The Effect of Patent Litigation and Patent Assertion Entities on Entrepreneurial Activity*

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Executive Summary

From 2004 through 2012, patent lawsuits in the U.S. more than doubled, from around 2,500 to over 5,000 annually;[1] these suits affected more than 12,600 defendants in 2012 (Pistorino, 2014). Patents themselves are often thought to proxy for innovation and associated entrepreneurial activity, but it is not clear whether this increase in patent litigation, often brought by Patent Assertion Entities ("PAEs"), is necessarily beneficial for innovation. New evidence suggests that more lawsuits can distract management from developing new and innovative products, and may cause them to ignore products targeted by lawsuits, in addition to the more obvious litigation costs (Tucker, 2012). To identify the implications of the rise in patent litigation for U.S. innovation and consumers, our work addresses the following questions: How do high levels of patent litigation shape entrepreneurial activity, such as investment in startups and the creation of jobs? What are the costs, if any, associated with high levels of patent litigation? And finally, what is the effect, if any, of patent litigation brought by PAEs on entrepreneurial activity?

This paper empirically investigates the statistical relation between levels of patent litigation and venture capital ("VC") investment in the U.S. We find that VC investment, a major funding source for entrepreneurial activity, initially increases with the number of litigated patents, but that there is a "tipping point" where further increases in the number of patents litigated are associated with decreased VC investment, which suggests an inverted U-shaped relation between patent litigation and VC investment. This appears strongest for technology patents, and negligible for products such as pharmaceuticals. There is some evidence of a similar inverted U-shaped relation between patent litigation and the creation of new small firms. Strikingly, we find evidence that litigation by frequent patent litigators, a proxy for PAE litigation, is directly associated with decreased VC investment with no positive effects initially.

Using our regression estimates to provide rough estimates of the economic significance of these effects, we found:

1. VC investment would have been at least $8.1 billion higher over the course of five years but-for litigation brought by frequent patent litigators.

[1] Data from LexisNexis Courtlink.

2. VC investment would likely have been roughly $109 million higher over the course of five years but-for patent litigation brought by firms that did not frequently litigate patents.

This sheds new light on a subset of the potential indirect costs of patent litigation, and suggests that the case studies presented at the end of this summary are not unique. For example, these figures appear to generalize the experience of Ditto, an eyewear startup, which was forced to lay off four of its 15 employees to pay legal expenses associated with a patent lawsuit, and received a lower valuation from investors as a result of the litigation.

In general, our results suggest two areas of focus for policymakers:

- We find empirical evidence that "higher quality" patents, such as patents that meet the thresholds of patentability in the U.S., the E.U., and Japan, are associated with reduced levels of litigation. This suggests that one approach to stemming excessive patent litigation would be to ensure that the patent approval process in the U.S. uses similar quality thresholds to the processes in the E.U. and Japan.

- We find that litigation by frequent litigators is associated with a direct and negative effect on innovation. Therefore, improvements to the patent litigation system which address the potentially harmful effects of such litigation should be considered. One potential remedy could be changing the current way that litigation costs are allocated; at present, there exist low barriers to bringing a lawsuit and currently defendants bear disproportionate risks and costs of being involved in patent litigation relative to plaintiffs.

We want to emphasize that in general our estimates represent only a subset of potential costs imposed by patent litigation and PAEs. Bessen and Meurer (2014) used survey evidence to estimate some of the direct cost of NPE activities such as legal fees and settlement costs. Using their micro-data combined with our measure of frequent patent litigator activity, suggests that there are $3.77 to $18.9 billion of these more direct costs associated with patent litigation that has this negative effect on entrepreneurial funding. This suggests that the indirect costs we measure are only a smaller subset of the potential range of costs associated with patent litigation.

Similarly, an important caveat of this study is that it measures the effect of patent litigation on innovation that reaches court. There may be many occasions that patent litigation is threatened through a demand letter and a company chooses to settle rather than face the risks and expense of litigation and that settlement is covered by a non-disclosure agreement. Such demand letters are costly, especially for smaller firms, as they may require the hiring of expensive legal assistance to decipher as well as more obvious settlement costs. If entrepreneurs, disproportionately as a group, decide to settle rather than litigate, our estimates may understate the true size of the empirical relation between patent litigation and VC funding.[2]

[2] In the case of CISCO Systems Inc. et al v. Innovatio IP Ventures LLC, Illinois Northern District Court, Case No. 1:11-cv-09309. which involved a PAE, there were 8,000 demand letters and only 26 cases that reached the court.

Contents

1 Case Studies

X-Plane

X-Plane - Based in South Carolina, Austin Meyer helped form the flight simulator program X-Plane in 1995, whose users have included NASA, the Federal Aviation Administration, and Boeing. X-Plane was made available on the Android operating system in 2010 for only a few dollars with an opportunity to reach the global audience that uses Android OS phones and tablets. Meyer was subsequently sued by Uniloc because Meyer used Google-provided copy-protection software. As a result of this lawsuit, X-Plane was forced to abandon product upgrades and new products that were in development out of fear they may attract more lawsuits.

Ditto

Ditto is an eyewear startup founded by Kate Doerksen (based in San Mateo, California) that allows customers to virtually "try on" glasses using a 3D modeling system that replicates the buyers face. The startup had received funding to expand and was raising additional capital when it was sued by Lennon Imaging Technology for patent infringement. Lennon Imaging Technology's lawsuit against Ditto was filed in the District Court for the Eastern District of Texas claiming it infringed on its patents covering "customer image capture and use thereof in a retailing system." While the lawsuit against Ditto was eventually dismissed, investors and potential buyers were still valuing the company $3 to $4 million less than they would otherwise. As a result, the company was forced to lay off four of its 15 employees to pay legal expenses.

