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What is the impact of software patent shifts? Evidence from *Lotus v. Borland* ☆

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Abstract

Economists have debated the extent to which strengthening patent protection spurs or detracts from technological innovation. This paper examines the reduction of software copyright protection in the *Lotus v. Borland* decision. If patent and copyright protections are substitutes, weakening of one form should be associated with an increased reliance on the other. We find that the firms affected by the diminution of copyright protection disproportionately accelerated their patenting in subsequent years. But little evidence can be found for any harmful effects on firms' performance and incentive to innovate: in fact, the increased reliance on patents is correlated with growth in measures such as sales and R&D expenditures.

JEL classification: K11; L51; 034

Keywords: Intellectual property; Patents; Copyright; Innovation

1. Introduction

One of the most enduring questions in the literature on the economics of technological change relates to the impact of patent protection. Economists have hotly debated the extent to which allowing strong patent rights spurs or detracts from technological innovation.

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In recent years, a particular hotbed for these discussions has related to the impact of patents in emerging industries. A substantial literature on incomplete contracting, beginning with Grossman and Hart (1986) and Hart and Moore (1990), suggests that firms will be unwilling to invest when risks of expropriation are high. A number of critics have charged that these problems are particularly prevalent among patent awards in high-technology industries: both academic researchers and practitioners have asserted that the poor quality of patent reviews has led to numerous awards being granted to parties that had little involvement with innovation, and consequently has made these expropriation problems likely for true innovators. By making such dubious property right grants, patent office officials may make it likely that firms will face substantial demand for licensing payments or will be unable to access the critical intellectual properties at all (see, for instance, Heller and Eisenberg, 1998; Shapiro, 2001; Jaffe and Lerner, 2004; Ziedonis, 2004). As a result, firms will have reduced incentive to innovate.

This paper examines these issues by studying the software industry. Patents have been intensely controversial in this industry, largely for the reasons delineated above. The limited work to date has been frequently cited by policymakers: see, for instance, the frequent references to Bessen and Hunt (2004) in debates about software patents in the European Parliament between 2003 and 2005. These studies, however, have been intensely controversial (see, for example, Hahn and Wallsten, 2003; Mann, 2005). Thus, there is a need for empirical evidence on the impact of patenting on the development of the software industry.

This paper is related to earlier empirical works, which have largely focused on understanding the impacts of a single intellectual property policy reform. Examples include studies of the broadening of Japanese patent scope (Sakakibara and Branstetter, 2001), the establishment of the Court of Appeals for the Federal Circuit in the United States (Kortum and Lerner, 1998; Hall and Ziedonis, 2001), and the strengthening of patent protection of pharmaceuticals in such nations as India (Lanjouw, 1998) and Italy (Scherer and Weisburst, 1995).

Unlike these studies, we focus on a change that involved an alternative form of intellectual property protection: the reduction of software copyright protection in the *Lotus v. Borland*[2] decision. If patent and copyright protections are substitutes, the weakening of one form of protection should be associated with an increased reliance on the other.[3] We rely on this methodology because there is no single event that unambiguously established the patentability of software, while the *Lotus v. Borland* decision had the clear earmarks of a shock to the system. We examine if the increased reliance on patents after this decision led to a decrease in innovation for the reasons spelled out by the critics.

In this analysis, we undertake a “differences-in-differences” analysis. We examine the subset of firms that were most effected by the decision in *Lotus v. Borland* as determined by the technology classes firms are sorted into. We do so in two ways: first by examining the nature of the critical technologies in each industry and then by examining the market reaction of firms to the critical judicial decision. We subsequently refer to these firms that were most affected by the judicial decision as “interface firms”.[4] We then compare the shifts in the behavior of these firms

[2] 788 F. Supp. 78 (D. Mass. 1992), 799 F. Supp. 203 (D. Mass. 1992), 831 F. Supp. 202 (D. Mass. 1993), 831 F. Supp. 223 (D. Mass. 1993); Rev’d, 49 F.3d 807 (1st Cir. 1995); Aff’d per curiam by evenly divided Court, 116 S. Ct. 804 (1996)).

[3] The view that patents and copyrights are substitutes has emerged from a considerable number of legal and economic analyses of these questions informed by practitioner discussions, including Menell (1989), Lemley and O’Brien (1997), and Graham and Mowery (2003). It is still possible, however, that patents and copyrights are not substitutes. Therefore, their relationship is part of what we are testing when we examine empirically the impact of the judicial decisions concerning copyright on the level of patent filings.

[4] The *Lotus v. Borland* case concerns the copyrightability of software interfaces. Therefore, we expect that the firms most affected by the judicial decision develop software in which interfaces are the key elements.

with other software firms, which should have been less affected by the increased reliance of patenting. If the advent of software patents really had a deleterious effect on innovative process in the software industry (e.g., Bessen and Hunt, 2004), these firms should have suffered a disproportionate slowdown in their innovation and expansion.

We find that the judicial decision appears to have had a considerable impact on patenting. The number of patent applications filed appears to have increased more dramatically for the interface firms than the others. We then examine the impact of this policy shift on firms' performance. Little evidence can be found for any harmful effects in a number of measures. In fact, the increased reliance on patent protection appears to be correlated with significant growth in a few measures, such as sales and R&D expenditures.

This finding must, of course, be interpreted with caution. Our division between affected and unaffected firms is somewhat crude. The environment is a complex one: many other changes, such as the widespread dissemination of the Internet, may have differentially affected firms during this period. While our result contradicts the claim by Bessen and Hunt (2004) that software patents substitute for R&D at the firm level, increased reliance on patenting could at the same time contribute to patent thickets that slow down overall innovation in the industry. Therefore, the patent thicket problem – an overlapping set of patent rights requiring those seeking to commercialize new technology obtain licenses from multiple patentees (Shapiro, 2001) – could still exist. Finally, the effect of the increased reliance on patent protection may take longer to be felt than examined here.

The outline of this paper is as follows. Section 2 briefly reviews the history of intellectual property protection in the U.S. software industry. Section 3 describes the construction of the dataset. Section 4 presents the analysis. The final section concludes the paper.

2. Intellectual property protection of software in the United States

The United States Patent and Trademark Office (USPTO) traditionally was reluctant to grant patents on computer software inventions. Through the 1970s, the Office resisted granting such patents on the grounds that computer programs were mathematical algorithms, and not in the categories allowed by Section 101 of the U.S. Patent Act: processes, machines, articles of manufacture, and compositions of matter.

Beginning with the 1981 decision in *Diamond v. Diehr*,[5] the U.S. Supreme Court supported patent applications for inventions involving software programs as well as controls external to these programs. These shifts were implemented in 1995, as the USPTO released the Final Computer Related Examination Guidelines.[6] Many observers suggested that these guidelines only codified a change that had already been put into practice.

Meanwhile, the feasibility of copyrights on computer software had first been suggested by the major reform of the copyright system in 1976. Through the 1980 amendment to the Copyright Act, Congress gave a statutory basis to copyright protection for software, but important ambiguities still remained.

