identification of a set of firms that are clearly in “the software industry”, which is otherwise difficult in a general-purpose technology like software (the discussion of the “technology dataset” below highlights the broad mix of industries involved in software patent litigation). Softletter also provides a data source of annual firm

²¹ Firms were only included in the list if over 50% of their sales came from packaged software.

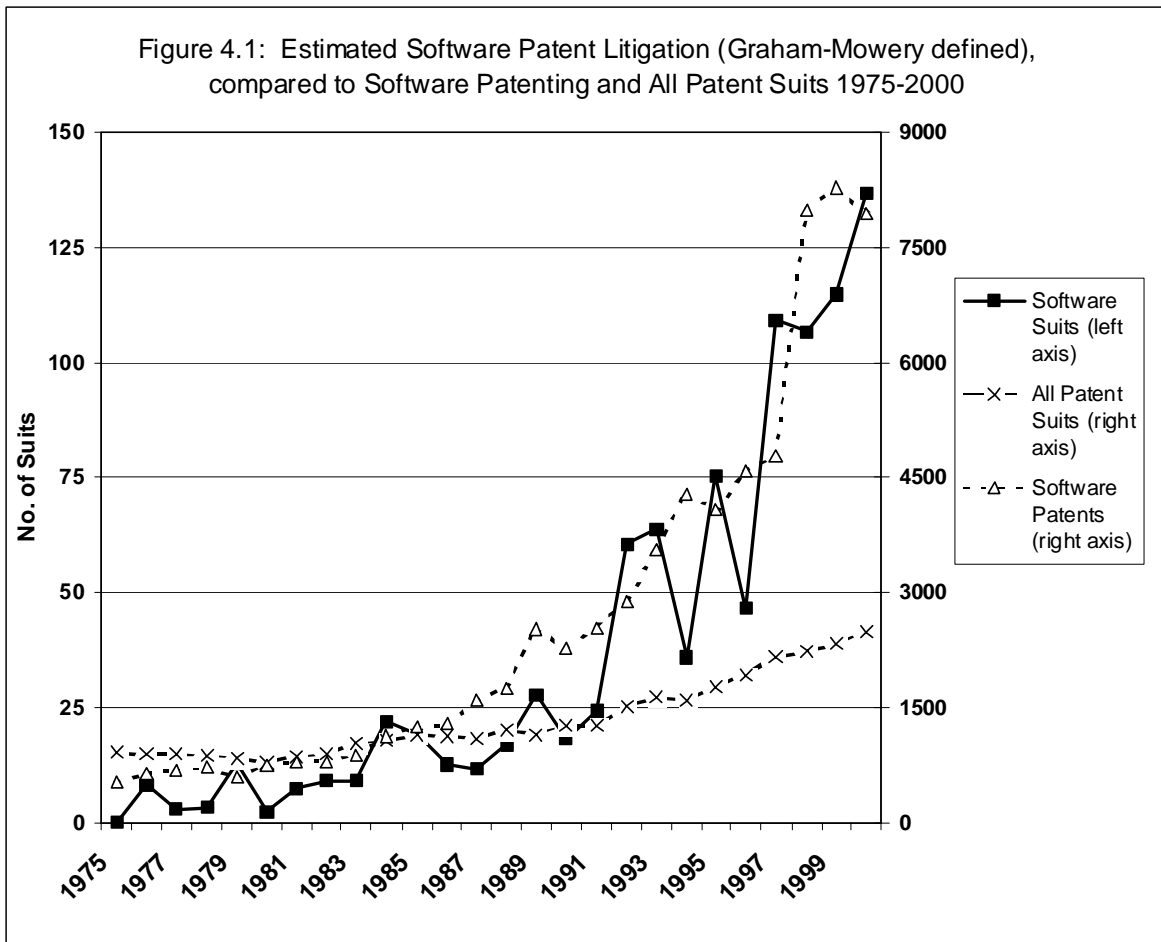
revenues (deflated by GDP in this analysis) and employment for both public and private firms on their lists.

The involvement of these packaged software firms in IP litigation is identified by searching for firm names from the industry dataset in the population of suits for all U.S. federal district courts, obtained from the Federal Judicial Center (FJC).²² The type of IP litigation—patent, copyright, or trademark—is identified by a code inserted by the Clerk of the Court in each suit record. Since the litigation data are obtained from the same source and identified using identical techniques, the possibility of biases stemming from idiosyncrasies of different data sources or sampling techniques is mitigated. Ad hoc corroboration with news reports was also used to verify the fidelity of the data. Further, mergers and acquisitions among the firms were tracked to ensure that ongoing litigation was assigned to the correct successor firms.

The manner in which the industry database is constructed ensures that virtually all the sizeable firms in the industry are included, and that the database includes a substantial amount of the revenue production in the industry. For instance, even in 1999, the smallest firm in the dataset had revenues of approximately \$ 4 million. The construction did however raise one troublesome issue, specifically whether a firm ought to be included in the dataset for years in which the firm did not appear as one of the “top 100 firms” in the

²² Federal Judicial Center. Federal Court Cases Integrated Database (various versions, 1970-2001), Ann Arbor, MI: Inter-university Consortium for Political and Social Research (distributor). The relevant cases were identifying by using firm-name search strings (based on the Softletter100 lists), which were constructed to err on the side of inclusion. The resulting dataset was then manually checked to confirm that the match was accurate in each case, and over 85% of the cases were discarded in this manner. In cases of doubt, the case was painstakingly researched using secondary sources (news articles and company information) to either confirm or deny the accuracy of the match. In a small number of cases (less than 3% of the data set) where a match could not be confirmed or denied, the suit data were excluded.

Softletter100 listing. In the results reported here, firms are included for all years irrespective of their presence on the Softletter100 list firm for that year. To determine whether that decision had an impact on the results, an alternative analysis was conducted including firms only for years when they were found on the list and resulted in no material difference in the results.



The second dataset we generate, the “technology dataset,” is focused on patent litigation in a specific set of software technology classes. These International Patent Classes are identified and discussed in Graham and Mowery (2003), and account for about

55% of patenting by packaged software firms.²³ Patent litigation data is obtained from the LitAlert® dataset that is based on patent litigation reported by U.S. district courts to the U. S. Patent and Trademark Office (USPTO). In turn, the USPTO data is matched to the FJC data described above using various common fields between the two samples.

Prior research (Lanjouw and Schankerman, 2001; Somaya, 2003a; 2003b) has demonstrated that suits in the USPTO data are a subset of the FJC “population” of all patent suits, and comprise approximately 56% of the FJC data after 1983. Since patent numbers, and accordingly patent classes, are available only in the USPTO data, the industry dataset is based on suits reported to the USPTO. A total of 657 patent suits were thus identified between 1975 and 2002. This broader software technology sample provides a useful reference point for the industry sample, and helps validate some of the results for software at large. However, it is not possible to identify copyright and trademark litigation using a technology-based approach, and those aspects of the analysis will *per force* be conducted using the industry dataset alone, based on the identities of the plaintiffs and defendants.

1.3.2 Key Features of Software Intellectual Property Litigation

Consistent with the increasing legitimacy of software patenting, Figure 4.1 illustrates a dramatic rise in both software patenting and patent litigation using the technology dataset (based on IPC classes).²⁴ The growth in patent litigation in the software technology classes easily outpaces the growth in patent litigation generally as

²³ This is corroborated in the data - when patent litigation from the industry dataset is compared with the technology dataset, the overlap is about 57% of the former (for suits that could be coded).

²⁴ The data used in this graph were adjusted (by year) for the fact that the USPTO data contain only a sample of all patent litigation.