Jump Rope

Peter Braxton raised nearly $250,000 in 2011 to jumpstart his Jump Rope app, which gives people who are tired of waiting in long lines at nightclubs, restaurants, airports or other venues the choice to pay to skip the line. Soon after Jump Rope secured investors and launched publicly, Braxton was sued for violating a patent that claims ownership over "a method and system for reserving future purchases of goods and services." The case was quickly dismissed from the District Court for the Northern District of Illinois after the judge ruled in near-record time and without hearing from any witnesses or permitting expensive discovery that the allegations against Jump Rope were meritless. Smart Options, the company who brought the charges against Jump Rope, was ordered to pay Braxton's legal fees, a sanction that is authorized by law but rarely imposed. But, because Smart Options is a PAE, with no product, no revenue, no technology, nor even an office, collecting those fees is nearly impossible.

2 Introduction

From 2004 through 2012, patent lawsuits in the U.S. more than doubled, from around 2,500 to over 5,000 annually[3] and these lawsuits affected more than 12,600 defendants in 2012 (Pistorino, 2014). However, it is not clear what this increase in patent litigation means for the innovation economy. During this same time period, patent litigation brought by frequent litigators, who provide a proxy for patent litigation brought by Patent Assertion Entities ("PAEs"), also increased from less than 500 patent lawsuits in 2004 to over 2,000 patent lawsuits in 2012. This rise in patent litigation brought by frequent litigators has been documented by others, such as Chien (2009); Bessen et al. (2012), who both find large increases over the last decade.

This paper empirically investigates the statistical relation between levels of patent litigation and Venture Capital (VC) investment in each industry in each district court. As described by Samila and Sorenson (2011), VC investment is positively correlated with firm starts, employment,

[3] Data from LexisNexis Courtlink.

and aggregate income in the region in which it occurs. Therefore, it is a useful and comprehensive measure of both entrepreneurial activity and the positive benefits of entrepreneurial activity for the economy. We also investigate the relation between levels of patent litigation and small business creation directly (Allred and Park, 2007).

We find statistical evidence that the relation between VC investment and patent litigation is non-linear; our parameter estimates suggest that there is an inverted-U-shaped relation between the extent of patent litigation and entrepreneurial activity. At low levels of patent litigation, an increase in patent litigation is associated with more VC investment, while at high levels of patent litigation, an increase in patent litigation is associated with decreased VC investment. This result is robust to multiple functional forms and to exclusions of potential outliers such as the Eastern District Court of Texas and the District Court of Delaware.[4] It is also robust to using an instrumental variables approach where we exploit exogenous variation in patent litigation levels that stems from perceived court bias and expertise.

This finding that low levels of litigation, which may indicate a well-functioning IP protection system, promote innovation, while high levels of litigation may depress innovation, echoes an existing literature on intellectual property rights. Prior research has shown that at low levels of intellectual property rights protection, an increase in the level of protection encourages innovation because it provides incentives to research and to disclose information (Gallini, 2002). However, at high levels of intellectual property protection, stronger intellectual property rights may discourage subsequent research on valuable, but potentially infringing, inventions (Gallini, 2002; Bessen and Maskin, 2009; Qian, 2007; Lerner, 2009).

We extend our analysis to account for the fact that not all types of patent litigation have similar effects. We first show that patent litigation in the technology sector, the software sector and (less precisely) the financial sector exhibit this inverted-U-shaped relation with VC funding most strongly. Patent litigation in the pharmaceutical and industrial sectors does not exhibit this pattern. We then distinguish between patent litigation from patent litigation brought by frequent

[4]The Eastern District Court of Texas is well known for its handling of large numbers of patent cases, regardless of whether or not the parties to the suit are based there. Based on our data, the District Court of Delaware also appears to handle a large volume of patent litigation.

litigators, the measure we use to proxy for the activity of PAEs. PAEs themselves do not make anything and obtain revenues simply from enforcing patents, meaning that there are asymmetries in the potential costs and risks of patent litigation. We find that unlike regular patent litigation, litigation launched by frequent litigators has a universally negative effect on VC funding with no initial positive relation.

The remainder of the article is organized as follows: Section 3 discusses the underlying conceptual model that motivates our statistical analysis. Section 4 describes the data that we use in our empirical analysis. Section 5 presents our empirical methodology. Section 6 presents the results of our analysis. Section 7 summarizes our estimated impacts on VC funding, employment by small firms, and other costs. Section 8 presents our conclusions and thoughts on the policy implications of our study.

3 Conceptual Model

This section describes why it seems plausible that there would be an economic relation between observed patent litigation and innovation, and in particular VC funding of entrepreneurial activity.

Patents themselves are often thought to proxy for innovation, but it is not clear whether an increase in patent litigation, often attributed to the increase in activity by PAEs, is necessarily beneficial for innovation. Traditionally, economists have thought of patents as a way of measuring the health of the innovation economy. Pioneering studies by Jaffe et al. (1993); Audretsch and Feldman (1996); Ahuja (2000) used the granting and citation patterns of patents as a way of measuring the diffusion and spread of knowledge and innovation. These studies have been used by policy makers to evaluate policies designed to promote innovation hubs. Much academic work has focused on measuring how the strength of intellectual property protection promotes innovation (Mansfield, 1986; Levin et al., 1987; Segerstrom, 1991; Chen and Puttitanun, 2005; Encaoua et al., 2006).

It is not clear that this documented increase in patent litigation has as positive effects on the innovation economy as does the underlying innovation process which leads to patenting. One way of interpreting such an increase in patent litigation is as a natural reflection of an increase in patent applications. Therefore, it could reflect growing underlying innovation in the economy. A stronger, positive interpretation is that growing patent litigation is itself a reflection of a better-functioning patent system which offers better protection to inventors and those involved with research and development. Strengthening property rights should theoretically increase dynamic incentives for innovators and entrepreneurs who want to commercialize these inventions, so an increase in patent litigation could have further positive effects above and beyond simply increasing the number of underlying patents.

However, there is another possible mechanism at work, which is that a high level of patent litigation is itself limiting innovation and entrepreneurial activity. This paper aims to provide some initial empirical evidence both for this less positive mechanism and for its statistical importance.