The most important of these related to the scope of copyright protection. The judicial system had long recognized a distinction between copyrights, which protects expression, and patents,

[5] See Appendix A for details about judicial decisions mentioned in this paper.

[6] The Final Computer Related Examination Guidelines created “safe harbor” exemptions for inventions having software programs to control something external to the software programs, or to manipulate numbers representing concrete, real world values. Also, software can be patented if it is claimed in connection with a specific machine or product, including such diverse inventions as graphics programs, spreadsheets, and word processing programs.

which protect useful procedures or machines. To what extent did copyright protection for software extend beyond the actual code?

Three decisions in the ensuing dozen years highlighted this confusion. The 1986 case of *Whelan v. Jaslow* concerned a dental laboratory management software system, which a dentist had hired a programmer to write for his minicomputer in the EDL language. After a few years, the programmer wrote a similar program for personal computers in BASIC. The dentist sued for copyright infringement, although the new program was in a different language and differed in some respects. The court, pointing to the similar interfaces used by the new program, argued that it was too close to the original program, and thus violated its copyright.

In the 1990 case of *Lotus v. Paperback Software and Mosaic Software*, the court again decided in favor of a plaintiff in an infringement case. Paperback and Mosaic both came out with spreadsheet programs that displayed extreme similarities to Lotus's 1-2-3. In the decision, the court basically determined that a company has the right to copyright the "look and feel" of its user interface.

The logic in these decisions was sharply criticized in the 1991 decision in *Computer Associates v. Altai*. In this decision, the court found in favor of the alleged copyright infringer, referring to the decisions in the earlier cases as "inadequate and inaccurate". In particular, the judge cast doubt on the proposition that the structure of the program or its interface could be used to determine whether the program was infringing.

It was against this backdrop that the case between Lotus and Borland was heard. Lotus argued that Borland had copied key aspects of its 1-2-3 spreadsheet for the Quattro programs, including menu commands and structure, long prompts, keystroke sequences, and macro language. At the district level, the court in July 1992 made a summary judgment ruling for Lotus, arguing the Quattro program was similar enough to infringe on the copyright of the 1-2-3 interface. Borland appealed to the appellate court for the first circuit, which in March 1995 reversed the decision, holding "that the Lotus menu command hierarchy is uncopyrightable subject matter", because it was little more than a "method of operation". Ten months later, this decision was upheld by an equally divided Supreme Court.

While the split in the court meant that the decision did not bind beyond the first circuit, the decisions attracted a great level of attention and were perceived as signaling a sharp limitation of the scope of copyright protection. This conclusion is evident from the writing of legal academics specializing in the intellectual property of software. For instance, Ronald Mann (2005) has commented that "the facade of pervasive copyright protection came crashing to a definitive ruin with the celebrated decision of the First Circuit in *Lotus v. Borland*," and "ever since Lotus lost protection for look and feel, copyright has not seemed valuable in the industry". Referring to this case, Pamela Samuelson observed, "*Whelan* totally died, but it took years".[7] Similarly, in the months after the decision, many practitioners urged software firms to seriously consider patent protection for user-interface components.

Thus, the treatment of patenting software changed only gradually over this period. It seems hard to identify a single event or shock that shifted perceptions. The value of copyrights for protecting software, however, was dramatically revised downward as a means of protecting computer interfaces after the *Lotus v. Borland* decision. If these two forms of intellectual property protection were substitutes, the affected firms should have increasingly relied on patent protection after the decision. Our analysis tests this hypothesis.

[7] http://www.softpanorama.org/Copyright/professor_samuelson.shtml (accessed March 13, 2006).

Although the *Computer Associates v. Altai* ruling in 1991 might also influence the software firms' patenting behavior, we choose to focus on the *Lotus v. Borland* case for a couple of reasons. First, the rulings in *Computer Associates* and other cases often relied on the similarity of the software programs, whereas *Lotus v. Borland* explicitly addressed the scope of protection for computer programs: the appeals court pointed out that the issue was not "substantial similarity" at all. Rather, it held that the menu structure of Lotus 1-2-3 was a "means of operation" and was not copyrightable in the first place (Karjala and Menell, 1995). Second, the effect of the *Computer Associates v. Altai* ruling in 1991 was weakened by the 1992 *Lotus v. Borland* ruling at the district court level, in which the Lotus 1-2-3 interface was determined to be copyrightable. The appearance of two conflicting rulings in a short period suggests that these earlier rulings did not set much of a precedent for copyrightability of software interfaces. As the 1996 Supreme Court ruling of the *Lotus v. Borland* case made the limits to the copyrightability of software interfaces abundantly clear and had the clear earmarks of a shock to the system, we focus on this policy shift.

3. The data

The primary data for the LECG software database, which this analysis employs, were purchased from Corporate Technology Information Services (CorpTech). The dataset was supplemented with variables from Compustat, the Center for Research into Securities Prices (CRSP) database, Venture Economics' VentureXpert (formerly known as Venture Intelligence) Database, and the USPTO's Patent database.

CorpTech was founded in 1986 to prepare an annual directory and customized databases for high technology firms in the United States. In 2000, it was acquired by OneSource, and has been its subsidiary since then. CorpTech is a unique source of information on 50,000 U.S. high technology manufacturing companies in 18 industries. Its data cover public and private companies (information that is not accessible through any other sources) and include large companies, new companies, emerging companies, and subsidiaries and operating units of U.S. and foreign companies.[8]

In all, we have 51,420 observations on 15,207 software companies for 1990–2002 from CorpTech.[9] The data are available every other year for even years: 1990, 1992, 1994, 1996, 1998, 2000 and 2002. Approximately 12% of our sample are firms that were publicly traded companies for all or some of the sample period. For these firms, we have added CUSIP (Committee on Uniform Securities Identification Procedures) numbers, allowing the data to be matched to Compustat and CRSP data. We encountered a few issues while adding CUSIP information to public companies. First, many companies in our dataset are subsidiaries. We added CUSIP information of parent companies for such companies. All information merged by CUSIP variable, such as Compustat data, reflects the parent company's information. Second, we could not locate CUSIP information for about 12% of all public companies in our dataset – some companies had ceased their operations, some companies became private, and others simply could not be located. Note that some of the firms that report themselves as public in CorpTech are traded on the pink sheets or overseas, and thus are not picked up by Compustat and CRSP.

[8] See CorpTech website at http://www.corptech.com/business-information/methodology.php (accessed March 13, 2006).

[9] We define software companies as those that have at least one detailed product classification beginning with "SOF". That is, to be included in our dataset, the firm had to consider software development as an intentional part of its business, thus listing the category of software it develops when interviewed by CorpTech. This definition excludes some firms that patent software but do not consider themselves software companies, such as Hewlett Packard. Subsidiaries of Hewlett Packard (and other such companies) are included if they listed at least one software development category ("SOF").