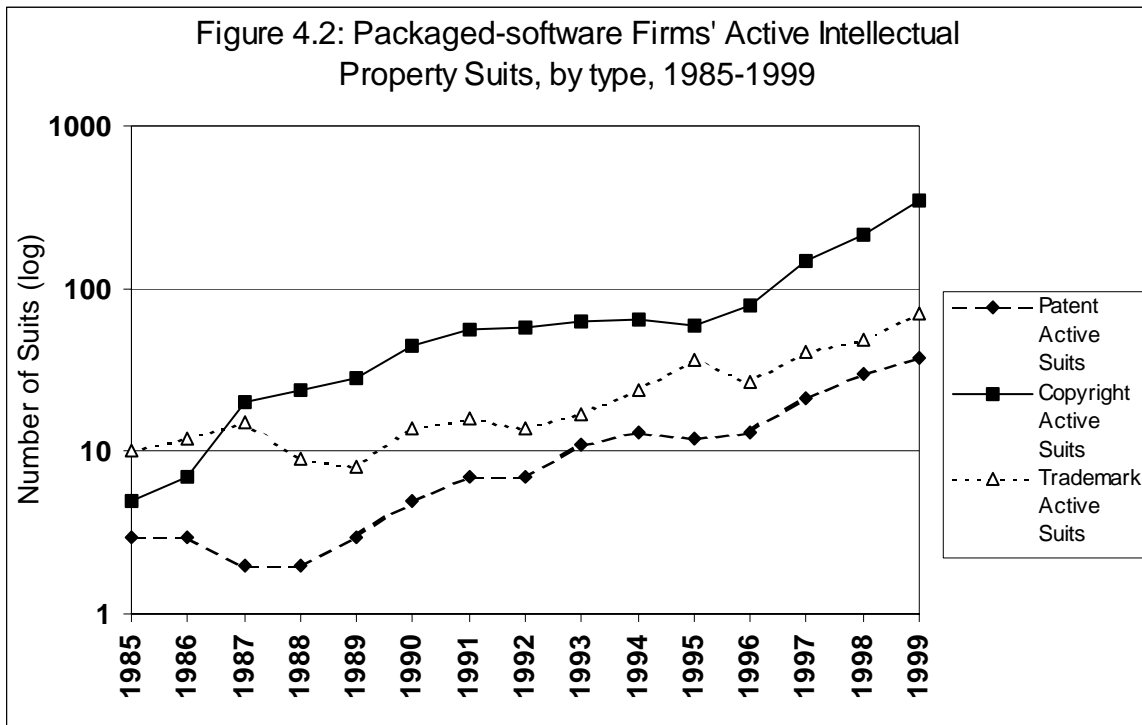
shown in the FJC data over this time period. A closer examination of software patent litigation reveals that the packaged-software firms (both from the industry sample and outside it) are involved only in a small fraction of the suits. The majority of the suits involve various types of hardware firms, and firms from other industries (from genomics and finance to healthcare, food and construction) that employ software in their products or processes. This finding is broadly consistent with Bessen and Hunt (2003) who suggest that the distribution of “software” patent ownership is skewed toward manufacturers, and that a relatively small share of all software patents are held by packaged software firms. A caveat is in order, however: Bessen and Hunt define a “software patent” as any patent containing software-related words in the claims,²⁵ a broad definition which may tend to over-represent non-software patents held by manufacturers.

Figure 4.2, which is based on the industry dataset, illustrates a similar rise in software patent litigation, and a corresponding dramatic rise in copyright litigation. The figure describes the active patent, copyright, and trademark suits in which a Softletter100 firm was involved between 1985 and 1999. A suit is defined as “active” beginning in the first year the suit is filed, and only ceases being active in the year following a disposition by settlement or by the court. Because the figure is plotted on a log scale, the increases demonstrated in the number of active suits in intellectual property litigation in all three types of IP during the late 1990s have actually been exponential.

In numbers, patent litigation, as measured by the number of active suits in any calendar year, increased from a mere 3 active suits in the year 1989 to 53 suits active in the

²⁵ Bessen and Hunt define a “software patent” as any patent that either uses the word “software,” or the words “computer” and “program,” in the specification. They exclude patents that use the words “semiconductor,” “chip,” “circuit,” “circuitry” or “bus” in the title.

year 1999.²⁶ Over the same time period, active copyright suits grew from 32 in 1989 to 357 in 1999. The dramatic growth in copyright litigation does not quite keep pace with compounded average growth rate of patent litigation, which is hardly surprising given the very low base from which patent litigation started. Moreover, as is evident from Figure 4.2, the growth rate of copyright litigation keeps pace with patent litigation in the latter half of the decade.



Given the observed declines in copyright registrations, copyright litigation growth is a somewhat surprising finding, and suggests that copyright may continue to play an important role in software despite its reported diminished value in the wake of the “look

²⁶ This substantial increase over the 1989-99 period is reflected in the year-on-year data in each of the measures of litigation used in this paper. Suit filings are a bit noisier and provide a somewhat lower relative estimate of patent litigation, since patent suits tend to last longer. When litigation is measured by suit days the trends track active suits very closely, but they are more difficult to read and interpret.

and feel” decisions. Indeed, the data demonstrate that even in 1999, the number of active copyright suits is approximately seven times the number of active patent suits. This statistic is not due to “longer” copyright litigation among packaged-software firms: In fact, copyright suits are on average recorded “active” for 1.6 years while patent suits are on average coded “active” for 1.9 years, thus suggesting that patent suits are more likely to be coded “active” than copyright suits. This additional number of active ongoing copyright suits may be an artifact of the fact that copyright has been available as a ground for suit longer than has patent. Due to the fact, however, that over 80% of the plaintiff- initiated patent suits have a duration of less than four years, a substantial share of these 1999 copyright suits were filed after the “look and feel” decisions, which are widely cited as weakening the economic value of copyright protection, were announced in 1994. While trademark suits have also grown, the number of active suits has declined since the mid-1980s.

It is instructive to note that despite this exponential growth in litigation, patent suits are only a small fraction of all intellectual property suits filed by software firms, particularly when compared to copyright suits. This large difference must be qualified, however, because the cost of “entry” to patent litigation is much higher than either copyright or trademark litigation. While the costs associated with filing and prosecuting a U.S. patent have been estimated to be between \$15,000 - \$100,000 (Graham et al., 2003), the costs of a U.S. trademark registration are ordinarily less than \$5,000²⁷ while those

²⁷ Larry Jordan, a partner at the Ann Arbor, MI, law firm of Jaffe, Raitt, Heuer and Weiss suggests that trademark registration in that market averages \$2,500-3,000. “Trademarks and copyrights: Register them on the Web,” [Technology Central](#), Detroit Regional Chamber of Commerce (2003). Mary Bellis estimates the

associated with a U.S. copyright registration are generally less than \$500.²⁸ The firm may choose to bear these comparatively high entry costs to patent litigation only when there exists some comparatively greater stakes to protect in the firm's overall appropriation decision (Somaya, 2003a). Nevertheless, comparing the raw numbers does provide some indication of patent litigation's relative importance.

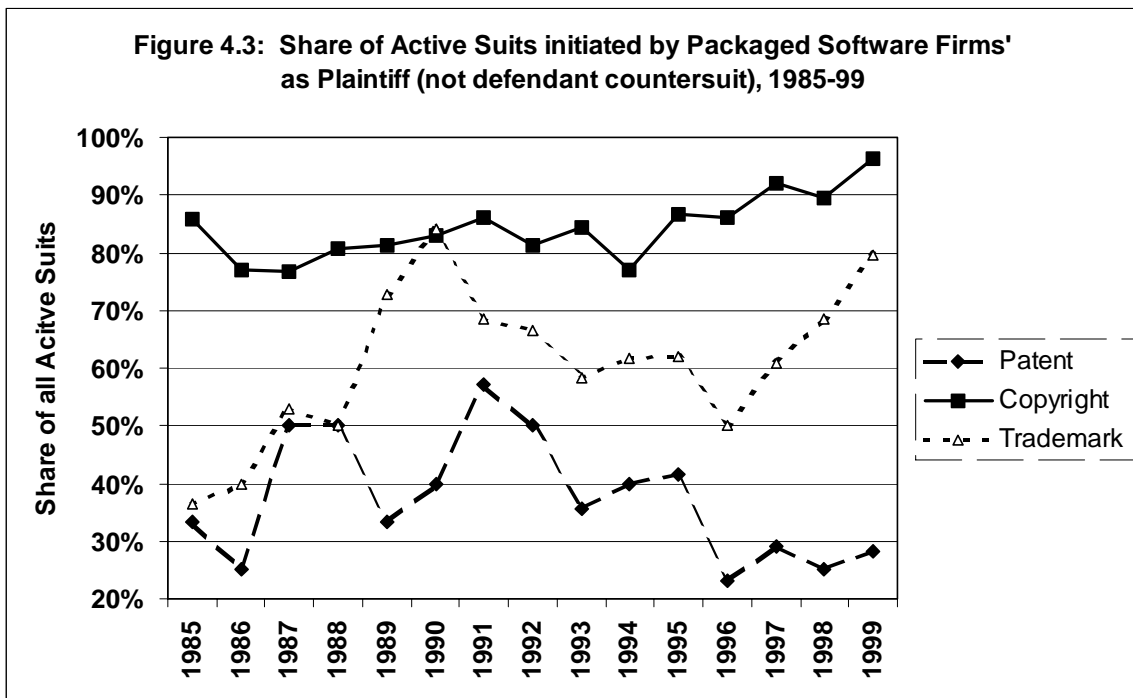
Figure 4.3 reports statistics for the share of "active suits" in each IP category (patent, copyright, or trademark) involving Softletter100 firms that were initiated by these firms in each focal year 1975-1999. These Softletter100-initiated suits are shown as shares of the total reported for the same three types of intellectual-property suits plotted above in Figure 4.2. Figure 4.3 discloses that patents held by the Softletter100 firms tend to be named in suits initiated by actors outside the package-software industry. In fact, the share of active suits in which the Softletter100 have asserted their own patents year-on-year has fluctuated between 25% in 1986 to 57% in 1991, and the share appears to have fallen substantially since 1991, with percentages falling to between 23-29% for the years 1996-1999.