There is existing research which is already suggestive that there may be a negative effect between patent litigation and innovation. Feldman (2013) conducted a survey of 200 venture capitalists and found that 100% of respondents indicated that an existing patent demand against a potential portfolio company could be a major investment deterrent, as well as being deterred by more obvious direct litigation costs (Bessen and Meurer, 2008). There is also the potential that patent litigation may halt the kind of innovative research and development that attracts VC investment (Smeets, 2014). As documented by Tucker (2012) in a case study of the medical imaging industry, firms can halt product R&D during patent litigation if they risk being found guilty of willful infringement and consequently being liable for treble damages.

There is also a very direct channel for patent litigation to deter VC funding. When a start-up applies for VC funding, they have to list all ongoing litigation. Some investors may prefer not to lend money to a start-up if they perceive a litigation risk or the potential for endless demands for license fees for their particular product or service, limiting the stream of potential future revenues. Further, there is evidence that ongoing litigation risk can lower the potential value of a firm's initial public offering (Lowry and Shu, 2002; Hanley and Hoberg, 2012), again deterring VC funding.

We recognize that there may be other positive effects of patent litigation on VC investment that should be traded off against the potential for these negative effects. For example, venture capitalists may view higher levels of patent litigation in that region or product sector as evidence of a well-functioning patent system that will protect their investment. Further, as discussed by Lemus and Temnyalov (2013), there is also the possibility that some start-ups will have greater incentives to invest in R&D to try to preempt patent litigation, which may in turn attract R&D funding. It is this trade-off which makes this an empirical question.

In our conceptual and empirical model, we also distinguish between regular patent litigation and patent litigation brought by frequent litigators, the measure we use to proxy for the activity of PAEs. PAEs themselves do not make anything and obtain revenues simply from enforcing patents, meaning that there are asymmetries in the potential costs and risks of patent litigation. Research such as Turner (2011); Bessen et al. (2012); Bessen and Meurer (2014) has identified this kind of patent litigation as having potentially negative effects. In particular, Chien (2014) provides evidence that entrepreneurial activity is negatively affected by PAEs; she finds that at least 55% of unique defendants in PAE suits make $10M per year or less. It is precisely these small and entrepreneurial firms that are the focus of this study. She also finds evidence that 40% of small companies that received a demand reported a "significant operational impact": delayed hiring or achievement of another milestone, change in the product, a pivot in business strategy, a shut-down business line, or lost valuation. Given that there is little positive upside from a venture capitalist's perspective from litigation brought by a PAE, it may be the case that litigation launched by frequent litigators has a universally negative effect on venture capital funding with no initial positive relation, as one might expect for regular patent litigation.

We also examine whether statistically differing levels of patent litigation affect employment at small businesses. This follows on from our conceptual model of how patent litigation may affect VC funding. It is important because as discussed by authors such as Birch (1987), there is some empirical evidence to suggest that small firms and entrepreneurial activity are responsible for a disproportionate share of job growth in developed economies. At high levels of patent litigation, young firms may have to spend money on patent litigation rather than hiring new employees, or litigation costs may lead firms to fire existing employees. For example, Ditto, a website designed to allow consumers to shop for glasses, faced significant legal fees stemming from a lawsuit that led the company to lay off four of its 15 employees.[5] If firms end up not thriving due to a lack of VC funding, then this may translate into a lower level of entrepreneurial activity and employment among small firms.

4 Data

4.1 Patent Litigation Data

We obtained data on patent litigation from CourtLink.[6] This data tracks each intellectual property suit filed in each of the 94 U.S. Federal District Courts. (Note that as robustness checks on our results we exclude both the Eastern District of Texas and the District Court of Delaware.) For each litigation observation, we retrieved the name of the court in which the case was filed,[7] the filing date, the case description which includes the plaintiff's name and the defendant's name, the docket number, the patent number for each patent at issue in the case,[8] and the USPTO's U.S. patent class for each patent at issue in the case. We matched this patent class with 24 industry sectors using NAICS 2-digit codes. The data we obtained spanned 1995-2012. If a case is transferred to multiple districts, we allocate it to the initial district court in which the case was filed. We convert the U.S. patent classes to NAICS industry classifications using a series of concordances. Specifically, we first use a concordance to translate the U.S. patent class to the International Patent Class ("IPC").[9] Individual U.S. patent classes are generally associated with multiple IPCs. In these instances, we apportion patents equally amongst potential IPCs.[10] We then use a concordance to map each IPC into industrial classifications. Patent to industry mapping is not a straightforward exercise. We use the method developed by Lybbert and Zolas (2012) which assigns probability weights for

[5] http://http://www.wired.com/business/2013/09/patent-trolls-versus-startups/

[6] LexisNexis CourtLink, LexisNexis, available at http://www.lexisnexis.com/en-us/products/courtlink-for-corporate-or-professionals.page.

[7] We exclude data from the Court of Federal Claims and the District of Puerto Rico.

[8] We run our analyses based on a sum of the number of patents litigated in each suit, rather than the number of unique suits. Suits often have several patents at issue, not all of which are in the same U.S. patent classes and will therefore be assigned to different industries. Results are consistent if we instead measure the number of patent suits, but doing this requires that suits be apportioned to various industries based on the classes of the patents at issue.

[9] Office of Patent Classification, U.S. Patent and Trademark Office, available at http://www.uspto.gov/web/patents/classification/.

[10] For example, if a patent is assigned to a U.S. patent class which is associated with four IPCs, 0.25 of a patent is assigned to each of the four IPCs.

