An Empirical Analysis of Patent Litigation in the Semiconductor Industry

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Abstract*

Semiconductor firms sell products that embed hundreds if not thousands of patented inventions, elevating concerns about patent-related hold-up in this sector. This paper examines the incidence and nature of patent lawsuits involving 136 dedicated U.S. semiconductor firms between 1973 and 2001. By supplementing patent litigation data with information drawn from archival sources, we estimate the probability that firms will be involved in patent lawsuits, either as enforcers of exclusionary rights or as targets of litigation filed by other patent owners. We further distinguish between disputes that involve product-market rivals and those that do not. Overall, we find little evidence that semiconductor firms have adopted a more aggressive stance towards patent enforcement since the 1970s, despite the effective strengthening of U.S. patent rights in the 1980s and widespread entry by small firms. In fact, their litigation rate as *enforcers* of patents remains relatively stable over the past two decades once we control for factors such as the number of patents they own and changes in R&D spending. In striking contrast, we find an escalation in their baseline risk as *targets* of litigation brought by outside patent owners.

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1. Introduction

The U.S. patent system is under fire. Record numbers of patents are being awarded in areas ranging from semiconductors and computer software to business methods and gene sequences, raising concerns about the costs and feasibility of navigating through overlapping claims in these areas (Shapiro, 2001). At the same time, the past two decades have witnessed a noticeable rise in patent litigation (Merz and Pace, 1994; Landes and Posner, 2003) as well as an escalation in the costs associated with patent enforcement (AIPLA, 2005). Calling for reform, legal scholars and economists are questioning whether the direct and indirect costs associated with obtaining and enforcing US patent rights are imposing an implicit tax on innovation in vital segments of the economy (e.g., Barton, 2000; Jaffe & Lerner, 2004).

If there is an "innovation tax" arising from patents, it is expected to be especially salient in sectors where products are complex and combine many patentable technologies that may be owned by a number of different parties. As suggested by a number of researchers (e.g., see Grindley and Teece 1997) and as shown by Arora et al. (2003), Information and Communication Technology (ICT) sectors, including semiconductors, are likely to fall in this class of sectors. Such firms typically require access to a "thicket" of external intellectual property to advance technology or to legally manufacture and sell products, elevating concerns about patent-related hold-up problems. According to an estimate from Intel, for example, by 2002 over 90,000 US patents related to central processing unit technologies had been awarded to more than 10,000 firms, universities, government labs, and independent inventors (Detkin 2002).

In prior studies, we examined the effects of a "pro-patent" shift in U.S. policy attributed to the 1982 formation of the Court of Appeals for the Federal Circuit (CAFC) on the innovative activities of firms in this sector (Hall and Ziedonis, 2001; Ziedonis 2004). On one hand, evidence from our prior study suggests that the patent reforms led capital-intensive firms in this sector to "ramp up" their patent portfolios more aggressively—largely to reduce litigation risks and to improve their bargaining positions in negotiations with external patent owners.[1] On the other hand, the strengthening of U.S. patent rights in the 1980s also may have facilitated entry into the industry by firms specializing in chip design. Interviews with representatives from design firms suggest that these firms (often relatively small in size) enforce their patent rights quite aggressively in court, primarily to establish proprietary rights in niche product markets (Hall and Ziedonis, 2001). In line with this view, Ziedonis (2003) finds that chip design firms enforce roughly 4 out of every 100 patents they own—a patent enforcement rate comparable to that reported in Lerner (1995) in the context of specialized biotechnology firms but somewhat lower than that reported in Lerner (2006) for financial sector patents.

In this paper, we examine factors that affect the probability that dedicated semiconductor firms will be involved in patent litigation—either as enforcers of exclusionary rights or as targets of litigation filed by other patent owners. We also explore the extent to which the incidence and

[1] Similarly, Cohen et al. (2000) report that the most prominent motives for patenting in technologically "complex" industries (including semiconductors) include the prevention of lawsuits and use of patents in license negotiations. Hall (2005) shows an escalation in the patent propensities of ICT firms more generally following the 1980s patent reforms.

nature of patent-related disputes in this sector changed following the CAFC's formation. We start with a sample of "potential litigants" that includes an unbalanced panel of 136 publicly traded U.S. firms that compete primarily in semiconductor-related product markets. As Lanjouw and Schankerman (2001) show, the main database used in patent litigation studies (Litalert by Derwent) has an under-reporting bias that is more pronounced prior to the mid-1980s. Because we want to capture patterns of litigation involving firms in our sample prior to the CAFC's establishment, we supplement Litalert data with information drawn from archival 10-K filings, news articles, trade journals such as the EETimes, and company press releases. In total, we identify over 500 patent lawsuits involving sample firms between 1973 and 2001. Not all firms are involved in patent-related litigation. Roughly 67% of the sample encounters one or more patent lawsuits during this three-decade period while the remainder of the sample does not. In 2000, sample firms collectively generated over $88 billion in revenues, spent $12 billion in R&D, and owned roughly 31,000 US patents.

With the exception of Lerner (1995) and Bessen and Meurer (2006), prior studies have estimated patent-related "litigation risk" primarily using matched pairs of litigated and non-litigated patents (e.g., Lanjouw and Schankerman, 2001; Somaya, 2003; Allison et al., 2004; Lerner, 2006). We prefer to estimate litigation probabilities at the level of firms rather than patents for several reasons. First, interpreting patent-level litigation risk is quite difficult within the information technology sector. If the number of patents firms file is causally related to litigation risk, as suggested above, it is unclear whether a reduction in lawsuits filed per patent reflects diminished or heightened concerns of patent hold-up. In addition, a firm-level analysis allows exploration of the relationship between litigation probability and patent portfolio size and characteristics, which is desirable given the importance of overall firm patent strategy in this context.

Shifting attention to litigation probabilities of firms also enables us to examine the role that different firms play in disputes over patents, while controlling for firm-level characteristics such as R&D spending, size, and patent propensity. Consistent with Bessen and Meurer (2006), we characterize a firm as a “patentee litigant” when they enforce patents against others and as a “target” when other parties assert patent rights against them. Our study differs from Bessen and Meurer’s cross-industry analyses, however, in that we observe “pre-CAFC” litigation. We also draw on industry-specific data to assess the relationships between litigants in semiconductor-related product markets in the years of dispute.