Copyright litigation (by filing party) looks significantly different than does patent litigation in which these firms are involved. The Softletter100 firms act as plaintiffs considerably more often in suits that involve their own software copyrights. The shares

costs with legal representation at \$1,000-2,000. "How To Understand and Use Trademarks and Trademark Registration," *Inventors*: About, Inc. (2003).

²⁸²⁸ Copyright protection itself is costless as it springs from authorship, but the cost to copyright litigation is a formal registration with the Copyright Office. The U.S. copyright registration fees is \$30. The Software Industry and Information Association (SIIA) offers a software copyright registration service at \$200 for its members, \$350 to non-members. Many law firms advertise fixed fees for consultation and filing the registration (e.g., Law offices of Richard Keyt, Phoenix, AZ, \$300; Law office of Tonya Evans, Philadelphia, PA, \$85). Attorney Larry Jordan suggests that copyright registration in the Detroit market averages \$200. "Trademarks and copyrights: Register them on the Web," *Technology Central*, Detroit Regional Chamber of Commerce (2003).

fluctuate between 77% (in year 1986) to 96% (in year 1999). In fact, the trend appears to be upward, suggesting that, as the 1990s progressed, it was more likely for Softletter100 firms involved in copyright litigation to act as the plaintiff in these suits. The share of software trademark suits in which Softletter100 firms were both involved and took the role of plaintiff has fluctuated substantially over time, but has tended to a higher share than the patent-plaintiff role, but less than the copyright-plaintiff role.



Figures 4.2 and 4.3 illustrate that patent suits involving the Softletter100 are of a different character from these same firms' copyright suits, not only in absolute numbers (Figure 4.2), but also because a large fraction of these patent suits name the packaged-software firms as the defendant—i.e., the target of the patent suit (Figure 4.3). This finding suggests that the large established firms in the packaged-software industry tend to be on the defensive end of patent suits, rather than using patent litigation to gain a

prospective proprietary advantage. In both copyright and trademark litigation, the opposite is true—the Softletter100 firms are initiating the suits, acting as the plaintiffs in a large fraction of the cases. Suits naming Softletter100-owned patents and filed against these industry incumbents tend to be originated by a mix of small software firms, individuals, and industry outsiders (typically hardware firms). This finding is particularly interesting because it shows, at least as far as patent litigation is concerned, a different pattern than that found in biotechnology firms as reported in Lerner (1995).

A closer look at the characteristics of patent litigation in software—in both the “industry” and “technology” datasets—illustrates interesting similarities and differences when compared with litigation in other areas of technology (Table 4.1). Because the time period over which these characteristics are measured may affect the results, the datasets have been segmented using several different methods, thus allowing comparisons between other segments, and with the results of prior research reported in Somaya (2003a) on other industries.

Table 4.1 demonstrates that litigation rates for “software patents” defined by reference to Graham and Mowery (2003) are 13.36 suits per thousand for the years 1985-2001. In order to compare with the findings in Somaya (2003a), software patent litigation rates were also calculated for the period 1983-1993 at 12.70 suits per thousand issued. Overall, Table 4.1 suggests that software patents are somewhat less likely to be litigated than is the “average” patent (reported by Somaya as 18.73 suits per thousand for all patents), although the difference is not statistically significant.

Table 4.1: Some Comparative Statistics on Software Patent Litigation

Industry Sample:	Software IPC-Based	Software IPC-Based	PC Software: Softletter 100-Based	Computers (Somaya, 2003a)	Research Medicines (Somaya, 2003a)	All Patents (Somaya, 2003a; 2003b)
Years:	1985-2001	1983-1993	1985-2000	1983-1993	1983-1993	1986-1995
Number of Suits:	621	170	127			
Variables:						
Declaratory Judgment Suits	0.167 (0.017)	0.153 (0.029)	0.167 (0.048)	0.096 (0.014)	0.123 (0.020)	-
Multi-patent Suits	0.248 (0.017)	0.076 (0.020)	-	0.076 (0.012)	0.023 (0.009)	0.040 (0.003)
Ratio Suits / Patents (00s)**	1.336 (0.492)	1.270 (0.487)	-	2.474 (0.891)	0.661 (0.201)	1.873 (0.212)
Individual-Assigned Patents	0.184 (0.016)	0.165 (0.028)	-	0.228 (0.021)	0.051 (0.014)	0.323 (0.006)
Foreign-Assigned Patents	0.063 (0.010)	0.041 (0.015)	-	0.052 (0.011)	0.236 (0.028)	0.121 (0.004)
Counter-Suits	-	-	0.071 (0.023)	0.143* (0.017)	0.027* (0.010)	-

Shares of total number of suits; Standard errors appear in parantheses ()

* Unbiased estimates computed from the observed sample ratios.

** For Software: Average suits per 100 contemporaneous patents.

Others: Average suits over patent life per 100 patents issued in 1975-78.

Bessen (2003) indicates that inventing-around and substitute technologies make appropriability difficult in complex product technologies such as computing. Single patents may accordingly be less useful in appropriating the value in these technologies, and

litigation in these sectors would be characterized by firms exerting multiple patents in court. Table 4.1 demonstrates that software patents are more likely than the average patent to be involved in a multi-patent litigation event. While Somaya (2003a) reports that 4 per 1,000 of all patents are involved in a multi-patent suit during 1986-1995, nearly twice as many (7.6 per thousand) software patents during 1983-1993 were involved in multi-patent suits. This statistic balloons to 24.8 software patents per thousand for software patents during the period 1985-2001.

This higher share of patents involved in multi-patent litigation is also demonstrated in computer technology more generally, which exhibit 7.6 patents per thousand involved in multi-patent suits during 1983-1993 (Somaya, 2003a). This pattern for software and computer technologies is substantially different than that for research medicines, which demonstrates 2.3 patents per thousand involved in multi-patent suits during 1983-1993 (Somaya, 2003a), thus suggesting that patents in the discrete-technology sector (research medicine) are less likely to be involved in multi-patent suits involving either software-computers or patents overall.

The incidence of foreign-assigned and unassigned patents in software litigation is similar to findings for computer patents reported in Somaya (2003a), but significantly different from Somaya's findings for research-medicine patents or the universe of all patents. Foreign-assigned software patents were involved in 6.3% and 4.1% of all software patent suits in the years 1985-2001 and 1983-1993, respectively. These shares roughly match Somaya's showing for the shares of foreign-assigned computer patents (5.2%), but are significantly different than the shares demonstrated in research medicine

(23.6%) patents involved in suits during 1983-1993. The software shares are also less than the share of foreign-assigned patents (12.1%) involved in all patent suits during 1986-1995.

These foreign-patent statistics are particularly noteworthy when compared against the share of US software patents granted to foreign entities. Analysis of "software patents" selected according to a common IPC-based definition demonstrates that the share of software patents assigned to foreign entities during 1983-1993 was 42.1%, and during 1985-1999 was 38.2%. These relatively large shares, when compared with the statistics on foreign-assigned patents involved in suits reported above, suggest that while foreign entities are taking advantage of the U.S. patent system to secure patent rights, these same entities may be much less likely than are their domestic competitors to enforce these rights in U.S. courts once they are secured.