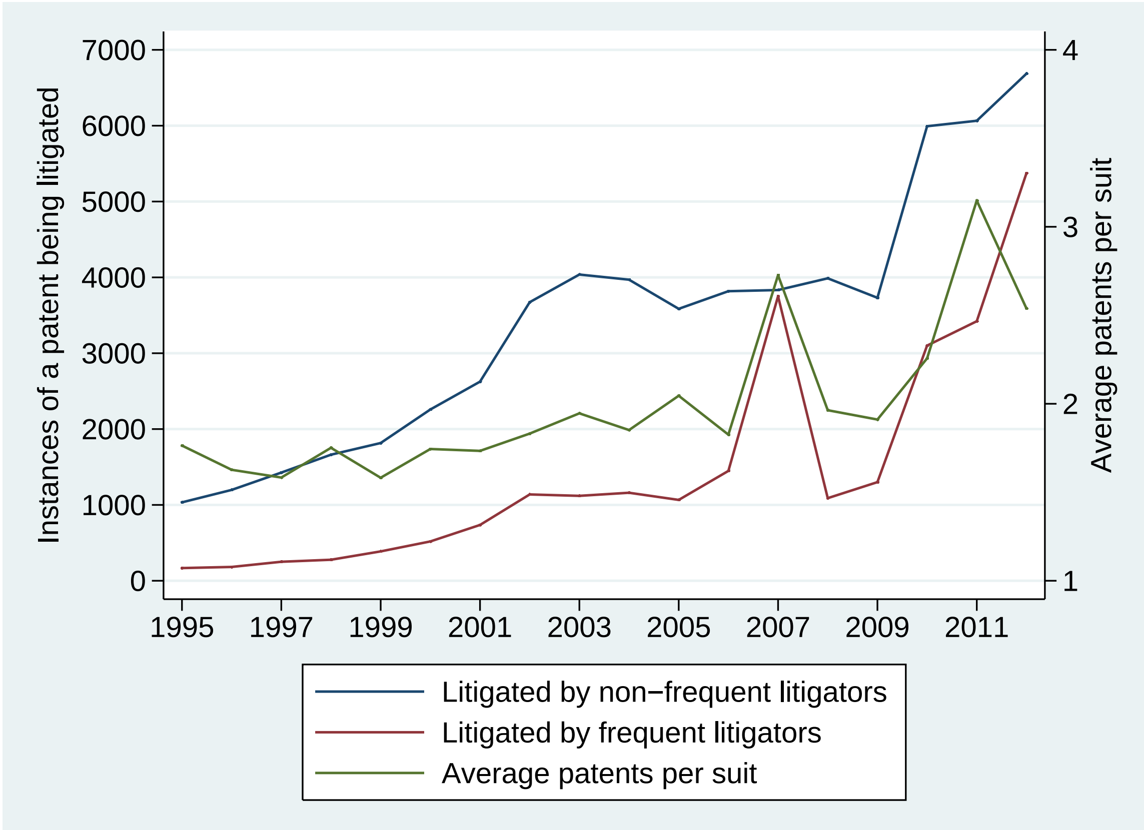
translating individual IPCs into International Standard Industrial Classifications ("ISICs"). Results are consistent if we instead map each IPC represented in our data directly to the ISIC with the highest probability weight determined by Lybbert and Zolas (2012). Finally, we convert the ISIC to the NAICS industry classification.[11]

As our key explanatory variable, we use "Total instances of a patent being litigated." Many patent litigation cases involve more than one patent (on average, each case involves 2.01 patents), and those different patents may have different industry origins. Our measure allows us to obtain counts of patents litigated at the industry level, as opposed to arbitrarily dividing cases between industries. Consequently, if two patents are asserted in one case, then in our measure, this case would count as two patents litigated. Our use of this measure, which is necessitated by our division of data into different industry sectors, means that our measure of patent litigation is somewhat higher in magnitude than other research which simply counts instances of patent litigation. Also, other studies have used the number of defendants sued. Prior to the enactment of the America Invents Act ("AIA") in September of 2011, PAEs often filed suit against multiple defendants in a single suit. Absent a manual review of the filing documents for each patent suit from 1995 through 2012, our data do not allow us to identify the name of each defendant involved in a suit, or even the number of defendants involved in each suit. We note that the bulk of our litigation data are from prior to the enactment and subsequent implementation of the AIA. Further, our results, particularly with regard to the costs of PAE litigation estimated later, would likely be stronger if we were able to identify the number of defendants involved in each suit.

The growth of the number of instances that a patent is litigated is immediately noticeable in our data; Figure 1 plots this growth from 1995-2012. Figure 1 also shows that the average number of patents involved in each lawsuit has increased over time as well. This growing complexity of the typical patent lawsuit provides external motivation for our measure. To check, though, that our decision to reflect the number of patents per lawsuit rather than simply the number of lawsuits did not drive our results, we also repeated our estimation at the court level (not the industry level), and obtained qualitatively similar results.

[11]North American Industry Classification System, U.S. Census Bureau, available at `http://www.census.gov/eos/www/naics/concordances/concordances.html`.

Figure 1: Total Patent Litigation and Frequent Litigator Patent Litigation, 1995 to 2012



Source: "LexisNexis CourtLink,", available at
http://www.lexisnexis.com/en-us/products/courtlink-for-corporate-or-professionals.page,
downloaded on Apr. 8, 2013.

One caveat that is worth mentioning is that we only use data on actual observed patent litigation. As discussed by Seigle (2013) in his testimony to Congress on the subject of "The Impact of Patent Assertion Entities on Innovation and the Economy," patent litigation may be only the tip of the iceberg when it comes to understanding the extent of legal proceedings and discussions that surround a firm's patent portfolio. In particular, there may be many occasions that patent litigation is threatened through a demand letter and a company chooses to settle rather than face the risks and expense of litigation. Indeed, evidence by RPX (2012) suggests that in a sample of 900 litigations, for the majority of them, legal costs exceed the settlement. Seigle (2013) suggests that demand letters often contain vaguely worded threats like "Plaintiff is prepared for full-scale litigation to enforce rights. This includes all motion practice as well as protracted discovery." These threats discourage targeted firms from engaging in litigation due to fears about costs.[12] Given this, the best way of interpreting our results is that we are using patent litigation that reaches courts as a proxy measure for underlying patent litigation activity. In the particular case CISCO Systems Inc. et al v. Innovatio IP Ventures LLC,[13] which involved a patent assertion entity, the court evidence suggests that there were 8,000 letters and only 26 cases that reached the court. If entrepreneurs, disproportionately as a group, decide to settle rather than litigate, our estimates may understate the true size of the empirical relation.