Overall, we find little evidence that semiconductor firms have adopted a more aggressive stance towards patent enforcement since the 1970s, despite the effective strengthening of U.S. patent rights in the mid-1980s and widespread entry by specialized firms. In fact, their litigation rate as *enforcers* of patents remains relatively stable over the past two decades once we control for factors such as the number of patents they own and changes in R&D spending. In striking contrast, we find an escalation in their baseline risk as *targets* of litigation brought by outside patent owners. While the majority of lawsuits launched against sample firms are made by rivals in semiconductor product markets, our estimates suggest that the probability that these firms will be sued by non-rivals nonetheless has increased over the past decade.

The remainder of this paper is organized as follows. In Section 2, we briefly discuss the changing U.S. patent landscape during the 1980s and its implications for patent enforcement within the semiconductor industry. Section 3 presents our data sources, summary statistics and methodology. Results are given in Section 4, which is followed by a discussion of the limitations of this study and the extensions we envision.

2. *The Changing Patent Landscape*[2]

The patent system has long been recognized as an important policy instrument used to promote innovation and technological progress. Two fundamental mechanisms underpin the system. First, an inventor discloses to the public a "novel", "useful", and "nonobvious" invention. In return, the inventor receives the right to exclude others from using that patented invention for a fixed period of time (20 years from the date of patent application in the United States). By providing exclusionary rights for some period of time and a more conducive environment in which to recoup R&D investments, the patent system aims to encourage inventors to direct more of their resources toward R&D than would otherwise be the case. At the same time, detailed information about the invention is disclosed to the public when the patent application is published.

The creation of the Court of Appeals for the Federal Circuit in 1982 is often credited with ushering in an era that generally afforded stronger legal protection for patent owners in the United States (Jaffe, 2000). Although the driving force behind the legal reform was a need to unify U.S. patent doctrine, the CAFC put in place a number of procedural and substantive rules that collectively favored patent owners. For example, the new court increased the evidentiary standards required to invalidate patents (Lerner, 1995; Henry and Turner, 2006), was more willing to halt allegedly infringing actions early in the dispute by granting preliminary

[2] This section is drawn from Ziedonis (2003).

injunctions (Lanjouw and Lerner, 2001), and was more willing to sustain large damage awards (Merges, 1997).

Not surprisingly, the use and importance of U.S. patents in semiconductors was affected by this changing landscape. By the early 1980s, a broad range of semiconductor technologies had diffused widely across the industry (Levin, 1982). Due to consent decrees with U.S. antitrust authorities signed in the 1950s, the "technological giants" in semiconductor production, largely IBM and AT&T, were effectively curtailed from enforcing patent rights against rival firms throughout the 1960s and 1970s. Instead, IBM & AT&T instituted liberal licensing policies that are widely credited with the rapid growth and pace of innovation in the early phase of the industry's development (Levin, 1982). Nonetheless, Tilton (1971, p. 76) concludes:

> "Certainly, the great probability that other firms were going to use the new technology with or without licenses is another reason for the liberal licensing policy. Secrecy is hard to maintain in the semiconductor field because of the great mobility of scientists and engineers and their desire to publish. Moreover, semiconductor firms, particularly the new, small ones, have demonstrated over and over again their disposition to infringe on patents."

Although cross-licensing remains an important mechanism with which firms trade access to one another's patents within the industry, the terms of these agreements changed (not surprisingly) during the "pro-patent" regime. Firms with large patent portfolios, such as Texas Instruments, IBM, and AT&T, adopted a more aggressive licensing strategy to profit directly from their patent portfolios—both by seeking licenses from a larger number of firms and by increasing royalty rates on use of their inventions. For example, Texas Instruments launched an aggressive patent licensing program in the mid-1980s, initially against Japanese competitors in markets for memory chips, earning more than $2 billion from licensing rights to its semiconductor patents between 1986 and 1993 (Grindley and Teece, 1997). Similarly, IBM's revenues from patent licensing increased from $646 million in 1995 to over $1.5 billion by 2000 (Ziedonis, 2003).

Recent controversy regarding patent hold-up problems in the industry centers on the licensing and litigation activities of so-called "patent trolls". While definitions vary, "trolls" are generally defined as individuals or patent holding companies that obtain patents of dubious merit and then use lawsuits to extract settlements, sometimes long after technologies have become standard or widely adopted within an industry (FTC, 2003). The recent conflict between Research-in-Motion (RIM), the maker of Blackberry hand-held devices, and NTP Inc, a patent holding company, represents a well-publicized example. After four years of legal wrangling and faced with a possible halt in sales on the U.S. market, Research-in-Motion paid NTP more than $600 million to settle its claims of patent infringement.[3] Lerner (2006) finds partial support for this "trolls hypothesis" in a recent study of litigated patents related to financial products and services: While litigated patents are disproportionately those awarded to individuals and small, private entities, they are not necessarily "low quality" as measured by citations-based indicators. Below, we define "trolls" quite broadly as entities that sue focal companies in our sample but that do not compete in semiconductor-related product markets in the year of the dispute.

[3] This settlement occurred in spite of the fact that 4 of the 5 patents held by NTP had already been rejected under a preliminary re-examination at the USPTO. Of these four, one had already received a final rejection under re-exam at the time of the settlement. Nonetheless, the Court refused to delay the case until the remainder decisions were final, so RIM was forced to settle. This case illustrates the extent to which assertion of even doubtful patents can be successful.

3. Data and sample statistics

Our data come from several different sources: Standard and Poor's Compustat for firm level balance sheet and income statement data, Derwent for patent data, and Derwent and additional sources, including news stories and press releases, for patent litigation data. The sample of firms with which we began was updated from that used in Hall and Ziedonis (2001) and Ziedonis (2003): it consists of 136 specialized U.S. semiconductor firms that are engaged in the manufacturing and/or design of semiconductor products and were observed during the years 1973-2001. We updated the financial and patent data for these firms through 2003 and augmented the 287 patent litigation cases used in Ziedonis (2003) with an additional 148 cases gleaned from Derwent and various press sources. The appendix provides more information about construction of the data.