Table 4.1 also compares the incidence of unassigned (by assumption individual-owned) patents in software litigation with several findings from Somaya (2003a). While unassigned software patents were litigated in 18.4% and 16.5% of all software patent suits in the years 1985-2001 and 1983-1993, respectively, and these shares roughly match Somaya's showing for the shares of unassigned computer patents (22.8%), these shares are significantly larger than those shown for research-medicine patents (5.1%) involved in suits during 1983-1993. The software shares are, however, significantly less than the share of unassigned patents (32.3%) Somaya (2003a) finds were involved in the universe of patent suits during 1986-1995.

To gain insight into the relative "use" of the courts by individual software patentees, it is instructive to compare these unassigned-patent litigation statistics with the

share of US software patents that are both granted and unassigned. The share of IPC-defined “software patents” unassigned to an entity during 1983-1993 was 6.2%, while during 1985-1999 this share fell to 5.0%. These relatively small shares, when compared with the statistics on unassigned patents involved in suits reported above, suggest that while individuals comprise an inordinately small share of software patent filings, they may be much more active in using these patents to enforce property rights in the courts once the patent is granted.

Perhaps the most interesting differences in Table 4.1 are in the defensive measures adopted in software patent litigation, especially when compared with the more broadly-defined “computer patents” used in Somaya (2003a). When the sample is restricted to the more narrow “software” definition used in Graham and Mowery (2003), there is a lower incidence of “counter-suits” than reported in Somaya (2003a) for “computer” patents overall. The sampling on “counter-suits” is accomplished by selecting suits in which a firm, already the target of a patent infringement suit, opts to file a suit using patents of its own. While these are not the only counter-suits that may be filed by firms, these suits are identifiable as “patent” counter-suits. Counter-suits filed on other grounds, including anti-trust, trade secret, and contract among others, are not included due to the difficulty in identifying whether matters related to the patent litigation are the subject matter of the counter-claims. By exclusively comparing counter-suits based on patents, the subject matter of the litigation is readily and certainly identifiable as a piece of firm intellectual property. One caveat is that such an approach may miss a common ground for countersuits in patent litigation—the antitrust complaint.

Software patent litigation is more likely than is “computer” litigation reported in Somaya (2003a) to involve another generic defensive measure—the declaratory judgment suit. In declaratory judgment suits, non-patentees act as first-movers, proactively taking patentees to court seeking to either invalidate the patentee’s patent or demonstrate that it is not being infringed. In cases where the patentholder is one of the Softletter firms studied in this paper, a declaratory judgment suit would be recorded as an active suit in which the Softletter firm was the defendant, and thus would not compromise part of the share of Softletter patent suits initiated by a Softletter firm (Figure 4.3) so long as the “declaratory” party was not another Softletter firm.

The declaratory judgment suit is essentially a request by the infringer asking the court to “declare” that the patent, or some limited part of the patent, is invalid, a finding that would render any infringement claim by the patentee moot so long as the infringement is based on the newly “invalidated” claims.²⁹ Because the declaratory judgment suit may be filed at any time and need not be made in response to an infringement court action by the patentee, the action offers an infringer a strategic opportunity. By choosing the timing, circumstances and venue of the suit, a non-patentee firm may improve its position with a declaratory judgment suit as compared to simply defending itself against a suit brought by the patentee.³⁰

²⁹ The party seeking the declaratory judgment from the court ordinarily faces a jury, but if there is no real dispute and a party is entitled to judgment, the party is entitled to a summary judgment from the judge prior to facing a jury. Declaratory judgments only involve the Markman hearing when issues of patent claim construction are at issue-- *Markman v. Westview Instruments, Inc.*, 52 F.3d 967 (Fed. Cir. 1995) gave the district court judge exclusive power over patent claim construction.

³⁰ This statistic for software as compared to computers (Somaya, 2003a) is unlikely to be an artifact of the Court of Appeals for the Federal Circuit in 1995 giving judges complete control over deciding issues of claim construction in *Markman v. Westview Instruments, Inc.*, 52 F.3d 967 (Fed. Cir. 1995). First, *Markman* did not deal with declaratory judgments *per se* but instead with issues of claim construction which, at most,

The comparatively low incidence of counter-suits may be a consequence of software firms being relative newcomers to patenting. This newcomer status may be exacerbated by the high costs of entry to “portfolio patenting” strategies in which firms collect multiple overlapping patents, a strategy particularly effective in cumulative technology industries, of which software is an example. Firms engaging in a “portfolio patenting” strategy may have as an objective of defending against hold-up by other patentees, thus software firms may be compared with the hardware patenters included in the Somaya (2003a) broader “computer” patentholders sample because they share the same cumulative-technology characteristics. However, the comparatively low incidence of counter-suits in pure software may be a consequence of the relative ineffectiveness of defensive patents when used against small-firm and individual patentees. Defensive patenting has been shown to work through mutual hold-up (Somaya, 2003a; Hall and Ziedonis, 2002): When a firm faces a patent suit as a defendant, it is able to threaten its rival with a counter-suit, thus holding-up the plaintiff’s operations as well. Consistent with the asymmetric stakes theory tested in Somaya (2003a), the likelihood of a settlement may be improved when both parties to litigation face significant costs associated with mutual hold-up, thereby making litigation stakes more symmetric and deterring both firms from going forward with the suit.

However, small firms and individuals are much less likely to have substantial “stakes” in the form of significant operations that can be held-up in this manner. In one

changes the subject matter over which the jury must deal when deciding whether a patent should be declared invalid. Moreover, because the change in declaratory judgment suit shares did not change significantly from the 1983-93 and 1985-2001 period, even though the number of suits represented in the latter period was much greater (n=621 compared to n=170), it is unlikely that changes in the post-1995 *Markman* regime have had substantial changes in the likelihood of using declaratory judgments.

extreme illustration, Goldtouch Technologies, Inc., a small entrant firm specializing in human-interface devices, sued Microsoft for over \$1 billion in damages for an alleged infringement of Goldtouch's patents. Even though Microsoft counter-sued, the impact of the counter-suit on Goldtouch was likely quite small when compared with the potential payoff from winning its own infringement suit given Microsoft's "deep pockets." By comparison, using declaratory judgment suits to preempt potential litigation may be a more effective strategy, especially since software patents are generally believed to be of poorer quality (Merges, 1999).

The intensive use of declaratory judgment may be demonstrated by reference to those patent suits in the industry dataset where Softletter100 firms were plaintiffs, with the caveat that the number of these suits is quite small. Of the 24 suits in this sample that were capable of being coded, 5 (21%) were counter-suits, but 9 (38)% were declaratory judgment cases. These figures give some indication of the relative importance of the declaratory judgment in defensive litigation strategy, but also the relatively small fraction (19%) of infringement cases in which Softletter100 firm-owned patents are involved that were filed by these same large, incumbent packaged-software firms.

1.4 DETERMINANTS OF SOFTWARE PATENT LITIGATION

We now turn to a more in-depth investigation of the motives for filing suit in the technology dataset. The analysis in this section follows similar analyses conducted in past research for patents in general (Lanjouw and Schankerman, 2001) and patents in specific industries (Somaya, 2003a; 2003b).

1.4.1 Data and Methods

For this analysis, a sub-sample of the dataset from 1985 to 2001 was used, reflecting the period when software patenting and litigation has been most active. Following prior studies, the primary patent being litigated in any given suit is the focus. This paper is concerned with the question: What factors are correlated with the probability that a software patent will be the subject of a lawsuit? There were 621 suits remaining in the technology dataset after imposing the year cutoffs, with 396 distinct primary patents. For each of these “focal” patents, a randomly-matched patent issued within one year of issue is identified from the same 7-digit IPC class as the focal patent. The matches are selected from the universe of all patents and the matched sample is created with replacement.