Table 1
Some characteristics of the sample

Year	Mean	S.D.	Minimum	Maximum
Panel A: Number of patent applications filed by each firm in this and previous year				
1990	0.64	14.98	0	556
1992	1.17	27.79	0	962
1994	1.34	31.97	0	1192
1996	2.78	63.66	0	2165
1998	2.12	5.99	0	1885
2000	0.04	0.94	0	34
Total	**1.29**	**38.61**	**0**	**2165**
Panel B: Sales by year (million dollars)				
1990	133.62	2496.52	0	89583.3
1992	123.96	2618.94	0	86846.68
1994	81.36	1757.36	0	94083.89
1996	110.59	1942.37	0	89515.8
1998	115.77	1140.54	0	50954.43
2000	98.66	1508.38	−0.34	87500
Total	**104.50**	**1841.86**	**−0.34**	**94083.89**
Panel C: Average number of employees per firm at the end of year				
1990	217.14	3789.06	1	127927
1992	346.66	6988.45	1	317100
1994	161.50	1266.30	1	50000
1996	215.62	4623.19	1	295000
1998	265.68	2997.68	1	121000
2000	406.24	5167.87	1	307401
Total	**297.312**	**4543.98**	**1**	**317100**

Panel A reports summary statistics for the number of patents filed by year. Panel B reports sales statistics by year. Panel C reports summary statistics for the number of employees in each firm by year.

From the patent data purchased from the USPTO, we identified all software patents. Previous studies have used two main approaches to identify software patents. One is based on keyword search, as in Bessen and Hunt (2004). The other relies on patent classifications (for example, Graham and Mowery, 2003, 2005). Layne-Farrar (2005) compares the two approaches and finds that keyword search leads to a high rate of obvious non-software patents, and while pure reliance on classifications could include hardware patents along with software ones, using classifications is a much safer method. We therefore used the International Patent Classification (IPC) system to identify patent awards. We included all patents classified under IPC G06F (Electric Digital Data Processing) and granted between 1976 and 2000 – a total of 76,920 patents. We merged these files using the name and location of the assignee in the USPTO database, as well as the subject of the award. In total we obtained 24,006 patent-to-company matches. The unmatched patents are largely awarded to individuals and foreign corporations.

The process of matching the VentureXpert data proceeded similarly, exploiting the detailed name, location and business line information compiled by Venture Economics.

Table 1 summarizes the sample along several key dimensions of firm performance. The number of patent filings is in the current and previous year – e.g., for 2000, the tabulation includes filings made in 1999 and 2000 – while for the other measures, the values at the end of the year are tabulated. The compilation of successful patent applications only includes patents awarded as of mid-2003. Thus, the compilation for 2000 is sharply lower than the others, not because fewer flings had been made, but because few of those filed in this period had yet been issued. There are few time trends apparent here: this reflects the fact that while many of the established firms grew rapidly over this period, there were also considerable entries of small new firms.

4. The analysis

We now proceed to analyze the patterns seen in the data. We first discuss the way in which we classify the observations into groups that are and are not likely to be affected by the *Lotus v. Borland* decision. We then present the results regarding patenting and other indicators of firm success. Finally, we examine the robustness of these results.

4.1. Classifying the firms

A central challenge here is to separate the firms into those likely to be affected by the copyright decision and those that do not. There is no one obvious approach to addressing this issue. We thus undertake two approaches.

We first undertake an *a priori* classification, assigning firms to be interface firms if their technology classes are likely to be affected by the decision. The CorpTech database contains 359 distinct technology classes, each with a detailed description. Based on our industry knowledge, we examine each technology class and try to determine whether the interface is likely to be a major component. We classify most firms that develop software geared toward non-technical users – such as spreadsheets, word processors and text editors, and financial analysis and management software – as interface firms. Most firms that produce software geared towards technologists and engineers, such as voice message systems software and software for controlling heating, ventilation, and air conditioning, are classified as non-interface firms. This procedure allows us to assign firms in about 85% of technology classes into interface or non-interface groups. The remaining technology classes – for example, software that controls printing operations and handles spooling of data to hardcopy devices – are ambiguous. Given the descriptions from CorpTech, it is not obvious to us how to classify firms in these classes. We consider these firms as non-interface firms in our analysis.[10]

In the end, we classify firms in 99 technology classes as interface firms. The categories into which most interface firms are sorted are accounting, banking, education, file management, financial analysis, health services, and insurance.

Alternatively, we try to identify the types of firms most affected by these decisions by examining market reactions. To implement this, we look at the subset of publicly traded software firms around the time of the three critical judicial decisions in the *Lotus v. Borland* case. These judicial decisions are: 1) on July 31, 1992, the district court ruled that the Lotus menu command hierarchy was copyrightable expression and Borland had illegally copied large parts of the Lotus 1-2-3 command structure; 2) on March 9, 1995, the First US Circuit Court of Appeals reversed the 1992 ruling and determined that Lotus' menu structures, incorporated into Borland's Quattro Pro spreadsheet, are "an uncopyrightable method of operation"; and 3) on January 16, 1996, the Supreme Court upheld the ruling, thus affirming the decision by the appeal court. We estimate an event study, where one observation is used for each firm and each judicial decision.

[10] Our results do not change much if we exclude these ambiguous classes, partly because only a small number of firms are in these classes.

Table 2
Comparisons between interface definitions

Dependent variable	Event window ($t-1$, $t+1$)		Event window ($t-2$, $t+2$)		Event window ($t-3$, $t+3$)	
	Strong/Medium	No response	Strong/Medium	No response	Strong/Medium	No response
Number of codes from regression analysis	91	268	86	273	111	248
Number of codes included in *a priori* selection	34	65	45	54	34	65
Percentage selected	0.37	0.24	0.52	0.20	0.31	0.26

In our alternative scheme, we look at the subset of publicly traded software firms around the time of the three judicial decisions in the *Lotus v. Borland* case. We estimate an event study, where one observation is used for each firm and judicial decision. The dependent variable is the absolute return of the firm in a window around the event. For independent variables, we employ dummy variables denoting the 359 distinct technology classes into which the firms are sorted, as well as dummy variables for each observation date. The industry dummy variables are coded as one if the firm was assigned to that class based on the 1994 classification scheme when such scheme is recorded by CorpTech or the classification scheme in the closest year to 1994. We then examine the coefficients on the technology classes based on the regressions. If the coefficient takes on the positive sign and is significant at the 10% level in a one-sided test, we define this as a “strongly” affected class. If the coefficient takes on the expected sign but is significant at a lower level, we define this as a “medium” class. Otherwise, we regard it as unaffected. We indicate here for different event windows, the number of firms assigned to the strong and medium groups. We also compare the distribution to the one based on our *a priori* classification scheme which is the primary one used in the paper.

The dependent variable is the absolute return of the firm in a window around the event.[11] For independent variables, we employ dummy variables denoting the 359 technology classes as well as dummy variables for each observation date. The industry dummy variables are coded as one if the firm was assigned to that class based on the 1994 classification scheme when such scheme is recorded by CorpTech or the classification scheme in the closest year to 1994. If we wish to identify the firms most affected by the decisions, we should look at the ones which had the strongest reaction.