Patents that ultimately end up in litigation are systematically different from those patents that are not litigated. As discussed by Chien (2011), litigated patents are more likely to be transferred, twice as likely to be maintained, and are cited twice as many times. Therefore, to supplement our patent litigation data, we also collected data on the number of patents granted in the U.S. by year from the USPTO for each U.S. patent class[14] and from the OECD patent database for each IPC section.[15] We use these data to assess potential drivers of the rise in patent litigation over time.

4.2 Frequent Patent Litigators

The definition of a PAE is somewhat controversial (FTC, 2011). For example, many definitions make it hard to distinguish between a university and what is commonly understood to be a patent troll (Lemley, 2007). Furthermore, because PAEs often hide under multiple shell companies and names, and act instead as large-scale patent aggregators, it is often hard to identify them precisely by name (Hagiu and Yoffie, 2013).

Therefore, rather than trying to identify PAEs by name, we take an empirical approach to identifying something analogous to a PAE in our data, and look for companies that are "frequent litigators." We define a frequent litigator as an entity that has filed twenty or more patent lawsuits.[16] This may be a somewhat conservative threshold - Chien (2012) suggests that 61% of all

[12] http://democrats.energycommerce.house.gov/sites/default/files/documents/Testimony-Seigle-OI-Patent-Assertion-Entities-Economy-2013-11-14.pdf.

[13] Illinois Northern District Court, Case No. 1:11-cv-09309.

[14] U.S. Patent and Trademark Office, available at http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cbcby.htm.

[15] Organisation for Economic Co-Operation and Development, available at http://stats.oecd.org/.

[16] We also show robustness to thresholds of 15 and 25 for frequent litigators.

defendants were sued by a PAE that had sued eight or more times, compared to 16% that were sued by a PAE that had sued less than eight times.

We realize that this is an imperfect measure of what is commonly thought of as PAEs, as it could potentially cover firms that make products but who for whatever reason are litigious towards others infringing on their patents; our definition would also exclude PAEs that are somewhat selective about the litigation they pursue. However, we find it reassuring that using our measure of frequent litigators, the number of suits associated with these frequent litigators over time corresponds to the number of suits by PAEs measured by Patent Freedom, a non-profit that tracks the actions of PAEs.[17]

For completeness, we also use an alternative measure of what constitutes a PAE, where we directly identify PAEs by name in our data. We do this by matching the plaintiff name to a list of the major PAEs published by Patent Freedom. As discussed above, PAEs often deliberately conceal their name when pursuing litigation, so we recognize that we were only able to identify a subset of PAEs through this procedure. For example, we were able to identify 238 PAE cases in 2012 compared to Patent Freedom's count of about 2,100. It is also reassuring that our measure of frequent litigators generally picks up those entities that we are able to directly identify as PAEs using this methodology.

4.3 Data on Entrepreneurial Activity

Our principal measure of entrepreneurial activity is VC investment. As described by Samila and Sorenson (2011), VC investment is positively correlated with firm starts, employment, and aggregate income in the region in which it occurs. Therefore, it is a useful and comprehensive measure of both entrepreneurial activity and the positive benefits of entrepreneurial activity for the economy. Our VC data come from Thomson One, which is the most comprehensive data source for VC investment available in the U.S. and was also the source of data for Samila and Sorenson (2011). We collected data on the amount of VC investment obtained by each startup from 1995 through 2012. This data included the name of the firm receiving the funding, the level of funding, the date the funding was

[17] `Patentfreedom.com`

received, the firm's state and county, and the NAICS industry classification. We then aggregated the data to the district court and two-digit NAICS industry level for each year. When combined with the CourtLink litigation data, the resulting VC panel dataset contained 37,260 observations.

One caveat with this approach is that we are assuming there is a relation between the district where the patent lawsuit was filed and the region where VC investment is received by entrepreneurial start-ups. However, there may be occasions where the patent litigation is launched in a different region from where the VC investment is received. One particular issue is that many patent lawsuits are launched in the Eastern District Court of Texas, regardless of the location of the parties being sued, due to a perception that such a forum is favorable to the patent holder (Leychkis, 2006). We address this by running an additional robustness check where we exclude the Eastern District Court of Texas and find similar results. We also conservatively exclude the Eastern District Court of Texas from our estimates of economic effects of the impacts of both frequent patent litigation and non-frequent patent litigation.

Employment data were collected from the U.S. Census Bureau for 1995 through 2011, the most recent year for which data were available. Available data include the number of establishments of various sizes, as well as the total employment in those establishment, at the county and NAICS industry levels. As the average start-up employs fewer than 35 workers, we use as our measure of innovation the number of establishments with fewer than 50 employees.[18] We matched these data to the district court, industry, and year in which the patent litigation occurred. When combined with the litigation data, the resulting small business panel dataset contains 35,190 observations over 17 years.

Table 1 summarizes the data that we use in our empirical analysis.

[18]We obtain similar results using total employment figures as well as using the total number of establishments, the number of establishments with less than ten employees, and the number of establishments with less than 100 employees.

Table 1: Summary statistics

	Mean	Std Dev	Min	Max	Observations
Venture Capital(USD Mil)	13.4	139.8	0	9891.6	37260
Firms $<$ 10 Empl. (00)	19.3	34.7	0	477.5	35190
Firms $<$ 50 Empl. (00)	25.1	43.5	0	550.4	35190
Firms $<$ 100 Empl. (00)	25.9	44.6	0	558.8	35190
Total instances of a Patent being litigated	2.36	14.3	0	740.2	37260
Total instances of a Patent being litigated by frequent litigator ($>$ 15)	0.83	8.15	0	576.9	37260
Total instances of a Patent being litigated by non-frequent litigator($<$ 15)	1.53	7.56	0	367.5	37260
Total instances of a Patent being litigated by frequent litigator ($>$ 20)	0.71	7.43	0	576.9	37260
Total instances of a Patent being litigated by non-frequent litigator($<$ 20)	1.65	8.41	0	395.1	37260
Total instances of a Patent being litigated by frequent litigator ($>$ 25)	0.59	6.69	0	576.9	37260
Total instances of a Patent being litigated by non-frequent litigator($<$ 25)	1.76	9.44	0	560.4	37260
Total instances of a Patent being litigated (NPE)	0.081	1.58	0	118.0	37260
Total instances of a Patent being litigated (Non-NPE, Freq)	0.67	7.09	0	576.9	37260
Cases Moved from Court	0.0011	0.011	0	0.28	37260
Cases Moved to Court	0.0014	0.023	0	0.87	37260