For each matched and litigated patent, a number of variables indicating potential value in litigation were coded. These include both backward and forward citations, the latter being adjusted for truncation in the citation series in the year that the citation data end (in 2001). Forward citations have been long established as a measure of patent value in the literature (Hall, Jaffe and Trajtenberg, 2002), but while some studies have found support for the use of backward citations as a proxy for technological innovativeness and thus value (Harhoff, Scherer, and Vopel, 1999), the significance of large numbers of backward citations as an indicator of value has also been called into question (Lanjouw and Schankerman, 1997). The use of forward citations as a measure of value must overcome claims of endogeneity because citations may occur after a patent is litigated.. Consistent with their use in Hall, Jaffe and Trajtenberg (2000), however, citations in this paper proxy for other underlying features of a patent known at the time of suit. Lanjouw and

Schankerman (1997) have also explored whether the “publicity” of litigation leads to future citation, demonstrating that the impact of litigation on patent citations is an order of magnitude smaller than the number of citations shown in litigated patents when compared to a non-litigated matched sample.³¹

Another variable that may affect the probability of litigation is the size of the inventor team that invented the patented innovation. Large teams may indicate greater organizational resources being deployed to support a project, and therefore may represent a larger commitment by the firm to the later-patented technology. A variable is also constructed measuring the number of countries involved in the invention (by location of inventors) to account for the “multi-nationality” of the individuals or assignee holding the patent. In the case of assigned patents, both the number of inventors and the number of countries are likely to be correlated with firm size, and thus this unobserved variable enters as a latent characteristic. Dummy variables were also coded for whether the patent was assigned to a foreign entity, or is un-assigned at time of issue. The latter coding, consistent with Hall, et al. (2003), proxies for a patent being held by an individual.

Table 4.2 reports the summary statistics for the variables described above. Since the forward and backward citation variables were both highly skewed, they were transformed by logs for the model estimation. The probability of a patent being litigated (i.e. being in the technology dataset sample, rather than the matched one) was estimated by a simple probit model. The results of the estimation are reported in Table 4.3.

³¹ Lanjouw and Schankerman find that there is a publicity effect, but that this effect on average adds only 0.5 future citations, while litigated patents are on average cited by 6.1 more patents than are non-litigated patents with otherwise identical characteristics.

Table 4.2 : Summary Statistics of IPC-based Software Matched-Patent Data

Variable:	Obs.	Mean	Std. Dev.	Min.	Max.
litigated patent	792	0.5	0.50	0	1
foreign assignee	792	0.19	0.39	0	1
unassigned (individual)	792	0.11	0.31	0	1
backward citations	792	14.7	22.3	3	345
forward citations (est.)	792	70.7	93.6	2.13	1061
delay in issuance	792	3.35	1.79	1.01	16.9
number of inventors	792	2.34	1.84	1	18
inventor countries (no. of)	792	1.02	0.15	1	2

Correlation Matrix:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) litigated patent	1							
(2) foreign assignee	-0.36	1						
(3) unassigned (individual)	0.21	-0.06	1					
(4) backward citations	0.10	-0.10	-0.04	1				
(5) forward citations (est.)	0.25	-0.17	-0.09	0.16	1			
(6) delay in issuance	0.11	0.00	0.07	0.20	0.01	1		
(7) number of inventors	0.04	-0.09	-0.17	0.12	0.20	0.07	1	
(8) inventor countries (no. of)	-0.07	0.05	0.03	-0.03	-0.03	0.03	0.10	1

Table 4.3: Probit Estimates for Litigated Software Patents

Dependent Variable = Litigated Patent	Model (1)	Model (2)	Model (3)	Model (4)
	coefficient	coefficient	coefficient	coefficient
constant	0.128 ** (std. err.) (0.052)	-1.530 *** (0.234)	-1.681 *** (0.248)	-1.098 *** (0.422)
foreign assignee	-1.350 *** (std. err.) (0.142)	-1.195 *** (0.150)	-1.214 *** (0.151)	-1.202 *** (0.151)
individual assignee	0.916 *** (std. err.) (0.165)	1.106 *** (0.173)	1.102 *** (0.174)	1.118 *** (0.176)
log - forward citations		0.862 *** (std. err.) (0.110)	0.863 *** (0.111)	0.869 *** (0.111)
log - backward citations		0.225 (std. err.) (0.169)	0.137 (0.176)	0.119 (0.176)
log - grant lag			0.219 * (std. err.) (0.116)	0.230 ** (0.116)
no. inventor countries				-0.576 * (std. err.) (0.338)
No of Obs.	792	792	792	792
Log Likelihood Ratio	-475.82	-438.70	-436.90	-435.38
Pseudo R-squared	0.1322	0.1999	0.2031	0.2059

1.4.2 Results and Discussion

The probit estimates (Table 4.3) for the determinants of software-patent litigation are similar in many respects to those shown in other industries. As expected, forward citations of software patents are significantly correlated with litigation, indicating that

patents that are more valuable tend to be litigated. Consistent with prior work (Lanjouw and Schankerman, 1997), backward citations are not significantly correlated with litigation, and foreign-owned patents are also significantly less likely to be litigated. By contrast, non-assigned patents are significantly more likely to be litigated, a pattern that is similar to patents in research medicines, but not other industries (Somaya, 2003a; 2003b). The contrast between individual and foreign-owned software patents is also evident when comparing the proportions of these patents in the litigated and matched samples (from Tables 4.1 and 4.2, respectively). While individual-owned patents comprise a larger fraction of litigated patents than foreign-owned patents, this pattern is reversed when comparing the matched patents (or the universe of software patents). This difference may suggest that individuals are more litigious in software, or simply that individuals tend to patent more selectively than do firms. By contrast, in the case of foreign patentees a general preference for litigation avoidance is a reasonable explanation. Given what are likely higher transactions costs associated with U.S. patenting, it is unlikely that foreign firms are being less selective than are U.S. patentees in obtaining patents.

The results show little support for the hypothesis that patents with larger teams of inventors (and hence patents innovated by larger organizations) may be more valuable, and thus more likely to be litigated. The “team-size” variable is significant at the 10% confidence interval if forward citations are not included in the analysis, making it likely that “value” information contained in variations in team-size (or firm size) is being captured by the forward citations variable. Interestingly, patents that entail a multinational team are significantly less likely to be litigated even after accounting for foreign

ownership, which may be an indication that larger firms, to the extent that team-multinationality is correlated with firm size, are less likely to initiate software patent suits.

1.5 COMPLEMENTARITY IN SOFTWARE FIRMS' USE OF INTELLECTUAL PROPERTY

This section explores relationships between the uses of different types of intellectual property by software firms. While secrecy is no doubt an important appropriability mechanism in software, it is inherently difficult to observe and study empirically. Thus, given the data constraints, this section focuses on patents, copyrights, and trademarks, the other three primary forms of intellectual property used in software.

1.5.1 Complementarity and Substitution Among Types of Intellectual Property

In prior literature, different types of intellectual property have tended to be characterized as substitutes to each other. This characterization is in part a reflection of the law, in which different types of IP protections are deemed suitable for the protection of different types of innovations. Thus, in its 1974 *Kewanee Oil versus Bicorn Corporation* decision,³² the U.S. Supreme Court observed that trade secret protection was employed for “lesser or different inventions” than those the patent laws protected. This legal view of intellectual property as strict “alternatives” was bolstered by a focus in much of the economics literature on the “innovation” as the unit of analysis, even if the same technology or product was comprised of different “types” of innovation.

A second pillar of the IP-as-substitutes view was the widespread focus on patent and trade secret protections in the early decades of the 20th Century, and their central role in protecting innovation in industries such as chemicals and manufacturing. Since the

³² 416 U.S. 470.

patent law explicitly requires that inventors disclose their invention, it was natural to assume that obtaining a patent required the compromise of a trade secret. Moreover, the idea that patent rights can substitute for trade secret protection when the latter fails, or *vice versa*, has been widely supported in theoretical studies of appropriability (Horstmann, MacDonald, and Slivinski, 1985; Teece, 1986; Friedman, Landes, and Posner, 1991; Arora, 1997). Furthermore, the Levin, et al. (1987) [“Yale Study”] survey of managers in a wide number of industries reported that patents were not used with secrecy: The Yale Study survey results indicated that the means of appropriation grouped into two categories, patent and non-patent mechanisms. While the non-patent mechanisms reported in the Yale Study included several non-secret devices, such as marketing, the study nevertheless suggested that patents tended not to be used with secrecy. These findings were reproduced for a sample of European firms by Konig and Licht (1995), and Sattler (2002) finds that secrecy and patenting load as different factors for a sample of German innovating companies.