We use different event windows to reflect possible delays in incorporating the information into the stock price. While the judicial decisions have a clear timing, there may be lags associated with understanding the implications of the decisions for particular firms. We thus use windows from 1 day before to 1 day after up to 3 days before to 3 days after.

We then examine the coefficients on the technology classes based on the regressions. If the coefficient takes on the positive sign and is significant at the 10% level in a one-sided test, we define this as a “strongly” affected class. If the coefficient takes on the expected sign but is significant at a lower level, we define this as a “medium” class. Otherwise, we regard it as unaffected. We then assign all firms – whether public or private – in the strong and medium classes to be the ones we anticipate being affected by the decision.

Although the second approach has the befit of being objective, our classification is based on a small subset of the firms in our dataset (about 12%), since the other firms are privately held. Moreover, the distribution of private firms is not uniform: for some technology classes, only very

[11] We could also use actual return of the firms as the dependent variable. But this approach is a little problematic: after all, our dataset contains both copyright holders and copyright infringers. A judicial decision that is unfavorable to one group would be favorable to the other. A better approach is to examine the absolute returns. The firms that moved the most in response to the decisions, whether in a positive or negative manner, may be the most appropriate ones to employ.

few firms are public. These firms may not be representative firms of these technology classes. Therefore, we base our primary analysis on our *a priori* classification scheme, and employ the analysis based on market reactions as a supplemental analysis.

Table 2 summarizes the different classification schemes employed. It indicates for each approach the number of firms assigned to the strong and medium groups. We also compare the distribution to that in our *a priori* scheme. One encouraging aspect is the considerable degree of overlap across the different schemes: in each case we are disproportionately choosing the same firms as the affected ones.

4.2. Impact on patenting and firm growth

We now proceed to understand the impact of the policy shift on patenting behavior. The analysis can be understood as a validation exercise for our selection process. If there is no increase in the relative number of patent applications filed for the group presumably affected by the *Lotus v. Borland* decision, we must worry that our identification of these firms or our claim that patents and copyrights are substitutes is problematic. We then examine how the changes in firms' patenting behavior affect their performance. If the arguments outlined in the introduction are valid, we should see detrimental effects from the increasing reliance on patent protection.

Fig. 1 displays the basic pattern regard to patenting. The number of patent applications filed by interface firms exceeds that by non-interface firms after 1992. In particular, beginning with 1995–96 there seems to be a substantial increase in the rate of patenting by these firms.

Table 3 presents similar before and after data for seven indicators of firm performance: sales, total assets, market capitalization, the number of employees, sales per employee, R&D expenditure and the number of product lines. In the case of sales and employees, as well as the ratio, we have data on the majority of the firms in the CorpTech database. In the case of the

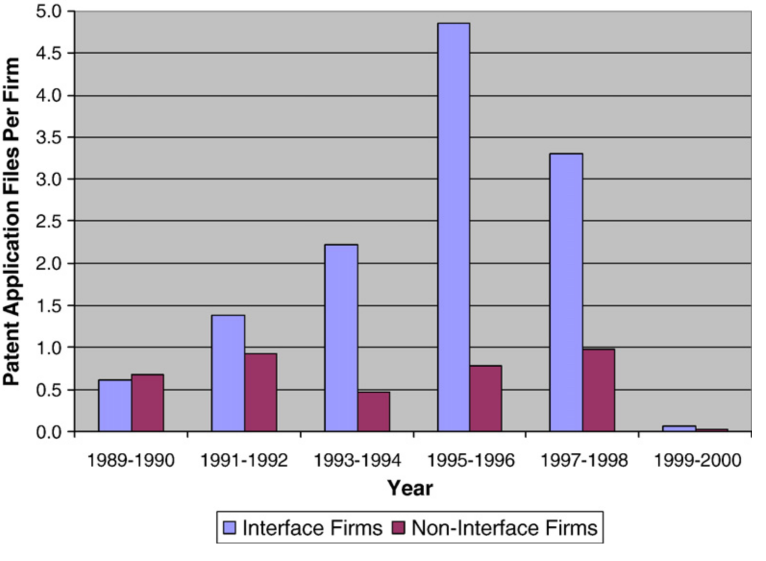

Fig. 1. Patenting behaviors by interface firms and non-interface firms. We compute the average number of patents filed by interface and non-interface firms each year. Note that as we only consider even years between 1990 and 2000, the number of patents filed in year t is the sum of patents filed in year t and year $t-1$. The number of patent applications filed in year 2000 is very low due to truncation: many patents filed in that year have not issued.

Table 3
Summary statistics for variables we use to measure firms' performance

Year	Interface firms			Non-interface firms		
	Mean	Median	S.D.	Mean	Median	S.D.
Panel A: Growth in sales						
1990	2.83	−0.33	9.36	1.00	−0.74	3.61
1992*	0.53	−0.03	4.24	1.94	−0.03	21.36
1994	0.54	−0.06	5.85	0.61	−0.06	7.77
1996	1.19	−0.06	11.85	0.99	−0.06	19.21
1998*	2.47	−0.08	31.71	0.55	−0.08	3.02
2000	0.65	−0.08	7.05	1.28	−0.08	21.40
Panel B: Growth in total assets						
1990						
1992	0.39	0.10	0.92	0.31	0.05	0.77
1994	0.86	0.14	3.87	0.52	0.16	1.28
1996	1.86	0.26	11.03	1.02	0.26	3.04
1998	1.14	0.11	8.00	0.72	0.16	1.88
2000*	3.65	0.08	20.03	1.72	0.06	8.36
Panel C: Growth in market capitalization						
1990						
1992	0.80	0.12	2.24	1.39	0.45	2.85
1994	0.47	0.11	1.37	0.45	0.16	1.10
1996	2.01	0.45	9.26	1.50	0.43	4.64
1998	1.82	0.00	21.56	0.49	0.00	1.41
2000	1.44	0.00	9.57	1.81	0.00	21.47
Panel D: Growth in number of employees						
1990	0.83	−0.25	3.88	0.21	−0.53	1.91
1992	0.43	0.00	4.11	0.24	0.00	1.05
1994	0.56	0.00	7.96	0.31	0.00	1.71
1996	0.60	0.00	5.58	1.14	0.00	25.60
1998	0.59	0.00	7.44	0.57	0.00	5.41
2000	0.59	0.00	5.29	0.90	0.00	14.43
Panel E: Growth in sales per employee						
1990	0.32	0.33	0.60	1.00	0.00	2.42
1992	0.23	−0.03	1.54	0.37	−0.03	1.84
1994	0.37	−0.06	3.08	0.28	−0.06	2.16
1996	0.26	−0.06	1.94	0.26	−0.06	1.44
1998	0.39	−0.08	4.55	0.15	−0.08	1.32
2000	−0.01	−0.14	0.80	−0.05	−0.15	0.66
Panel F: Growth in R&D expenditure						
1990	0.29	0.25	0.37	0.31	0.17	0.48
1992	0.57	0.11	2.77	0.28	0.11	0.66
1994*	0.27	0.15	0.52	0.50	0.15	1.31
1996	0.65	0.25	1.95	0.72	0.29	1.81
1998	0.37	0.17	1.42	0.34	0.13	0.84
2000	0.63	0.20	2.27	0.59	0.20	1.35