Note: Each observation is for a court-industry-year

5 Methodology

We use a simple econometric panel framework to measure the statistical relation between patent litigation and two proxy measures for innovation. Specifically, we allow our dependent variable $EntrepreneurialActivity_{it}$, in region i in industry sector j at time t, to be a function of:

$$EntrepreneurialActivity_{ijt} = \beta_1 PatentLitigation_{ijt} + \beta_2 PatentLitigation^2_{ijt} + \gamma_i + \omega_j + \delta_t \quad (1)$$

In this specification, β_1 and β_2 capture our main effect of interest, that is, the relation between the level of patent litigation in that region for that industry in that time period and entrepreneurial activity. β_1 captures the linear relation between the two. β_2 allows the relation to be non-linear, and in particular, could potentially capture any negative effects from patent litigation above a certain threshold. δ_t is a set of fixed effects for each time period that captures differences in the economy-wide time trend of entrepreneurial activity, ω_j is a series of fixed effects for each industry sector that captures different baseline levels of entrepreneurial activity for that industry, and γ_i is a series of fixed effects which capture different levels of entrepreneurial activity in different regions.

This specification means that identification comes through changes in the level of patent litigation in a particular region or product category that do not follow the national trend. If such changes come from exogenous factors, such as changes in district court policies or changes in personnel or changes in the perceptions among litigators about the likely success of their cases, then we can think of β_1 and β_2 as capturing a causal relation between patent litigation and entrepreneurial activity. We recognize there is the potential for there to be some degree of endogeneity or even reverse causality, which is why we provide multiple robustness checks and specifications.

We also want to determine the effect of the type of plaintiff on innovation. If litigation brought by one of our proxy definitions for a PAE had an incremental effect on innovation beyond that observed for the overall level of litigation, we can study this by accounting for plaintiff type in Equation 1. We therefore estimate separate regressions splitting the patent counts into those not litigated by a PAE and those litigated by a PAE in our later analysis. We estimate separate regressions using counts based on each of our proxy variables for the number of lawsuits that could be attributed to a PAE.

$$EntrepreneurialActivity_{ijt} = \beta_1 NonPAELitigation_{ijt} + \beta_2 NonPAELitigation^2_{ijt} + \beta_3 PAELitigation_{ijt} + \beta_4 PAELitigation^2_{ijt} + \gamma_i + \omega_j + \delta_t \quad (2)$$

6 Results

6.1 Effect of Patent Litigation on Entrepreneurial Activity

Following the specification described by equation (1), we regress the amount of VC investment in each NAICS two-digit industry code in each federal court district in each year from 1995 to 2012 on the number of patents litigated, the number of patents litigated squared, and fixed effects for year, industry, and district court.

Table 2 provides results for our initial specification. In Columns (2) through (4), we incrementally add fixed effects to build up to the final specification provided in equation (1). Column (5) presents results from a more saturated specification which allows for fixed effects at the court-product pair level. Across all columns, we see a similar pattern for the effect of patent litigation on VC investment. Specifically, the positive term on the linear term for patent litigation suggests that VC investment initially increases as patent litigation increases. However, the negative term for the square of patent litigation suggests that this increasing relation is not permanent, but instead is subject to diminishing and eventually negative returns. This is reflected in a plot of the raw data shown in Figure 2. (It is important to note that a relatively small number of observations appear to be driving the relation shown in Figure 2.)

Table 2: The relation between VC investment and patent litigation

	(1)	(2)	(3)	(4)	(5)
Total instances of a Patent being litigated	6.648***	6.753***	6.399***	6.341***	1.003*
	(0.781)	(0.789)	(0.754)	(0.800)	(0.536)
Total instances^2 of a Patent being litigated	-0.00864***	-0.00880***	-0.00835***	-0.00831***	-0.00192**
	(0.00154)	(0.00155)	(0.00146)	(0.00153)	(0.000842)
Year Fixed Effects	No	Yes	Yes	Yes	Yes
District Court Fixed Effects	No	No	Yes	Yes	No
Industry Sector Fixed Effects	No	No	No	Yes	No
Court-Industry Fixed Effects	No	No	No	No	Yes
Observations	37260	37260	37260	37260	37260
R-Squared	0.186	0.192	0.251	0.270	0.705

Ordinary Least Squares Estimates. The dependent variable is total VC investment ($ Mil) in a region-industry-year. The data spans 1995-2012. Robust standard errors reported in parentheses below. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 2: Raw Data: Inverted U-shaped relation between patent litigation and VC funding