An alternative and more nuanced view of firms’ use of intellectual property has also been developed. Building upon the Yale Study, Cohen, Nelson, and Walsh (1994) analyzed the findings of a later appropriability survey, and found that different appropriability mechanisms—specifically patenting and secrecy—are often used together to protect innovations in the same firm. While the authors’ quantitative analyses support the suggestion in the Yale Study that employing patenting is distinct from using other capabilities (e.g., lead time, sales, and manufacturing), they also find that secrecy does not necessarily comprise a distinct strategy, but may instead be a complement to patenting.

This suggestion is supported by the findings reported in Graham (2004) that secrecy and patent often work as complements.

1.5.2 Intellectual Property Substitution and Complementarity in Software

While recent research has moved away from the notion that different forms of legal IP protection are inherently substitutes, the types of IP evaluated are for the most part still limited to patents and (trade) secrets. Moreover, with the exception of Graham (2004), empirical studies comparing the use of different types of IP within firms have generally been limited to survey data. Innovation in the software sector may offer a unique an opportunity: The variety of formal intellectual property protections used to protect industrial products in the software industry (patent, trademark, *and* copyright) allows an analysis of the use by software firms of different types of IP, without relying on self-reported survey data alone.

Questions concerning the types of IP most effective in protecting software innovations have often sparked vigorous debate in legal research. Menell (1987) suggested that copyright was an inappropriate protection for software because it would fail to encourage innovation and hinder the functioning of markets, and recommended patent protection instead. Samuelson (1984) also faulted copyright as being ill-suited to software, but suggested a *sui generis* form of intellectual property as an alternative. More recently, scholars have examined the role of the IP regime in facilitating the formation of software component markets, and argued again in favor of patent protection (Lemley and O'Brien, 1997). Open source groups on the other hand have argued vociferously against patent protection, and maintain that copyright law, a modified version of which forms the

legal mechanism used by many open source licenses to police their communities, is best suited to software (Graham and Mowery, 2004).

Fundamentally, these legal debates suggest that different forms of IP, particularly patent and copyright, are *alternative* tools to protect technology in software. The observed decrease in copyright registrations at the same time that the legitimacy and use of software patenting increased (Graham and Mowery, 2003) appears to be consistent with this view of IP-as-substitutes. A rationale for this conclusion is that copyright has failed to provide adequate protection for certain innovations, such as the functional elements litigated in the “look-and-feel” lawsuits, and that patents have therefore been substituted to protect the valuable elements that copyright has failed to protect. This rationale is supported by the findings of an interview-based study of patenting (Liebeskind, 2000) suggesting that since software patents are sometimes weak and generally difficult to enforce, a combination of other types of IP may be used as substitutes. However, as noted earlier in this paper, there does not appear to be a corresponding trend in the litigation data. While litigation data for patents in this sector may be “spotty” due to timing issues associated with the relatively late arrival of patents, the limited evidence presented on copyright data shows a substantial increase in copyright litigation during an era when firms’ propensities to copyright had been falling (Graham and Mowery, 2003).

The hypothesis that different types of IP may be complementary in use can be motivated through arguments about “common inputs” and “complementary effects.” A critical common input for the effective use of any form of IP protection is an IP-aware management and its legal support staff. Having acquired a certain IP-related level of

managerial capability, firms may find it cost-effective (in both the pecuniary sense, as well as the costs of attention and awareness) to pursue strategies involving other forms of legal IP. While some IP-related tasks such as patent prosecution and litigation can no doubt be subcontracted to law firms, capability-building tasks such as formulating, monitoring, and implementing an IP strategy may be more efficiently conducted in-house, and may afford the firm added benefit by economizing on agency and contracting costs the firm would suffer in contracting-out all tasks necessary to pursue the IP strategy. Similarly, firms may develop a reputation for aggressiveness in IP litigation in one area, and then leverage this strategic asset as a common input for litigation on all IP fronts, which would also suggest similar complementary effects (Sullivan, 2000). There may thus be economies of scale and scope in pursuing different IP strategies, or management capabilities may be transferable or deployable once built in one form of IP to another form.

Alternatively, different forms of IP may work more effectively in conjunction with each other, and thus serve as complements. For example, patent protection may prevent the sale of close substitutes to a software product, thus making the product relatively more valuable. Such a lucrative product, in turn, is likely to attract copyright (and trademark) infringement, which the owner may be relatively more motivated to curb through enforcement due to its relatively greater value. Similarly, recent research by Lybecker (2003) suggests that stronger patent rights for pharmaceuticals are more likely to elicit counterfeiting, and therefore require stronger anti-counterfeiting enforcement.

Software firms employ patent, copyright, and trademark concurrently, using these overlapping rights to protect the same product. For instance, both a patent and trademark

were filed to protect Magnitude Information System, Inc.'s product "E-fuel," an e-commerce transaction monitoring tool. Registered as U.S. trademark "E-fuel" in 1999, the disclosure disclosed "software for compilation-receipt of information from the user." Concurrently, Magnitude was holding the copyright on the software code as the author of the "computer program," and the firm was seeking a patent: The firm was granted US patent "Computer Activity Monitoring" in 2000. Similarly, HiddenMind Technology, Inc. has used overlapping IP rights to protect its "ActiveUniverse" product. This mobile workforce information management system was trademarked by HiddenMind in 2000, described in the application as "software for distributing data, messages, and other software." While HiddenMind held the copyright at creation, the firm was also pursuing a U.S. patent that ultimately issued in 2002 as a system for "Transmitting data content." These cases suggest that firms operating in the software space may be using all three types of IP to protect the same innovation.

1.5.3 Data and Methods

Whether different types of software IP are characterized by substitution or complementarity is examined in this section. The focus is on the industry data set comprised of Softletter-sampled firms: These firms were among the top 100 firms (by sales revenues) in the PC-standard software industry for at least one year between 1986 and 2000. The sample includes virtually all the sizeable firms within this narrowly defined, but distinct, sub-segment of the software industry. In addition to IP litigation data, data on sales, employment, age, location, and ownership changes were collected on these packaged-software firms (including private firms). Therefore, an unbalanced firm-

year panel was created that straddles the early 1990s, the era when the intellectual property regime changed in the U.S. in support of software patents, as a result of actions by both the USPTO and the courts.

An interesting research challenge in this context is how the enforcement of IP through litigation should be measured. Merely focusing on the suits filed in any given year misspecifies the measure in two ways. First, it weights all IP suits equally, irrespective of the size or importance of the suit and, second, it places all the weight of litigation on the year the suit was filed rather than distributing it over the life of the suit. While using the number of active suits in a given year addresses the latter issue, this method fails to fully address the former. Thus, using that measure would equally weight a suit that is active for only fifteen days with one that is active for the entire year. Accordingly, the foregoing analysis employs the the number of suit-days in a year for each firm as the litigation dependent variable. Use of this weighted variable is supported by prior research (Somaya, 2003c) showing that the duration of patent suits is correlated with other measures of patent value, and can be viewed as a strategic variable in relation to litigation.

To shed light upon the complementarity puzzle in IP uses, the foregoing analysis attempts to determine the extent to which a firms' involvement in litigation over the different types of IP "move" together. An adequate analysis must first take account of alternative explanations for different levels of IP litigation by firms, and then allow an examination of the correlation between the unexplained parts of their litigation in different types of intellectual property. This is best accomplished in a seemingly unrelated

regression structure of regression equations (SUR), where the error terms for each regression are correlated with each other. The specification is as follows:

$$\begin{aligned}
 P_P &= X_{PP}\beta_{PP} + \varepsilon_{PP} \\
 P_D &= X_{PD}\beta_{PD} + \varepsilon_{PD} \\
 C_P &= X_{CP}\beta_{CP} + \varepsilon_{CP} \\
 C_D &= X_{CD}\beta_{CD} + \varepsilon_{CD} \\
 T_P &= X_{TP}\beta_{TP} + \varepsilon_{TP} \\
 T_D &= X_{TD}\beta_{TD} + \varepsilon_{TD}
 \end{aligned}$$

where the left hand variables P, C, and T denote suit-days in patent, copyright, and trademark suits respectively, and the subscripts P and D denote whether the focal firm is a plaintiff or defendant in the suit. The right hand independent variables X, coefficients β , and error terms ε are indexed with the IP-type (patent, copyright, and trademark) and plaintiff/ defendant respectively. Further, the error terms ε are correlated between each these equations

Alternate drivers of IP litigation can be accounted-for by including revenue, and revenue per employee (a measure of firm resources available per employee) among the independent variables.³³ In addition, firm- and year-fixed effects are included to account for idiosyncratic differences between firms and years. While the model could likely be improved by employing R&D expenditures in place of (or in addition to) revenues, R&D data for the private firms in the sample is unavailable because these data are not reported in SEC disclosures (unlike the publicly-traded firms). In spite of this omission, the approach is validated by the well-established finding of strong correlation between R&D and

³³ Fortunately, although many of the Softletter firms are not publicly traded, the Softletter100 discloses the total number of firm employees.

revenues in past research, especially when the analysis controls for fixed effects. Thus, the task of constructing a series of equations that reasonably predicts the use by firms of litigation is limited by the available data.