In this paper, we restrict the years analyzed to 1973-2001, so that the panel eventually analyzed consists of 136 firms observed for periods of 1 to 29 years. 12 firms are there for the entire period, but almost half the firms are observed for periods of 10 years or less, reflecting the relatively young age of the sector.[4] Figures 1 and 2 show the trends in patenting by these firms. Because of the omission of large players such as IBM and the Japanese manufacturers, our sample accounts for a relative small share of total patenting in semiconductor technologies (about 20 per cent in the later years). However Figure 2 shows that they are indeed specialized in electronics and to a lesser extent in semiconductor technologies. Patenting by our firms began

[4] The 12 survivors include the largest firms: AMD, Analog Devices, Diodes Inc, Intel, Intl Rectifier, Natl Semiconductor, Semtech, Siliconix, Solitron Devices, Standard Microsystems, Texas Instruments, and White Electronic Designs. In 1982, the year of the CAFC's establishment, there were 41 firms in the sample.

growing first in 1984, as suggested by the analysis in Hall and Ziedonis (2001), and shifted into high gear in the mid-1990s. The median number of patents granted per employee was less than one until the mid-1980s and rose steadily to about eight by 2000-2001.

To study the questions raised in the introduction to this paper, we classified the case filings into those where the firm held the patent being litigated (either was a plaintiff in an infringement suit or a defendant in a validity suit) and those where the firm was a target in patent litigation (the opposite two situations). As the appendix makes clear, there are a number of complications such as ownership changes that arise in making these classifications, and many of them were therefore hand-coded based on litigation histories. We then further classified the litigation where the firm was a target into those where the opponent was a rival in the product market and those where the opponent was non-rival. Table 1 presents a summary of the number of cases that fell into each category and Figures 3 and 4 give an indication of the trends. It is important to understand the distinction between the first two columns of Table 1: the first column gives the total number of disputes involving at least one of our sample firms, whereas the second column is the total number of times that our firms appear in disputes. The difference is due to disputes *between* two firms in our sample; because our analysis is firm-level, these disputes will appear twice in the analysis.

Figure 3 shows that litigation has risen along with the increase in patenting, and also that there has been a substantial increase in suits involving non-rival entities during the past ten years, supporting the claims of some in the industry (FTC, 2003). Figure 4 shows how litigation probability for our firms has changed over time. As suggested by interviews reported in Hall and Ziedonis (2001), the overall probability of litigation on a per-patent basis rose steeply after the creation of the CAFC and the strengthening of patent enforcement that followed. However, it then falls again to the pre-1982 level, possibly because of the success of the defensive portfolio strategy in reducing litigation between rivals.

Table 2 reports summary statistics for firms in our sample, broken down into two groups: those with manufacturing facilities and firms that specialize in the design but not the fabrication of semiconductor devices. The latter group is generally considerably smaller and younger but has much higher R&D and patent stock per employee. Surprisingly, they are also more capital intensive, where capital is measured as the net book value of property, plant and equipment. This may reflect the relative lower level of employment in these firms. In both groups, the firms involved in patent litigation are much larger than the others, as well as being more R&D and patent-intensive. Interestingly, firms that litigate their own patents or are the target of patentholders that are also product market rivals are very similar to each other, whereas the targets of non-rival firms are much larger, as well as more capital, R&D, and patent intensive. This fact suggests that the motives of the non-rival firms may be related to a desire to target firms with deep pockets. It could also suggest, however, that firms where sunk costs are large and therefore hold-up is more costly may be more likely to settle than to fight a dispute.

4. Methodology and main results

To explore the changes in litigation trends and their determinants further, we estimated a series of probit regressions that predict whether or not a firm is involved in a particular type of patent litigation in any year as a function of its characteristics.[5] The model is the following:

$$\Pr(patentlitigation \mid X_{it}) = \Phi(X_{it}\beta) \qquad (1.1)$$

[5] We also experimented with an ordered probit regression where the dependent variable was the number of cases initiated in a year. The results were qualitatively similar to those from the simpler probit regression.

where *i* indexes firms and *t* indexes years. *Φ(.)* denotes the standard normal distribution. In the tables we show average of the derivative of this probability with respect to each right hand side variable X^j which is implied by the estimates:

$$\frac{\partial \Pr(patentlitigation \mid X_{it})}{\partial X_{it}^{j}} = \beta_j \varphi(X_{it}\beta) \qquad (1.2)$$

The firm characteristics *X* that we include in the estimation equation are the following:

Whether or not the firm specializes in design – the raw data suggested that such firms were more likely to be involved in litigation, possibly because their intangible knowledge assets are more central to their value-creation strategies (see also, Ziedonis 2003). In contrast, manufacturers are able to rely on sunk capital costs to protect themselves from entry (although not from hold-up).

Size of the firm - log of the number of employees. Clearly larger firms are more likely to be involved in more suits, simply by reason of their size.

Capital intensity of the firm – log of the ratio of net plant and equipment to the number of employees. Our earlier work found that this was an important predictor of patenting post-1984, due to the fear of hold-up of these assets in litigation. Thus it is unclear how this variable will enter an equation that predicts the probability of being involved in litigation. If the patent portfolio race strategy is successful, we might expect that this variable would be negatively correlated with the probability of being involved in litigation.

R&D intensity of the firm – log of the ratio of current R&D spending to employees. This is a measure of the importance of knowledge assets to the firm that is independent of whether or not they have patents attached to them.

Patent yield of the firm – log of the ratio of a patent stock (annual patent grants by application date, cumulated to a stock using the usual 15% depreciation rate) to R&D spending. This measure captures the relative importance of patents in the firm's strategy and the success of their R&D program. We also included a dummy for those firms with no patents, but it was never significant.

Texas Instruments – a separate dummy was included for this firm. Our earlier work found that TI was an important first mover in patent litigation and in the patent portfolio race in this sector, and so we allowed a separate mean for TI's litigation probability.