Table 3 (*continued*)

Year	Interface firms			Non-interface firms		
	Mean	Median	S.D.	Mean	Median	S.D.
Panel G: Growth in the number of product lines						
1990*	2.37	0.50	7.03	−0.29	−0.40	0.47
1992*	0.60	0.00	1.56	0.16	0.00	0.65
1994*	0.22	0.00	1.13	0.05	0.00	0.48
1996*	0.33	0.00	1.50	0.05	0.00	0.47
1998*	0.26	0.00	1.14	0.04	0.00	0.43
2000*	0.22	0.00	1.19	0.02	0.00	0.41

We use a number of variables to measure firms' performance such as the growth in sales, total assets, market capitalization, the number of employees, sales per employee, R&D expenditure and the number of product lines. In Panels A to G, we report the means, medians, standard deviations of these measures for interface firms and non-interface firms respectively. An asterisk (*) after a year number indicates that the value of interface firms is significantly greater than that of non-interface firms in that year with 90% confidence level by a one-tail *t*-test.

others, we have data only for a much smaller subset of firms that are in Compustat. The table presents the mean, median and standard deviation of each performance indicator for interface firms and non-interface firms, respectively. We observe that the growth rate for interface firms is greater than for non-interface firms in several cases, such as sales in 1992 and 1998 and total assets in 2000. Interestingly, interface firms have been expanding their product lines more rapidly than non-interface firms in all even years between 1990 and 2000.

We then turn to examining these patterns in a regression framework. We first examine the impact of the *Lotus v. Borland* ruling on patenting. We undertake a "differences-in-differences" approach to compare the differences in patenting activities before and after the policy shift for those affected and those not. Table 4 presents the results from three different regression specifications: OLS, Poisson and Negative Binomial. For the OLS specification, the natural logarithm of the number of patents filed in the current and previous year plus one is used as the dependent variable. For the Poisson and Negative Binomial specifications, the number of patents filed in the current and previous year is used as the dependent variable. Year dummies, the dummy for interface firm, and the interaction terms between interface firm and year dummies are used as explanatory variables.

As the observed difference in patenting activities may result from underlying shifts in firm-level or industry-level characteristics rather than the policy shift, we need to control for these characteristics. We thus include firm-level controls such as the age of the firm, lagged value of the sales, and the lagged total number of patents filed.[12] The entry rate in each technology class is also used to control for industry-level competition, as firms may rely more heavily on patents to gain competitive advantages when the industry becomes more competitive. The entry rate is calculated as the ratio between the number of new entries in a technology class and the total number of firms in that class. For firms that have multiple lines of business, we use the average of the entry rate in each technology class that the firms have been sorted into. It is possible that some firms in a technology class are not recorded by CorpTech. Those firms are most likely small ones so that they were not on CorpTech's radar screen. Their absence would not have a large impact on the competitive environment.

[12] In all our regression analyses, lagged values for year t are referring to the values in year $t-2$ (reflecting the fact we have observations on a biannual basis).

Table 4
Regression analysis of the patenting behaviors of interface firms before and after the Lotus v. Borland lawsuit

	OLS	Negative Binomial	Negative Binomial	Negative Binomial	Poisson	Poisson	Poisson
Interface	−0.02	0.82	−1.19	−1.19	−0.58	−0.49	−0.54
	[0.01] ***	[0.60]	[0.37] ***	[0.37] ***	[0.03] ***	[0.03] ***	[0.03] ***
Interface * Year 1996	0.03	3.31	1.18	1.18	2.85	0.97	1.15
	[0.01] **	[0.82] ***	[0.52] **	[0.52] **	[0.05] ***	[0.06] ***	[0.06] ***
Interface * Year 1998	0.03	1.01	1.52	1.42	2.19	1.54	1.62
	[0.01] ***	[0.84]	[0.51] ***	[0.52] ***	[0.05] ***	[0.05] ***	[0.05] ***
Year 1994	0.00	−2.60	0.50	0.75	−1.54	−1.51	−1.46
	[0.01]	[0.57] ***	[0.38]	[0.39] *	[0.04] ***	[0.04] ***	[0.04] ***
Year 1996	−0.01	−2.67	0.88	0.90	−1.39	−1.43	−1.53
	[0.01]	[0.63] ***	[0.43] **	[0.45] **	[0.05] ***	[0.05] ***	[0.05] ***
Year 1998	−0.01	−1.60	−0.01	0.39	−1.78	−1.16	−1.08
	[0.01]	[0.66] **	[0.44]	[0.47]	[0.05] ***	[0.04] ***	[0.04] ***
Age of the firm	0.00	−0.00	−0.02	−0.01	−0.03	0.01	0.00
	[0.00]	[0.01]	[0.01] *	[0.01]	[0.00] ***	[0.00] ***	[0.00] ***
Lagged value of sales	0.02	5.02	2.96	3.20	0.08	0.05	0.06
	[0.01] ***	[1.31] ***	[0.54] ***	[0.56] ***	[0.00] ***	[0.00] ***	[0.00] ***
Lagged number of patents applied	0.00		0.08	0.08		0.00	0.00
	[0.00] ***		[0.02] ***	[0.02] ***		[0.00] ***	[0.00] ***
Entry rate	0.03	1.52		3.08	−1.27		1.27
	[0.03]	[1.82]		[1.43] **	[0.09] ***		[0.10] ***
Observations	12085	12085	12122	12085	12085	12122	12085
R^2	0.40	0.02	0.12	0.13	0.10	0.52	0.52

The sample consists of biannual observations of 15,207 software firms between 1992 and 1998. We use a number of specifications including OLS, Negative Binomial and Poisson. The first row indicates the particular type of specification used. The number of patents filed each year is used as the dependent variable in all regressions. Entry rate is defined as the percentage of new entries in a technology class and is used to control for industry competition. Lagged total number of patents applied is the total number of patents filed by a firm in the past and is used as a way to include fixed effects in the regressions. Heteroskedastic-adjusted standard errors in brackets. [14]

* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

As we do not have any observations before year 1990, we are not able to compute the entry rates in year 1990. Therefore, in our analysis we exclude year 1990. As our dataset only contains very few patent applications filed between 1999 and 2000, we also exclude year 2000.[13]

The results in Table 4 are consistent with the hypothesis that the reduction in the copyright protection leads to more patenting, as evidenced by the significantly positive coefficients for the interaction terms between the interface dummy and year dummies. Our results also indicate several things. First, *ceteris paribus*, interface firms tend to file fewer patents than non-interface firms on average. Second, firms tend to patent more if they have filed many patent applications in the past. Finally, a more competitive environment tends to motivate firms to file more patent applications.