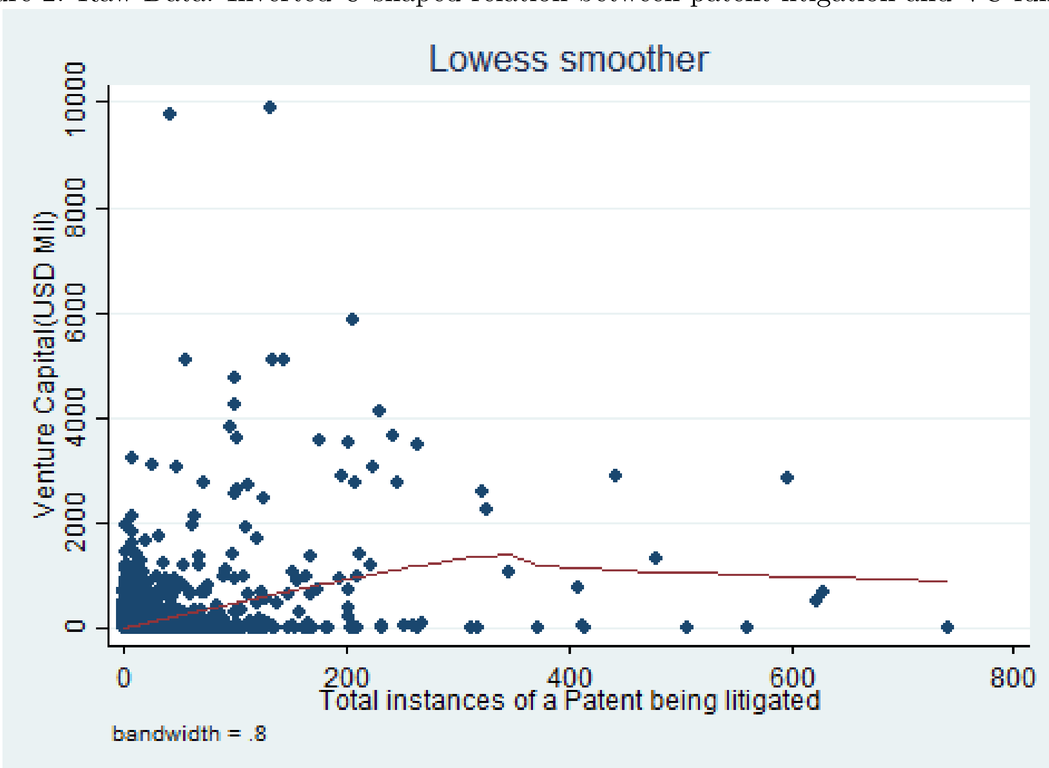


Figure uses raw data and reports results of Lowess smoothing and locally weighted regression of patents on VC funding

6.2 Robustness Checks

Since the results of Table 2 suggest an important and newly identified relation between VC investment and excess levels of patent litigation, we conducted further robustness checks. These are reported in Table 3. One concern is that our results could be driven by our use of a parametric specification that identifies non-linearities through a squared term. Column (1) reports the results of using a non-parametric specification where we observe the effect of a court-product district pair exhibiting an above average level of patent litigation that year. Column (2) reports a specification where we zero-mean and standardize the patent and patent square term. This standardization process should help deal with the potential of outliers driving our results by imposing a normal distribution on their spread. The way it should be interpreted is that each variable measures the effects of an increase of one standard deviation away from the mean.

Another concern is that our results could be driven by outliers. One obvious potential outlier is the Eastern District Court of Texas, which hears many patent litigation suits due to its expertise in patent litigation. An obvious concern is that our estimates could be driven by the relatively low level of VC investment in this particular region which is not known as an entrepreneurial hub. Column (3) reports the results of a specification that excludes the Eastern Court of Texas, and shows that our results are similar when this district is excluded, and Column (4) presents results from a specification that excludes both the Eastern District Court of Texas and the District Court of Delaware.

Column (5) of Table 3 reports the results of a specification where we only use data from 2002-2012. This limited time window addresses the concern that our estimates could be driven by the long time span of our data and the fact that the environment surrounding VC investment may have changed substantially over 17 years; once again, our results are similar. This robustness check also ensures that our estimates are not driven by the 'tech bubble' of 1999-2000.

Column (6) reports results where standard errors are clustered at the industry-sector level. Reflecting the simulation results presented in Bertrand et al. (2004), this should provide a conservative approach to evaluating the precision of our estimates. As the results indicate, we still obtain a reasonable amount of precision. Finally, Column (7) provides non-weighted estimates which assign

Table 3: Robustness checks for results in Table 2

	Non-Parametric (1)	Standardized (2)	Exclude East Texas (3)	Exclude ET and DE (4)	2002-2012 (5)	Cluster Industry (6)	Non-weighted (7)
Above average patent litigation that year	-2.665***						
	(1.023)						
Mean Centered Patents		90.56***					
		(11.42)					
Mean Centered Patent Sq		-48.02***					
		(8.827)					
Total instances of a Patent being litigated			7.567***	8.968***	5.218***	6.341***	
			(0.964)	(1.087)	(0.735)	(1.687)	
Total instances^2 of a Patent being litigated			-0.00946***	-0.0109***	-0.00613***	-0.00831***	
			(0.00211)	(0.00231)	(0.00142)	(0.00285)	
Total instances of a Patent being litigated (non-weighted)							2.639***
							(0.411)
Total instances^2 of a Patent being litigated (non-weighted)							-0.00131***
							(0.000301)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District Court Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	37260	37260	36846	36432	22770	37260	37260
R-Squared	0.150	0.270	0.297	0.328	0.355	0.270	0.221

Ordinary Least Squares Estimates. The dependent variable is VC investment ($ Mil) in a region-industry-year from 1995-2012. Robust standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

patents to a single class, and does not use the alternative methodology developed by Lybbert and Zolas (2012) which assigns probability weights for translating individual IPCs. Again, the results appear robust.

6.3 Alternative Dependent Variable: Small Business Creation

We also wanted to explore whether this empirical regularity was confined to VC investment, or had more widespread consequences to firm creation and employment. To explore this we introduced a new dependent variable which measured the number of small firms in each district court and product observation. Following the approach suggested by equation (1), we regress the number of small firms in each state, in each year (from 1995 through 2011), on the number of patents litigated, the number of patents litigated squared, and fixed effects for each year. Column (1) of Table 4 presents results from this specification using as our dependent variable the number of small firms, defined as firms with fewer than 50 employees, in each industry sector-district court observation. Again, we see a similar pattern where there is a positive effect from the linear term for patent litigation, but a negative effect for the non-linear term. This suggests there is an inverted U-shaped relation between the establishment of new small firms and patent litigation. Columns (2) and (3) show the results of our specification using alternative thresholds for identifying small firms. In general, the size and direction of the estimates are similar, and simply reflect the different magnitude of the underlying dependent variable. It is reassuring evidence that the effect we measure is not driven by the particular cut-off point of 50 employees.