Year effects – six dummies for five-year periods (1973-77, 1978-82, 1983-87, 1988-92, 1993-97, 1998-2001). We grouped the years for greater precision in the estimates because of the volatility shown in the individual data years that is visible in Figure 3.

Table 3 shows the results of the probability estimation using three different definitions of the dependent variable: 1) whether or not the firm had a new case involving patent litigation filed in that year; 2) whether or not the firm was either the defendant in an infringement suit or the plaintiff in a validity suit (that is, the firm was a target); 3) whether or not the firm was either a plaintiff in an infringement suit or the defendant in a validity suit (that is, the firm had a patent litigated). All the regressions have reasonable explanatory power, with R-squares above 0.2. Design firms are about 6 per cent more likely to be involved in patent litigation, other things equal; the increase in probability is equally split between being a target and being a litigant. Doubling a firm's size also increases its probability of involvement by about 6 per cent, again more often as a target. Texas Instruments is 4 per cent less likely to be involved in patent litigation, but that is entirely due to the fact that it is less likely to be a target.

An interesting result is that although capital intensity helps to predict patent litigation (regressions not shown), it is highly correlated with R&D intensity in the sample. Once we include R&D intensity, the capital intensity effect vanishes. Recall that capital intensity does predict patenting, other things equal. Performing R&D and having patents both increase the probability of patent litigation. Controlling for R&D, having more patents per R&D dollar increases the probability slightly, but the effect comes entirely from the increased probability of litigating patents, which is not surprising. On the other hand, doing R&D increases the probability of being a target, whereas patenting intensity has a very weak impact on being a target. Thus even though capital-intensive firms are engaging in patent portfolio races and are therefore no more likely to be involved in patent litigation than other firms, there is still a very small residual positive effect of having a portfolio on being a target.

Table 4 breaks things down even further and examines the impact of firm characteristics on the probability of being the target of rival or non-rival entities. The definition of a rival entity is one that has integrated circuit sales during the year in question according to ICE (1976-2002). The results for rivals are basically the same as those for all targets (litigation with rivals is about two thirds of all patent litigation where the firm is a target). However, nothing other than firm size and (to a lesser extent) R&D intensity predicts non-rival litigation. A firm that doubles in size is predicted to experience a one per cent increase in litigation probability from non-rival entities. Our firms range in size from about 5 employees to 90,000, with an interquartile range of 146 to 1300. This implies that a firm which moves from the first quartile to the third quartile of size experiences an increase in non-rival litigation probability of 10 per cent, which is not insignificant. However, it is dwarfed by the increase in rival litigation probability (about 30 per cent).

Turning to the year effects, we note that they show a substantial increase in the probability of being a target of litigation in any one year, even controlling for changes in firm characteristics, but no corresponding increase in the probability of litigating one's own patents. Figures 5 and 6 show the time trends from the probability regression that controls for firm characteristics. The increase in the probability that a firm is involved in litigation is almost entirely due to the increased probability that it will be a target. From Figure 6 we can see that the increase in target probability is driven by rival litigation until the 1997/1998 period. The final period in this figure suggests that the increase in target probability is being increasingly driven by increases in non-rival litigation. We are in the process of exploring these results further in order to more fully characterize rivals and non-rivals, because many of the putative rivals appear to be firms that are in the process of exiting semiconductor product markets.

5. *Discussion and conclusions*

Semiconductor firms sell products that embed hundreds if not thousands of patented inventions, elevating concerns about patent-related hold-up in this sector. This paper examines the incidence and nature of patent lawsuits involving 136 firms in the semiconductor industry between 1973 and 2001. By supplementing patent litigation data with information drawn from archival sources, we estimate the probability that firms will be involved in patent lawsuits, either as enforcers of exclusionary rights or as targets of litigation filed by other patent owners. We further distinguish between disputes that involve product-market rivals and those that do not.

Overall, we find little evidence that dedicated US. semiconductor firms adopted a more aggressive stance towards patent enforcement since the 1970s, despite the effective strengthening of U.S. patent rights in the mid-1980s and widespread entry by small firms. In fact, their litigation rate as *enforcers* of patents remains relatively stable over the past two decades once we control for factors such as the number of patents they own and changes in R&D spending. In sharp contrast, we find an escalation in their baseline risk as *targets* of litigation brought by outside patent owners. Despite widespread concerns about lawsuits filed by “trolls”, or non-producing entities, we find that the increased probability that semiconductor firms will be a target of litigation during the “pro-patent” era is primarily due to lawsuits filed by other firms competing in semiconductor-related product markets. We do, however, observe a noticeable increase in “non-rival” disputes filed against these firms since the mid-1990s.

It is interesting to compare our results with those of Bessen and Meurer (2006), who use a much larger sample of patent litigation suits in all sectors (~16,500 suits filed 1984-2000) drawn from Derwent. For comparability to their specifications we computed logit and Poisson regressions (where the dependent variable is the number of suits in a year) using our data.[6] Where they can be compared, our results are not that different from theirs. We found that the probability of being a target goes up somewhat more rapidly with size and R&D intensity for semiconductor firms than for firms as a whole. In these characteristics the semiconductor firms were somewhat between the Chemical/pharmaceutical (henceforth chemicals) sector and the “thickets” industries sector in Bessen and Meurer, although the differences are probably not significant. The one major difference is that capital intensity does not depress the litigation probability the way it does in the chemicals sector, a result which is consistent with the idea that the holdup threat is greater for capital intensive firms.

[6] These regressions are not shown, but they are available from the authors on request.

The probability of litigating one's own patents also goes up somewhat more rapidly with size and R&D intensity, with the result again lying somewhere between that for chemicals and thicket industries. For the chemicals sectors, Bessen and Maurer found that capital intensity significantly depressed patent litigation probabilities and R&D intensity significantly increased them, whereas neither had an effect on the probability of initiating a suit in thickets industries. In our Poisson regression, we found that the latter was true for semiconductor firms, although in the logit regression R&D intensity had a small positive impact. The conclusion is that semiconductor firms behave like other firms in thickets industries with respect to their own litigation, but compared to other thickets industries, as targets their size and their large sunk technology costs make them look more like firms in chemicals.