[13] In addition, we are concerned that the *State Street* case (resolved by the Supreme Court in 1999) may have increased the number of financial patents and may make the regression results difficult to interpret.

[14] We also run fixed effects and random effects Poisson specification and obtain similar results.

We now examine the impact of patenting activities on firms' performance. The causality between a firm's patenting activity and its performance is difficult to examine directly as more patenting activities could be the cause as well as the reaction of better performance. The *Lotus v. Borland* decision presents an exogenous shock and allows us to employ the instrumental estimator to address this problem. The regressions presented in Table 4 are used as the first stage. In the second stage, we use the predicted number of patents from the first stage as an instrument variable. Table 5 reports the results. In Table 5, the predicted number of patents is derived from the full-model Poisson specification in Table 4.

For dependent variables, we use the growth rates of seven measures: sales, total assets, market capitalization, employment, sales per employee, R&D expenditure and number of lines of business. As above, each observation of a firm at a 2-year interval is used as an independent observation.

We first estimate the growth measures without using the patenting variable. The idea here is to examine whether firms in sectors with more generous patent policies grow more rapidly, regardless of their specific patenting activity. Then we add the lagged predicted number of patents

Table 5
Regression analysis of the impact of the change of patenting behaviors on firms' financial performance

Panel A

	Sales growth	Sales growth	Total asset growth	Total asset growth
Year 1994	−0.600	−0.650	−13.215	−1.283
	[1.166]	[1.158]	[11.842]	[0.441] *
Year 1996	5.033	5.003	−1.513	−0.711
	[1.668] *	[1.656] *	[0.963]	[0.569]
Year 1998	−0.790	−0.756	−2.333	2.166
	[1.712]	[1.699]	[5.122]	[2.554]
Interface	−0.280	−0.260	17.903	1.028
	[1.088]	[1.080]	[16.836]	[0.658]
Interface * Year 1996	−5.123	−5.273	−17.120	−0.252
	[2.161] **	[2.287] **	[16.857]	[1.032]
Interface * Year 1998	2.060	−2.141	−19.299	−3.446
	[2.221]	[2.224]	[16.058]	[2.803]
Age of the firm	0.103	0.052	0.172	−0.048
	[0.044] **	[0.044]	[0.224]	[0.014] *
Entry rate	1.403	1.517	−27.239	4.778
	[4.479]	[4.447]	[32.821]	[3.891]
Lagged predicted number of patents		0.000		−0.000
		[0.000] ***		[0.000]
Interface * Year 1996 * Lagged predicted number of patents		0.210		−0.001
		[0.875]		[0.006]
Interface * Year 1998 * Lagged predicted number of patents		2.972		0.000
		[0.205] *		[0.000] *
Lagged value of sales	−0.119	−0.252		
	[0.234]	[0.235]		
Lagged total asset			−0.000	−0.000
			[0.000]	[0.000] *
Observations	12473	12462	2372	2125
R^2	0.00	0.02	0.00	0.01

(continued on next page)

Table 5 (*continued*)

Panel B

	Market cap growth	Market cap growth	Employees growth	Employees growth	Sales per employee growth	Sales per employee growth
Year 1994	−1.147	−1.217	0.066	0.045	0.286	0.286
	[0.966]	[1.045]	[0.173]	[0.172]	[0.075] *	[0.075] *
Year 1996	−0.078	−0.351	0.180	0.187	0.231	0.230
	[1.277]	[1.392]	[0.146]	[0.151]	[0.061] *	[0.061] *
Year 1998	−1.351	−1.674	0.158	0.153	0.134	0.134
	[1.081]	[1.198]	[0.213]	[0.218]	[0.052] *	[0.052] *
Interface	−0.284	−0.745	0.217	0.214	0.039	0.040
	[0.772]	[0.899]	[0.110] **	[0.114] ***	[0.043]	[0.043]
Interface * Year 1996	0.774	1.288	0.022	−0.036	−0.039	−0.271
	[1.663]	[1.801]	[0.199]	[0.204]	[0.091]	[0.188]
Interface * Year 1998	1.681	2.156	0.771	1.086	0.200	0.113
	[1.402]	[1.522]	[0.855]	[1.265]	[0.150]	[0.140]
Age of the firm	−0.011	−0.010	−0.008	−0.006	−0.001	−0.001
	[0.016]	[0.019]	[0.008]	[0.007]	[0.002]	[0.002]
Entry rate	−2.201	−2.555	−1.756	−1.865	0.098	0.096
	[2.987]	[3.366]	[1.898]	[1.969]	[0.165]	[0.000]
Lagged predicted number of patents		−0.000		0.011		−0.000
		[0.000]		[0.017]		[0.000]
Interface * Year 1996 * Lagged predicted number of patents		−0.010		0.067		0.250
		[0.034]		[0.103]		[0.231]
Interface * Year 1998 * Lagged predicted number of patents		0.000		−0.264		0.065
		[0.002]		[0.360]		[0.090]
Lagged market cap	−0.000	−0.000				
	[0.000]	[0.000]				
Lagged number of employees			0.000	0.000		
			[0.000]	[0.000]		
Lagged sales per employee					−15.267	−15.907
					[9.677]	[10.310]
Observations	2080	1852	11031	10840	9338	9333
R^2	0.00	0.00	0.00	0.00	0.00	0.01

and its interaction with interface and year dummies to examine to what extent the difference in their patenting activity affects their performance. As control variables, we first employ the lagged value of each growth measure: for instance, the level of sales at the beginning of the 2-year interval if the growth rate of sales is used as the dependent variable. We also include entry rate and the age of the firm. An OLS specification is used for all regressions. We then repeat the above procedures for the inception of venture financing. A probit model is employed here.

As reported in Table 5, we find little evidence that more generous or restrictive patent policies significantly affect the growth rates of the firms: in almost all regressions without the predicted patenting variable, no significant differences between interface and non-interface firms are detected. Only in the cases of sales growth in 1996 and product line growth in 1998 that we observe significant declines for interface firms. We do not have a ready explanation for these

Table 5 (*continued*)