Table 4.4: Parameter Estimates / Correlation Matrix of Residuals

Parameter Estimates - Regression Equations (std. err. in parentheses)

	copyrt_P	copyrt_D	patent_P	patent_D	trdmrk_P	trdmrk_D
Revenue	1.359 (0.193)*	0.875 (0.171)*	0.458 (0.123)*	1.027 (0.137)*	0.714 (0.186)*	0.409 (0.163)*
Rev. per Employee	-2.317 (1.434)	-4.123 (1.268)*	0.698 (0.913)*	-2.035 (1.014)*	2.983 (1.383)*	3.205 (1.208)*
Obs.	391	391	391	391	391	391
"R-square" of Equation	0.780	0.589	0.426	0.724	0.555	0.497
Correlation matrix of residuals:						
copyrt_P	1					
copyrt_D	0.115	1				
patent_P	0.097	0.072	1			
patent_D	0.153	0.108	0.214	1		
trdmrk_P	0.144	0.016	0.076	0.144	1	
trdmrk_D	-0.026	0.084	0.098	0.117	0.185	1

Breusch-Pagan test of independence: **chi2 (15) = 86.564, Pr = 0.0000**

* indicates a parameter significant at the 95% confidence interval

After controlling for the independent variables, correlation between the residual errors can then be interpreted as evidence for inter-relatedness between the firms' use of intellectual property. Thus, controlling for the various independent variables, if the incidence of any one type of IP litigation increases along with the incidence of another type of IP litigation (if the residuals are positively correlated) one can surmise that there is

some form of complementarity between these two types. Likewise, if the residuals are negatively correlated, this would suggest that the two types of IP act as substitutes.

1.5.4 Results and Discussion

The empirical model described in the previous section is estimated with Generalized Least Squares (GLS), and the estimates are reported in Table 4.4. The model with all firms included was unwieldy to estimate due to the proliferation of parameters, and therefore the analysis uses a restricted sample including only those firms with litigation in at least two areas of IP. This restriction limits the sample to 51 firms, and 391 firm-year observations for each of the dependent variables, and may be criticized for biasing the results somewhat toward a finding of complementarity.

It is important to note that the estimates reported in Table 4.4 all stem from a single six-equation model. Thus, each column in the table contains the estimates for one of these six equations, with the correlations reported in the bottom half of the table being related to the model as a whole (Note: “copyrt_P” corresponds to “plaintiff in a copyright suit” and “copyrt_D” corresponds to “defendant in a copyright suit” and so forth). In all cases, the incidence of IP litigation is positively and significantly correlated with revenues, as one would expect. Interestingly, revenue per employee is generally significantly and positively correlated with higher IP litigation, except in the cases where the firms are patent- or copyright-defendants. It appears therefore that more “successful” firms (as indicated by high revenues per employee) tend to attract less patent and copyright enforcement against them.

The correlations between the residual errors are highly significant as a group, thus the hypothesis that the use of different types of IP is unrelated may be rejected. A closer examination of the correlations reveals two broad patterns. First, the magnitude of correlation is quite high between the plaintiff and defendant roles for each type of IP. This result may be due in part to the filing of declaratory judgment suits or other forms of retaliation (such as counter-suits) against a filed infringement suit. Second, the magnitude of correlation is high between the use of copyright and trademark in a plaintiff role and the “use” of patent litigation in a defendant role.

Furthermore, the coefficients in each of these cases are positive, suggesting that different types of IP enforcement are being used in concert, rather than independently or in lieu of each other. While it is noteworthy that the correlation is strong between the defendant role in patent enforcement and all other type-roles of IP litigation, this relationship should nevertheless not surprise the reader. As noted earlier, Softletter100 firms are more likely to be defendants in patent suits, and are often responding to patent enforcement by others even in their plaintiff role (as the plaintiff, through declaratory judgment actions and counter suits). Thus it appears that these firms’ efforts in patent litigation are weighted disproportionately to defensive strategies, an observation that is supported both by the findings on these firm’s share of declaratory judgment suits (Table 4.1) and by the strong plaintiff-defendant correlations.

While it appears that the paper may present some *prima facie* evidence for complementarity in IP use, the results also pose a challenge in understanding the source of this complementarity in view of the correlations with the defendant-patent role. Two

interpretations are possible. First, it is conceivable that software firms that are targeted for patent enforcement by others develop a broad IP capability that the firm then puts to a broader use in other areas of firm strategy. This argument is essentially one about common inputs. Second, it is possible that certain unobserved characteristics of firms induce them to use trademark and copyright enforcement at the same time as they are targeted by patent enforcement. Since the model incorporates fixed effects, such characteristics will have to be time varying, such as the emergence of a successful product or success in an area of business. In either case, the suggestions are speculative, and further analysis of the precise drivers of the IP complementarity in software awaits future research.

1.6 CONCLUSION

This paper presented a wide-ranging investigation into intellectual property litigation in software, including an exploratory study of complementarity or substitution between different types of IP use in software firms. The research uncovered a number of interesting facts about software IP litigation that has not been previously remarked upon in academic research. First, despite the increasing use of patents by software firms, the vast majority of intellectual property suits undertaken by software firms actually involves copyright law, and the growth rate of copyright litigation is continuing to keep pace with patent litigation, even in percentage terms.

Patent litigation in software is also peculiar in that the majority of litigation is initiated by smaller firms, individuals, and industry outsiders against the large incumbent firms in the PC-software industry. Moreover, even suits brought by the incumbent firms

are often in response to enforcement by others, either in the form of declaratory judgment suits or counter-suits. There also appears to be a much stronger reliance on the part of firms upon the declaratory judgment suit as a defensive mechanism, especially when compared with the use of mutual hold-up strategies through counter-suits.

We also uncover two interesting patterns that require further investigation, which are left for future research. First, prior research has reported that the extension of patent protection to software stimulated increased patenting by software firms, and a relative decline in copyright registrations (Graham and Mowery, 2003). But the research reflected in this paper finds that copyright litigation has continued to grow despite the changes in the institutional environment. At a fundamental level, one would expect copyright registration and enforcement trends to be correlated, and it is unclear if the observed differences are artifacts of the data, the low barriers and weak incentives for registering copyrights, or some other secular trend.

Second, even though the paper uncovers some evidence for complementarity in IP use among software firms, it is unclear what mechanism underlies this inter-relationship. Moreover, the nature of the results are more meaningfully interpreted if the term “use” of the patent system is somewhat broadly defined, so that even firms that are defending against patent suits can be said to be “users” of the system, albeit in a subtle manner. While there is some justification for this approach here, since the large Softletter100 firms are mostly defendants in patent suits, more work is needed to understand this phenomenon.

Finally, this research has some inherent limitations. First, it is limited to the three main types of intellectual property governed by federal law. This design does provide

some advantages, avoiding a criticism leveled at prior work in that it enables the use of broadly comparable litigation data. However, this approach does not allow the study of different types of intellectual property (e.g., trade secret) and other appropriability mechanisms (e.g., complementary capabilities and lead-time). Moreover, software technology exhibits several unique characteristics, including the relatively high importance of both copyrights and patents for appropriability in the same products. While software is no doubt an important, pervasive, and fast-growing sector of the economy, some of the findings are inherently sector-specific and cannot be perfectly extended to other technologies and sectors.