This is a preliminary version of the paper and it raises a number of questions. Perhaps most importantly, a closer examination of the rivals who target our sample firms with patent litigation reveals that many of them are not true "rivals," but instead are firms that are in the process of exiting the industry in one way or another.[7] For example, long after struggling in computer and semiconductor-related product markets, Wang Laboratories launched an aggressive patent enforcement campaign against dedicated semiconductor producers prior to filing bankruptcy in 1992. Since our data sources report internal chip production for Wang in the focal litigation years, we treat the dispute as one between "rivals" when in fact Wang's threat as a viable competitor in the related product markets had long eroded. Unisys and its enforcement of patented encryption technologies is a related example. This suggests that a more nuanced

[7] This idea is supported by the probability regressions, where missing or low q is a strong predictor of the probability of litigating a patent, other things equal. In a revised version of this paper we will explore this result more fully.

description of the litigants may be appropriate, using the actual level and rate of change of IC sales, and possibly more information on their patent portfolio composition.

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Figure 1

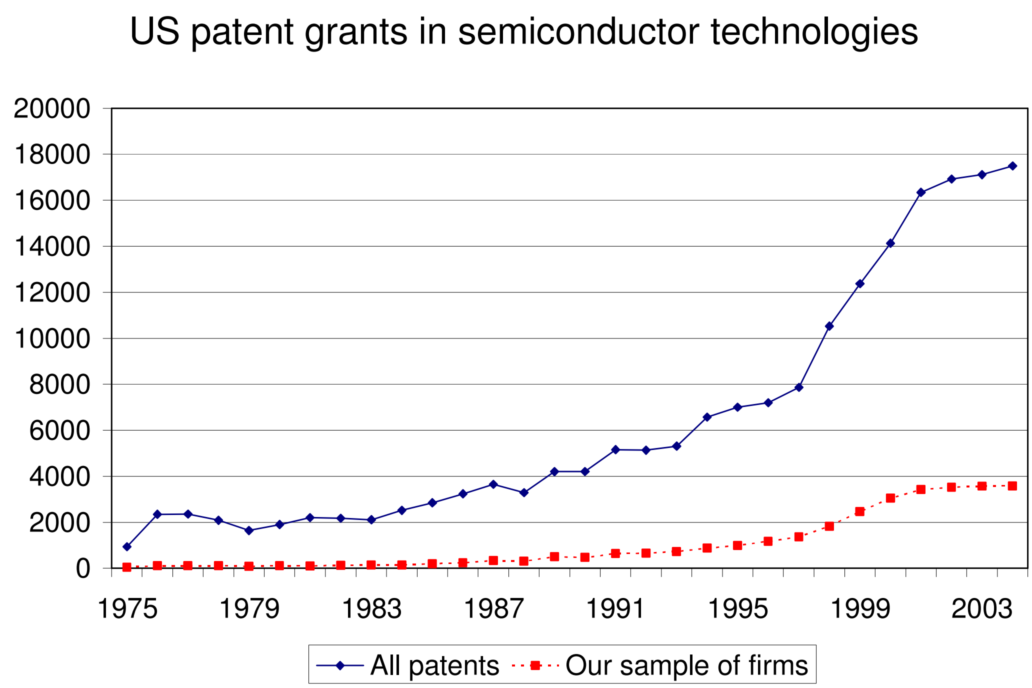

Figure 2

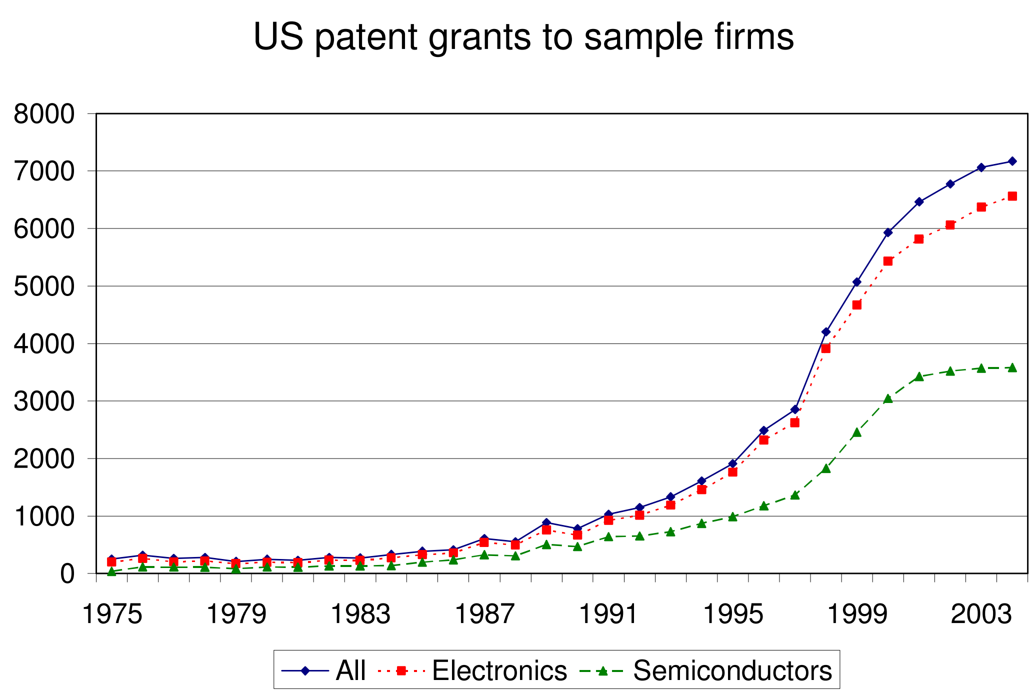

Figure 3

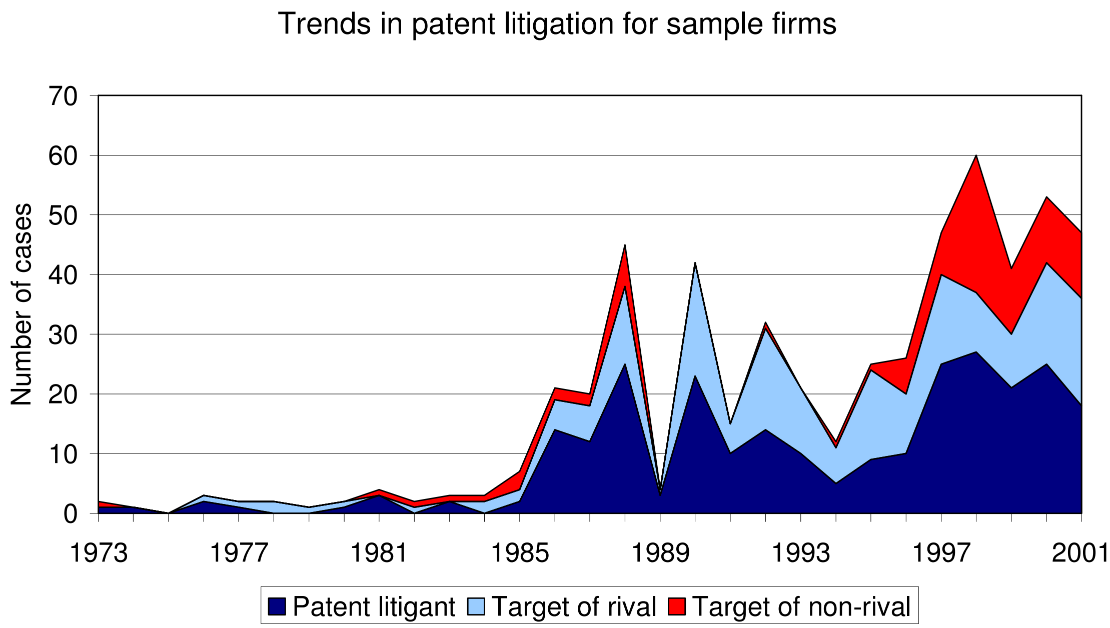

Figure 4

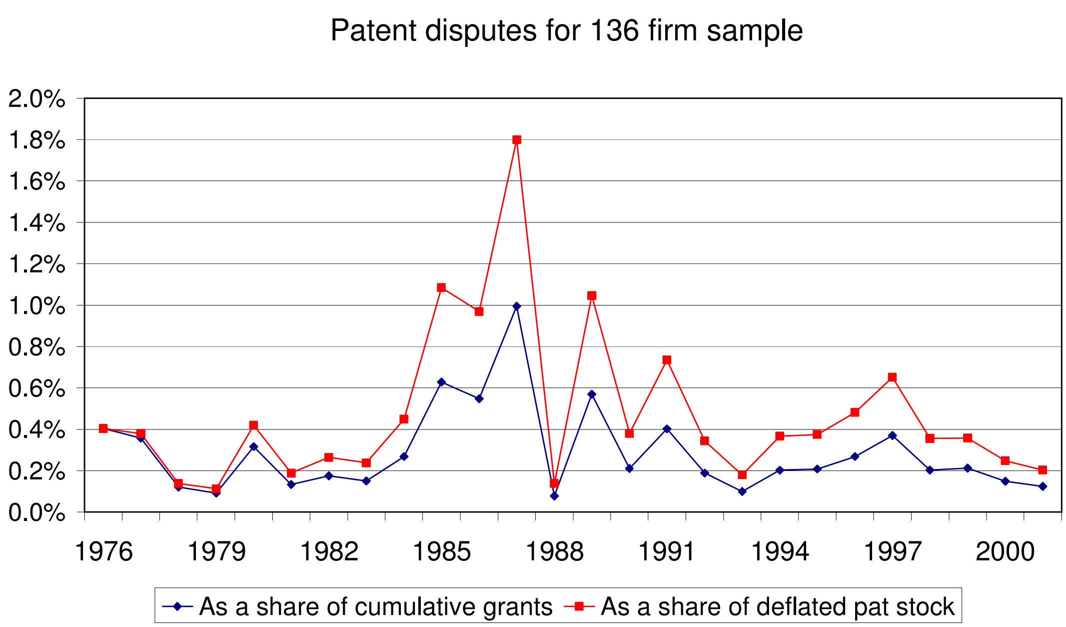

Figure 5

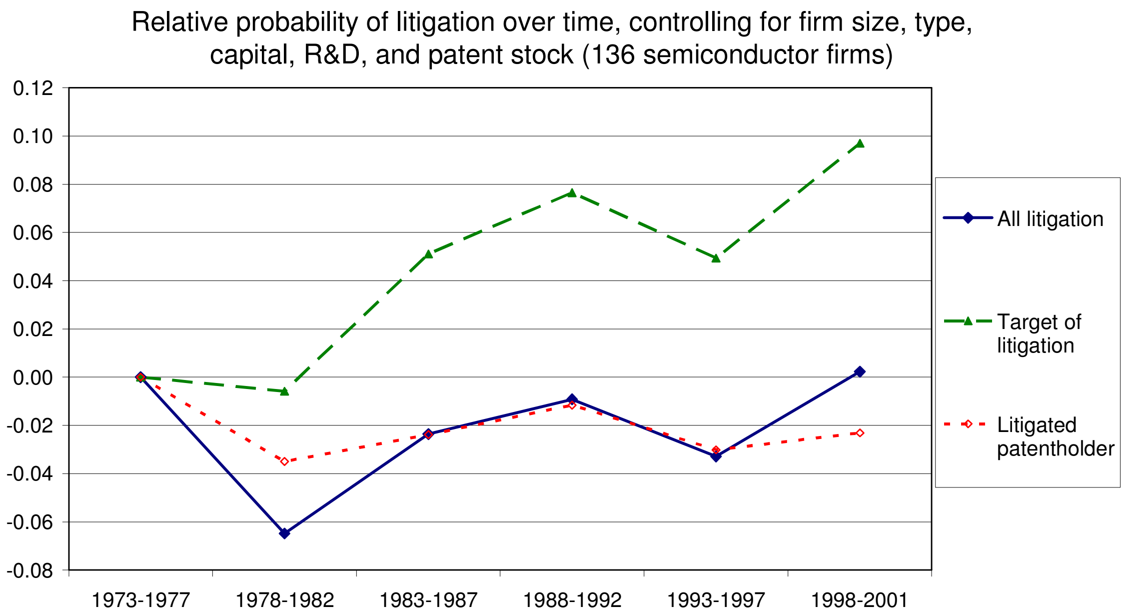

Figure 6

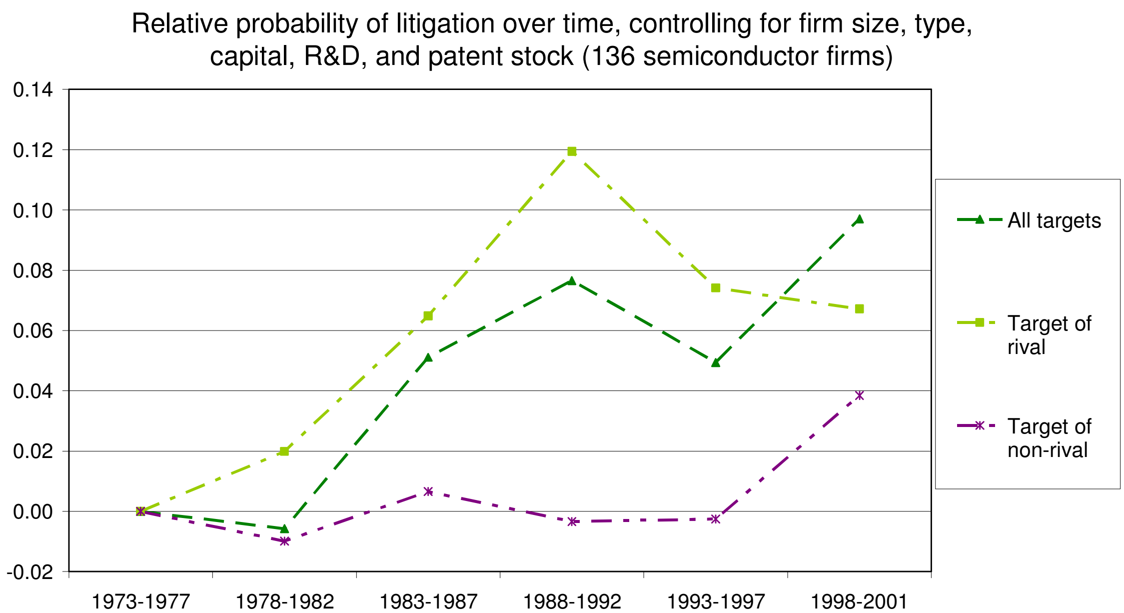

Table 1
Patent case filings for 136 semiconductor firms

Period	Total disputes	Total number in which appear	As patent litigant	As target	As target of rival	As target of non-rival
1973-1982	17	19	9	10	7	3
1983-1992	140	192	105	87	70	17
1993-2001	278	336	150	182	111	71
All years	435	547	264	279	188	91

Data for a population of 136 U.S. specialized semiconductor firms

All cases involve one or more patents. If patents are held by a sample firm, case is classified as patent litigant. If held by the opponent, they are classified as target cases. Note that some cases appear twice if they are between two firms in our sample; this is indicated by the difference between column 1 and 2.

Table 2
Sample Medians: 136 U.S. Semiconductor Firms (1973-2001)
(1819 firm-year observations)

	All	Litigants	Non-Litigants	Targets	Litigated patentholders	Targets of rivals	Targets of non-rivals