Panel C

	R&D growth	R&D growth	Product line growth	Product line growth	Get first round finance	Get first round finance
Year 1994	−0.034	−0.033	−0.104	−0.105	0.091	0.238
	[0.087]	[0.087]	[0.021] *	[0.020] *	[0.102]	[0.130] ***
Year 1996	0.261	0.261	−0.069	−0.069	0.131	0.152
	[0.164]	[0.164]	[0.027] *	[0.027] *	[0.126]	[0.174]
Year 1998	−0.111	−0.111	−0.065	−0.064	0.389	0.390
	[0.079]	[0.079]	[0.025] **	[0.025] **	[0.110] *	[0.156] **
Interface	0.039	0.039	0.481	0.480	0.133	0.049
	[0.084]	[0.084]	[0.021] *	[0.021] *	[0.092]	[0.131]
Interface * Year 1996	−0.190	−0.188	0.008	−0.012	0.004	0.130
	[0.188]	[0.190]	[0.035]	[0.035]	[0.165]	[0.220]
Interface * Year 1998	−0.071	−0.076	−0.075	−0.084	0.027	0.100
	[0.110]	[0.110]	[0.032] **	[0.032] *	[0.138]	[0.183]
Age of the firm	−0.006	−0.006	0.002	0.002	−0.028	−0.020
	[0.001] *	[0.001] *	[0.001] *	[0.001] *	[0.005] *	[0.006] *
Entry rate	−0.258	−0.258	0.144	0.146	0.383	0.712
	[0.268]	[0.269]	[0.072] **	[0.072] **	[0.261]	[0.397] ***
Lagged predicted number of patents	−0.000	−0.000	−0.000	−0.000		−0.000
	[0.000]	[0.000]	[0.000]	[0.000]		[0.000]
Interface * Year 1996 * Lagged predicted number of patents		−0.000		0.016		−0.022
		[0.001]		[0.002] *		[0.108]
Interface * Year 1998 * Lagged predicted number of patents		0.000		0.001		−0.005
		[0.000] *		[0.000] *		[0.046]
Lagged R&D	−0.000	−0.000				
	[0.000] *	[0.000] *				
Lagged number of product lines			−0.059	−0.059		
			[0.002] *	[0.002] *		
Observations	1785	1785	21 535	21 535	31 792	20 247
R^2	0.02	0.02	0.07	0.08	0.04	0.03

The sample consists of biannual observations of 15,207 software firms between 1992 and 1998. We present the results in three panels, using various dependent variables. The first row of each table indicates the performance measures we use as dependent variables. For each measure, we first run the regressions without using the predicted number of patents. This examines whether firms in sectors with more generous patent policies grow more rapidly, regardless of their specific patenting activity. Then we add the lagged predicted number of patents and its interaction with interface and year dummies to examine to what extent the difference in their patenting activity affects their performance. All regressions employ an ordinary least squares specification except in the case of the inception of venture financing where we employ a probit specification. Heteroskedastic-adjusted standard errors in brackets.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

declines. Consistent with our early observation, interface firms in general are more active in expanding their business lines, despite the relative decline in 1998.

Once we control for firm patenting behavior, we find no evidence for any harmful effects from the judicial decision: none of the growth measures and the inception of venture financing seem negatively affected by this policy shift. In fact, we find that the increased reliance on patent protection is correlated with significant growth in sales, total assets, and R&D expenditure in 1998, and business lines in 1996 and 1998. The increased reliance on patenting appeared to lead to some increase in firms' incentive to innovate. One possible explanation is that the final ruling of *Lotus v. Borland* might have actually spurred innovation, since programmers were free to create products that had the "look and feel" of existing popular programs before these products are patented.

4.3. Exploring robustness

A natural concern is whether the results above are a consequence of the way in which the firms are identified or due to some confounding events. We thus repeat the analysis in several ways to explore the robustness of the finding.

Table 6 summarizes some of these robustness analyses. Rather than relying on the *a priori* scheme, we use the alternative approach based on market reactions with different event windows to identify these affected firms. Except in the case where we use the window 1 day before and 1 day after, the table shows the same pattern to the one reported in the final column of Table 4. The result also suggests that there might be lags associated with understanding the implications of the

Table 6
Robustness checks using other definitions for interface firms

Event windows	($t-1$, $t+1$)	($t-2$, $t+2$)	($t-3$, $t+3$)
Interface	−1.251	−1.119	−0.131
	[0.657] *	[0.034] **	[0.037] **
Interface * Year 1996	−0.321	2.712	1.849
	[1.815]	[0.082] **	[0.082] **
Interface * Year 1998	−0.077	1.695	1.392
	[0.876]	[0.051] **	[0.058] **
Year 1994	−1.413	−1.494	−1.505
	[0.580] ***	[0.040] **	[0.041] **
Year 1996	−0.613	−2.850	−2.343
	[0.894]	[0.074] **	[0.076] **
Year 1998	−0.021	−1.199	−1.104
	[0.588]	[0.045] **	[0.054] **
Age of the firm	0.001	0.007	0.005
	[0.018]	[0.001] **	[0.001] **
Lagged value of sales	0.052	0.060	0.000
	[0.020] **	[0.001] **	[0.000] **
Lagged total number of patents applied	0.002	0.002	0.002
	[0.000] **	[0.000] **	[0.000] **
Entry rate	0.483	1.392	1.802
	[2.409]	[0.097] **	[0.103] **
Observations	12085	12085	12085
R^2	0.53	0.52	0.52

The sample consists of biannual observations of 15,207 software firms between 1992 and 1998. As a robustness check, we try to identify affected firms using an event study around three judicial dates. Then we repeat the regressions in Table 4 using these new definitions and report results here. In all cases, results from the Poisson specification are reported. Heteroskedastic-adjusted standard errors in brackets.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

decisions. In unreported regressions, we show that when we replicate the analysis in Table 5 with event window 2 or 3 days before and after, we obtain similar results.

Because the software industry is one in which a small number of firms generate a large share of total revenue, we weight observations by the square root of the firm size to account for importance of different firms and repeat the analysis. We obtain similar results except that we no longer find significant correlation between increased reliance on patenting and growth in total assets.

In our analysis, a firm is considered as an interface firm if it has one or more business lines in the affected group. This scheme would include firms as interface firms even if they only have a small portion of business lines in the affected group. In an unreported analysis, we repeat our analyses in Tables 4 and 5 using a new classification scheme in which a firm is considered affected only if it has more than 50% of its business lines in the affected group. We compare these firms to the ones that have no business lines in the affected group. The results are similar to those in Tables 4 and 5.

We are also concerned about different user groups these software firms target. In particular, software firms can develop software for enterprises or home users. The policy shift may affect these two groups differently if one group cares more about intellectual property protection than the other. To address this concern, we repeat the analyses, after eliminating all firms whose products run on mainframe computers. The results are similar except that when we replicate the analysis in Table 4, the coefficients of the interaction terms, (interface * year 1996) and (interface * year 1998), more than double in all specifications. This suggests that firms targeting at enterprises are less responsive to the judicial decision, possibly because interface design is not the most important element of their products.

Our fifth concern is whether the results are shaped by confounding events. In particular, was there an event that may have affected interface firms different from other corporations? We explore the most visible candidate: the widespread diffusion of access to the World Wide Web in the mid-1990s. While it is not obvious that interface firms would be more affected, this possibility is worrisome. To address this concern, we repeat the analyses in Tables 4 and 5, now eliminating all firms geared towards the Internet (we identify these by eliminating firms that develops products based on Web browsers or have Java as a key software platform). We obtain similar results.