References

- Arora, A. (1997). "Licensing tacit knowledge: Intellectual Property Rights and the Market for Know-how." *Economics of Innovation and New Technology* 4: 41-59.
- Bessen, J. (2003). "Patent Thickets: Strategic Patenting of Complex Technologies." Working paper, Research on Innovation.
- Bessen, J. and R. Hunt (2003). "An Empirical Look at Software Patents." Working paper, Research on Innovation.
- Cockburn, I.M., S. Kortum, S. Stern (2002). "Are All Patent Examiners Equal? The Impact of Examiner Characteristics." National Bureau of Economic Research, working paper 8980.
- Corcoran, R. and L. Zarfes (1999). "Quality Review and Control in the PTO: The Historical Evolution." *Journal of the Patent and Trademark Office Society* 81: 5-9.
- Cohen, W., A. Goto, A. Nagata, R. Nelson and J. Walsh (2001). "R&D Spillovers, Patents and Incentives to Innovation in Japan and the United States." DRUID Conference Working Paper.
- Cohen, W., R. Nelson, and J. Walsh (2001). "Protecting Their Intellectual Assets: Appropriability Conditions and Why Firms Patent and Why They Do Not in the American Manufacturing Sector." NBER working paper 7552.
- Cohen, W., R. Nelson and J. Walsh (2002). "Links and Impacts: The Influence of Public Research on Industrial R&D." *Management Science* 48: 1-23.
- Friedman, D., W. Landes, and R. Posner (1991). "Some Economics of Trade Secret Law." *Journal of Economic Perspectives* 5(1): 61-72.
- Graham, S. (2004). "Hiding in the Patent's Shadow: Firms' Use of Secrecy to Capture Value from New Discoveries." Dissertation Chapter, University of California, Berkeley.
- Graham, S. and D. C. Mowery (2004). "The Use of USPTO 'Continuation' Applications in the Patenting of Software: Implications for Free and Open Source." Working paper, University of California, Berkeley.
- Graham, S. and D. C. Mowery (2003). "Intellectual Property Protection in the U.S. Software Industry," in W. Cohen and S. Merrill, eds., *Proceedings of the Science, Technology, and Economic Policy Board of the National Academy of Sciences*. Washington, D.C.: NAS Press.
- Graham, S., Hall, B., Harhoff, D. and Mowery, D. (2003). "Exploring the Effects of Patent Oppositions: A Comparative Study of US and European Patents," in W. Cohen and S. Merrill,

eds., Proceedings of the Science, Technology, and Economic Policy Board of the National Academy of Sciences. Washington, D.C.: NAS Press.

Green, J. and S. Scotchmer (1995). "On the Division of Profit between Sequential Innovators," *The Rand Journal of Economics* 26, pp. 20-33.

Grindley, P. C. and D. J. Teece (1996). "Licensing and Cross-Licensing in Electronics : Managing Intellectual Capital for Design Freedom and Wealth Creation." University of California at Berkeley, Center for Research in Management, Consortium on Competitiveness & Cooperation Working Paper.

Hall, B.H. and R.H. Ziedonis (2001). "The Patent Paradox Revisited: Determinants of Patenting in the US Semiconductor Industry, 1980-1994." *Rand Journal of Economics* 32(1): 101-28.

Hall, B.H., A. Jaffe, and M. Trajtenberg (2000). "Market Value and Patent Citations: A First Look." National Bureau of Economic Research, working paper 7741.

Hall, B.H., A. Jaffe, and M. Trajtenberg. (2001). "The NBER Patent Citations Data File: Lessons, Insights, and Methodological Tools." National Bureau of Economic Research, working paper 8498.

Harhoff, D. and M. Reitzig (2000). "Determinants of Opposition against EPO Patent Grants—The Case of Biotechnology and Pharmaceuticals." Working paper, INNO-tec, University of Munich.

Horstman, I., G. MacDonald, and A. Slivinsky (1985). "Patents as information transfer mechanism." *Journal of Political Economy* 93: 837-858.

Kortum, S. and J. Lerner (1999). "What Is Behind the Recent Surge in Patenting?" *Research Policy* 28(1): 1-22.

Lanjouw, J.O. and M. Schankerman (1997). "Stylized Facts of Patent Litigation: Value, Scope, and Ownership." National Bureau of Economic Research, working paper 6297.

Lanjouw, J. O. and M. Schankerman (2001). "Characteristics of Patent Litigation: A Window on Competition." *RAND Journal of Economics* 32(1): 129-51.

Lemley, M. A. (2001). "Rational Ignorance at the Patent Office." *Northwestern University Law Review* 95: 1495-1532.

Lemley, M. A. and D. W. O'Brien (1997). "Encouraging Software Reuse." *Stanford Law Review* 49(2): 255-305.

Lemley, M.A. (1994). "An Empirical Study of the Twenty-Year Patent Term." *AIPLA Quarterly Journal* 22: 369-417.

Levin, R. C., A. K. Klevorick, R. R. Nelson and S. G. Winter (1987). "Appropriating the Returns from Industrial Research and Development." *Brookings Papers on Economic Activity* (3): 783-820.

Liebeskind, J. Porter, Oliver, A. L., Zucker, L. G., and Brewer, M. (1996). "Social Networks, Learning and Flexibility: Sourcing Scientific Knowledge in New Biotechnology Firms." *7 Organization Science* (4), 428-43.

Liebeskind, J. Porter (1997). "Keeping Organizational Secrets: Institutional Protective Mechanisms and Their Costs." *6 Industrial and Corporate Change* (3), 623-63.

Lowe, R. (2002). "Entrepreneurship and Information Asymmetry: Theory and Evidence from Start-up Licenses at the University of California." U.C. Berkeley Dissertation.

Lybecker, K. (2003). "Product Piracy: The Sale of Counterfeit Pharmaceuticals in Developing Countries." Working Paper Drexel University.

Merges, R. P. (1996). "Property Rights Theory and the Commons - the Case of Scientific Research." *Social Philosophy & Policy* 13(2): 145-167.

Merges, R. P. (1997). *Patent Law and Policy*. Charlottesville: Michie.

Merges, R. P. (1999). "As Many as Six Impossible Patents Before Breakfast: Property Rights for Business Concepts and Patent System Reform." *Berkeley Law and Technology Journal* 14: 577-616.

Merges, R. P. and R. R. Nelson (1994). "On Limiting or Encouraging Rivalry in Technical Progress: The Effect of Patent Scope Decisions." *Journal of Economic Behavior & Organization* 25(1): 1-24.

Nordhaus, W. (1969). *Invention, Growth, and Welfare*. Cambridge, MA: MIT Press.

Pakes, A. and M. Simpson (1989). "Patent Renewal Data." *Brookings Papers: Microeconomics, Special Issue*: 331-410.

Quillen, C. D. and O. H. Webster (2001). "Continuing Patent Applications and Performance of the U.S. Patent Office." *Federal Circuit Bar Journal* 1: 1-21.

Samuelson, P., M. Denber and R. J. Glushko (1992). "Developments on the Intellectual Property Front." *Communications of the ACM* 35(6): 33-39.

Samuelson, P., R. Davis, M. Kapor and J. H. Reichman (1994). "A Manifesto Concerning the Legal Protection of Computer Programs." *Columbia Law Review* 94: 2308-2431.

Scherer, F.M. (1994). "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions." *American Economic Review* 55: 1097- 1125.

Scotchmer, S. (1996). "Protecting Early Innovators: Should Second-Generation Products Be Patentable?" *Rand Journal of Economics* 27(2): 322-331.

Shapiro, C. (2001). "Navigating the Patent Thicket: Cross Licensing, Patent Pools, and Standard-Setting." Institute for Business and Economic Research, U.C. Berkeley, working paper.

Somaya, D. (2003a). "Strategic Determinants of Decisions Not to Settle Patent Litigation." *Strategic Management Journal* 24: 17-38.

Somaya, D. (2003b). *Firm Strategies and Trends in Patent Litigation in the United States. Advances in the Study of Entrepreneurship, Innovation, and Economic Growth*. G. Libecap ed., JAI Press (Forthcoming).

Somaya, D. (2003c). "The Duration of Patent Litigation: Firm Strategies and Litigation Tactics in Computers and Research Medicines." Working Paper, Robert H. Smith School of Business.

Teece, D.J. (1986). "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing, and Public Policy." *Research Policy* (6), 285-305.

Teece, D.J., G. Pisano and A. Shuen (1997). "Dynamic Capabilities and Strategic Management", *Strategic Management Journal*, 18, 509-534.

Tirole, J. (1988). *The Theory of Industrial Organization*. Boston: MIT Press.