Panel A: Manufacturers (n = 84)							
Observations	1344	189	1152	136	97	93	55
Year founded	1969	1969	1968	1969	1969	1969	1969
Employment	577.5	3750	468	4418	4300	3690	7200
Capital per employee	$24,090	$61,226	$20,401	$66,325	$60,151	$60,027	$93,436
R&D per employee	$7,118	$20,076	$5,433	$20,952	$18,321	$20,431	$28,815
Patent stk per $M R&D	2.16	2.18	2.15	1.92	2.61	1.77	2.05
Undeflated patent stock	15	197	11	197	272	166	425
Share with no patents	13.2%	1.6%	15.1%	0.7%	2.1%	0.0%	1.8%
Share with no R&D	7.0%	0.0%	8.2%	0.0%	0.0%	0.0%	0.0%
Panel B: Design Firms (n = 52)							
Observations	475	93	384	66	42	49	19
Year founded	1984	1984	1984	1984	1984	1984	1984
Employment	184	348	159.5	431	365	348	440
Capital per employee	$36,030	$39,670	$35,384	$36,867	$39,105	$34,552	$45,187
R&D per employee	$53,789	$63,539	$52,882	$61,809	$57,389	$52,786	$73,267
Patent stk per $M R&D	1.37	1.27	1.38	1.29	1.33	1.46	1.16
Deflated patent stock	18	40	15	33	59	33	35
Share with no patents	5.3%	0.0%	6.5%	0.0%	0.0%	0.0%	0.0%
Share with no R&D	0.4%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%

Table 3
Probability of being involved in litigation in a year
136 semiconductor firms, 1973-2001 (1819 observations, 282 obs with 547 litigation events)