5. Conclusions

The growth of software patenting has triggered numerous concerns among academics, practitioners and policymakers. In particular, the diversity of the patent holdings in this area, and the alleged failure of the patent awards to always reward true innovators, have led to concerns of expropriation problems for innovators. Such claims evoke concerns expressed in the theoretical literature on incomplete contracts, which suggests that uncertain property rights will deter investments. These claims, however, have not been scrutinized empirically.

In this paper, we focus on the reduction of software copyright protection in the *Lotus v. Borland* decision. If patent and copyright protections are substitutes, then the weakening of one form of protection should be associated with an increasing reliance on the other. We rely on this methodology because there is no single event that unambiguously established the patentability of software, while this had the clear earmarks of a shock to the system.

We examine the subset of firms that were most affected by the decision in *Lotus v. Borland*, as determined by the technology classes they are sorted into, and compare the shifts in the behavior of these firms with other software firms, which should have been less affected by the decreased effectiveness of copyright. We find that the judicial decision appears to have had a considerable impact on patenting. The number of patent applications filed appears to have increased more dramatically for the interface firms than the others. But little evidence can be found for any harmful effects from this policy shift. In fact, the increased reliance on patent protection appears to be correlated with significant growth in a few performance measures such as growth in sales and the number of business lines. In addition, the increased reliance on patent protection is correlated to greater R&D expenditure. While our interpretation must be cautious, we conclude there is little evidence of harm at the firm level from the increased reliance on software patenting.

Appendix A. Details of some of the judicial decisions discussed in the paper

A.1. Diamond v. Diehr (450 US 175 (1981))

The case of *Diamond v. Diehr* provided the first instance in which the U.S. Supreme Court ordered the USPTO to grant a patent on an invention even though computer software was utilized. In that case, the invention related to a method for determining how rubber should be heated in order to be best "cured". The invention utilized a computer to calculate and control the heating times for the rubber. However, the invention included not only the computer program, but also included steps relating to heating rubber, and removing the rubber from the heat. The Supreme Court stated that in this case, the invention was not merely a mathematical algorithm, but was a process for molding rubber, and hence was patentable.

A.2. Whelan v. Jaslow (797 F.2d 1222 (3d Cir. 1986))

The case of *Whelan v. Jaslow* concerned a dental laboratory management software system, which a dentist had hired a programmer to write for his minicomputer in the EDL language. After a few years, the programmer wrote a similar program for personal computers in BASIC. The dentist sued for copyright infringement, although the new program was in a different language and differed in some respects. The court, pointing to the similar interfaces used by the new program, argued that it was too close to the original program, and thus violated its copyright. The implication was that copyright protection of computer programs might extend beyond the programs' literal code to their structure, sequence and organization.

A.3. Lotus v. Paperback Software and Mosaic Software (740 F. Supp. 37 (D. Mass. 1990))

In 1990, Lotus sued Paperback Software and Mosaic Software, which had produced spreadsheets that had the same interface as 1-2-3. While there was no issue of copying code, Lotus claimed that copying the interface itself constituted copyright infringement. The court decided in favor of Lotus and basically determined that a company has the right to copyright the "look and feel" of its user interface. Both Paperback Software and Mosaic Software went out of business as a result.

A.4. Computer Associates v. Altai (775 F. Supp. 544 (EDNY 1991))

In this 1988 case, Computer Associates brought a copyright infringement against Altai, alleging that Altai had copied substantial portions of Computer Associates ADAPTER program.

In 1991, the District Court found that Altai's program was not substantially similar to the one from Computer Associates and, accordingly, did not infringe.

References

Bessen, James, Hunt, Robert M., 2004. An Empirical Look at Software Patents. Working Paper 03-17/R. Federal Reserve Bank of Philadelphia.

Graham, Stuart, Mowery, David, 2003. Intellectual property protection in the U.S. software industry. In: Cohen, Wesley, Merrill, Steven (Eds.), Patents in the Knowledge-based Economy: Proceedings of the Science, Technology and Economic Policy Board. National Academies Press, Washington.

Graham, Stuart, Mowery, David, 2005. Software patents: good news or bad news. In: Hahn, Robert W. (Ed.), Intellectual Property Rights in Frontier Industries: Software and Biotechnology. AEI Press, Washington.

Grossman, Sanford J., Hart, Oliver D., 1986. The costs and benefits of ownership: a theory of vertical and lateral integration. Journal of Political Economy 94, 691–719.

Hahn, Robert W., Wallsten, Scott, 2003. A Review of Bessen and Hunt's Analysis of Software Patents. AEI-Brookings Joint Center Working Paper.

Hall, Bronwyn H., Ziedonis, Rosemarie H., 2001. The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor industry, 1979–1995. Rand Journal of Economics 32, 101–128.

Hart, Oliver, Moore, John, 1990. Property rights and the nature of the firm. Journal of Political Economy 98, 1119–1158.

Heller, Michael A., Eisenberg, Rebecca S., 1998. Can patents deter innovation? The anticommons in biomedical research. Science 280, 698–701.

Jaffe, Adam B., Lerner, Josh, 2004. Innovation and Its Discontents. Princeton University Press, Princeton.

Karjala, Dennis S., Menell, Peter S., 1995. Brief Amicus Curiae: Applying fundamental copyright principles to Lotus Development Corp. v. Borland. Berkeley Technology Law Journal 10, 177–187.

Kortum, Samuel, Lerner, Josh, 1998. Stronger protection or technological revolution: what is behind the recent surge in patenting? Carnegie–Rochester Conference Series on Public Policy, vol. 48, pp. 247–304.

Lanjouw, Jean O., 1998. The introduction of pharmaceutical product patents in India: 'Heartless exploitation of the poor and suffering'? Working Paper, vol. 6366. National Bureau of Economic Research.

Layne-Farrar, Anne, 2005. Defining software patents: a research field guide. Working Paper 05-14. AEI-Brookings Joint Center.

Lemley, Mark, O'Brien, David, 1997. Encouraging software reuse. Stanford Law Review 49, 255–305.

Mann, Ronald J., 2005. Do patents facilitate financing in the software industry? Texas Law Review 83, 961–1030.

Menell, Peter S., 1989. An analysis of the scope of copyright protection for computer programs. Stanford Law Review 41, 1045–1104.

Sakakibara, Mariko, Branstetter, Lee, 2001. Do stronger patents induce more innovation? Evidence from the 1988 Japanese patent law reforms. Rand Journal of Economics 32, 77–100.

Scherer, F.M., Weisburst, Sanford, 1995. Economic effects of strengthening pharmaceutical patent protection in Italy. International Review of Industrial Property and Copyright Law 6, 1009–1024.

Shapiro, Carl, 2001. Navigating the patent thickets: cross-licenses, patent pools, and standard-setting. In: Jaffe, Adam B., Lerner, Josh, Stern, Scott (Eds.), Innovation Policy and the Economy, vol. 1. National Bureau of Economic Research, Cambridge, MA.

Ziedonis, Rosemarie H., 2004. Don't fence me in: fragmented markets for technology and the patent acquisition strategies of firms. Management Science 50, 804–882.