	All		**Targets**		**Litigated patents**	
# Litigation Events (obs)	**547 (282)**		**279 (202)**		**268 (140)**	
	dF/dx	**Std. err.**	**dF/dx**	**Std. err.**	**dF/dx**	**Std. err.**
D (design)	**0.055**	**0.027**	*0.032*	*0.020*	**0.039**	**0.019**
Log (employment)	**0.060**	**0.005**	**0.038**	**0.005**	**0.026**	**0.004**
Log (assets/employee)	0.010	0.012	0.000	0.008	0.009	0.009
Log (R&D/employee)	**0.049**	**0.009**	**0.028**	**0.007**	**0.019**	**0.007**
Log (pat app stock/R&D)	**0.023**	**0.007**	*0.008*	*0.004*	**0.015**	**0.004**
Missing patents	-0.028	0.035	-0.038	0.017	0.000	0.026
D (Texas Instruments)	**-0.035**	**0.014**	**-0.035**	**0.007**	-0.006	0.013
1973-1977	0		0		0	
1978-1982	-0.065	0.022	-0.006	0.030	-0.035	0.009
1983-1987	-0.024	0.045	0.051	0.059	-0.024	0.017
1988-1992	-0.009	0.050	0.077	0.057	-0.012	0.026
1993-1997	-0.033	0.047	0.049	0.050	-0.030	0.025
1998-2001	0.002	0.055	0.097	0.069	-0.023	0.023
Chi-squared (vars only)	**698.2**		**516.1**		**397.3**	
deg of freedom	7		7		7	
pseudo R-squared	0.261		0.238		0.237	
Log-likelihood*2	823.8		607.2		467.6	
# variables	12		12		12	
*2*LogL (year dummies only)*	*125.6*		*91.1*		*70.3*	
#vars	*5*		*5*		*5*	

The method of estimation is maximum likelihood on a probit model. Robust standard errors clustered on firms are shown. The average derivative of the estimated probability with respect to each variable and its standard error are shown in the table. For the dummy variables, the change in probability for a move from 0 to 1 is shown. Changes in probability that are significant at the 5% (10%) level are shown in bold (italics).

Table 4
Probability of being a target in suits by rivals vs. non-rivals in a year
136 semiconductor firms, 1973-2001 (1819 firm-year observations)

	Targets		**Targets vs. Rivals**		**Targets v. Non-Rivals**	
# Litigation Events (obs)	**279 (202)**		**188 (141)**		**91 (75)**	
	dF/dx	**Std. err.**	**dF/dx**	**Std. err.**	**dF/dx**	**Std. err.**
D (design)	*0.037*	*0.023*	*0.031*	*0.018*	0.003	0.009
Log (employment)	**0.045**	**0.004**	**0.031**	**0.003**	**0.011**	**0.002**
Log (assets/employee)	0.000	0.009	-0.004	0.006	0.003	0.004
Log (R&D/employee)	**0.033**	**0.008**	**0.025**	**0.006**	**0.007**	**0.003**
Log (pat app stock/emply)	**0.011**	**0.005**	*0.007*	*0.004*	0.002	0.002
D (Texas Instruments)	**-0.042**	**0.008**	**-0.035**	**0.005**	-0.002	0.007
1973-1977	0		0		0	
1978-1982	-0.006	0.035	0.020	0.041	-0.010	0.009
1983-1987	0.056	0.064	0.065	0.069	0.007	0.022
1988-1992	0.085	0.062	0.119	0.076	-0.003	0.015
1993-1997	0.057	0.055	0.074	0.058	-0.003	0.016
1998-2001	0.110	0.074	0.067	0.061	0.038	0.041
Chi-squared (vars only)	**660.4**		**272.6**		**184.7**	
deg of freedom	6		6		6	
pseudo R-squared	0.232		0.181		0.255	
Log-likelihood*2	823.8		342.0		322.9	
# variables	11		11		11	
*2*LogL (time only)*	*163.4*		*69.4*		*138.2*	
#vars	*5*		*5*		*5*	

The method of estimation is maximum likelihood on a probit model. Robust standard errors clustered on firms are shown. The average derivative of the estimated probability with respect to each variable and its standard error are shown in the table. For the dummy variables, the change in probability for a move from 0 to 1 is shown. Changes in probability that are significant at the 5% (10%) level are shown in bold (italics).

Appendix A. Construction of Litigation Database

This paper builds on an earlier database used in Ziedonis (2003), which identified U.S. patent lawsuits filed from January 1973 through July 2000 for the same sample of 136 firms. To construct the initial sample, names, former names, and majority-controlled subsidiaries were identified for each firm using business directories such as Hoover's Business Directory and *The Directory of Corporate Affiliations*. Name searches were conducted using two patent litigation databases: (1) Derwent's Litalert database[8] of patent lawsuits filed in U.S. District Courts and (2) the International Trade Commission's database of section 337 patent infringement cases.[9] In total, 287 cases were identified that involved sample firms as plaintiffs, defendants, or patent assignees.[10] Of these, 259 were filed in US District Courts and 28 were filed with the ITC.

We extend the Ziedonis (2003) database in two main ways. First, in light of underreporting biases in Litalert (discussed in the text), we compiled archival 10-K filings for each firm in years that they were publicly traded. We used information reported about patent lawsuits in each 10-k filing to identify cases previously unreported in Litalert. We also used it to enhance information

[8] The Litalert database is the most common database used in patent litigation studies, largely due to the fact that (unlike alternative data available from the Federal Judicial Center) it identifies patents involved in the disputes and lists multiple parties in each dispute. See Lanjouw and Schankerman (2001) for additional discussion.

[9] Under Section 337 of the Tariff Act of 1970, a firm can challenge the importation of products that infringe its US patent rights. Since ITC cases involve a separate administrative and judicial process than cases filed in US courts (Mutti and Yeung 1996), we include them in the sample as separate cases. Cases were searched and downloaded from the ITC website at: http//info.usitc/gov/337.

[10] In initial Litalert sample, we removed two duplicative records (where identical information was filed under different case numbers) and 57 sequential cases (where a change in venue or an outcome of a previously filed case was announced but the patents and litigated parties involved in the lawsuit were the same).

about existing cases, including the nature of the dispute, the relationships between the parties, and the patents involved (if reported). We conducted similar searches using news directories, trade journals such as *EETimes* and *Semiconductor Business News*, and company press releases. Finally, we updated the sample (using all sources mentioned above) to include cases filed in the second half of 2000 through 2001.

In combination, this process added 148 patent litigation events to initial sample of 287 disputes from Ziedonis (2003). Of the final set of 435 litigated disputes, 133 (31%) were ones added from the archival 10-k and news searches that were not otherwise reported in Litalert. The qualitative information we compiled about the cases enabled us to identify the nature of the dispute in all but three cases. Consistent with statistics reported in Lanjouw and Schankerman (2001) and Bessen and Meurer (2006), patent infringement lawsuits represent the overwhelming majority (85%) of disputes in our final sample.