In general, our data suggest that the relation between the founding of new small enterprises in the U.S. and patent litigation is less advanced along the inverted U-shape into diminishing returns than it is for VC investment. This pattern is observed both in our parameterized regression and the raw data as shown by Figure 3. A less pronounced inverted U-shape makes intuitive sense because the effects of excessive patent litigation on VC investment tends to be immediate, whereas we would expect the effects of excessive patent litigation on small businesses to take longer to materialize, as it may take a few years for the costs of excessive litigation to drive firms out of business or become sufficient to discourage entrepreneurs. In addition, it may be the case that small business starts are less affected by litigation because individuals considering starting a business are less likely to be deterred by the threat of litigation.

Figure 3: Raw Data: Inverted U-shaped relation between patent litigation and small business creation

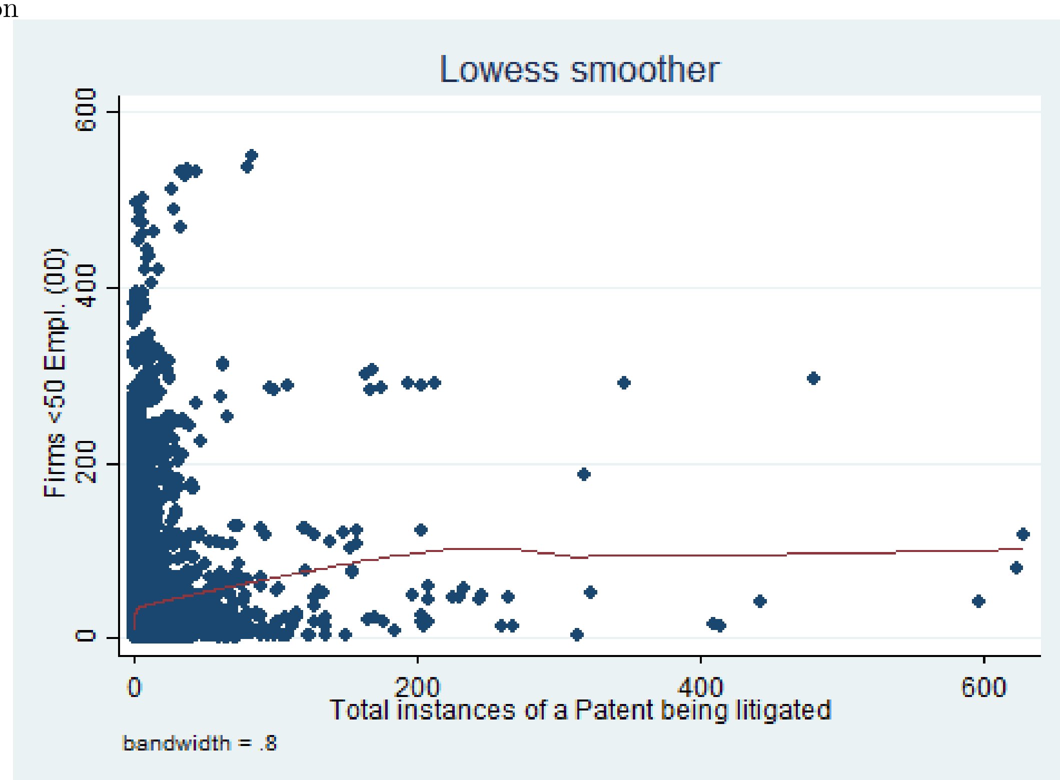


Figure uses raw data and reports results of Lowess smoothing and locally weighted regression of patents on small establishments under 50 employees.

Table 4: Effect of 'Total instances of a Patent being litigated' on small firm creation

	(1) Firms < 50 Empl. (00)	(2) Firms < 10 Empl. (00)	(3) Firms < 100 Empl. (00)
Total instances of a Patent being litigated	0.181***	0.151***	0.194***
	(0.0537)	(0.0465)	(0.0546)
Total instances^2 of a Patent being litigated	-0.000297**	-0.000250**	-0.000318***
	(0.000118)	(0.000103)	(0.000120)
Year Fixed Effects	Yes	Yes	Yes
District Court Fixed Effects	Yes	Yes	Yes
Industry Sector Fixed Effects	Yes	Yes	Yes
Observations	35190	35190	35190
R-Squared	0.585	0.570	0.587

Ordinary Least Squares Estimates. The dependent variable is number of small firms by region-industry-year. The sample spans 1995-2011. Robust standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6.4 By Sector

We then re-estimated our model looking at different sectors. This is important because, as discussed by Bessen and Meurer (2006), the nature of the sector and the fuzziness of the patent boundaries and consequent interpretability within that sector may affect the level of patent litigation. As documented by GAO (2013), cases involving software patents accounted for 89 percent of the increase in defendants over the 2000-2010 period, again suggesting that the changes in patent litigation are not uniform across sectors.

Specifically, we distinguished in our data between non-technology sectors such as health, chemicals and manufacturing,[19], the technology sector[20], the software sector,[21] and the financial sector, which has seen the most extensive patent reform.

Table 5 reports our results. Column (1) suggests that in industries where patents traditionally apply to a single molecule, as is the case in pharmaceuticals or chemical processes, there is less effect on VC investment, perhaps reflecting the lower degree of ambiguity that surrounds patents in such industries. This accords with survey evidence presented by Chien (2013) that suggests that in the "Bio and Pharma" space, venture capitalists have seen far fewer PAE demand letters. Column (2) suggests a large but imprecisely measured effect (since the point estimates are not significant) of patent litigation on the financial services industry. As emphasized by Lerner (2006) this is an industry which has had a large shift in potentially damaging patent litigation in this period, however, since litigation tends to be concentrated in a few geographical regions we do not have enough cross-sectional variation to precisely measure the effect for a single sector.[22]

In Column (3), we display the results for the technology sector, and Column (4) displays the results for software patents alone. The most pronounced effects are in this sector. Column (5) compares software patents litigated to instances of all other types of patents litigated. These results imply that the tipping point of instances of software patents litigated, beyond which VC

[19]Specifically NAICS codes 62, 11, 21 and 22 ("Health", "Agriculture, Forestry, Fishing and Hunting", "Mining, Quarrying, and Oil and Gas Extraction."

[20]Specifically, NAICS codes 51,54,55 -"Information" + "Professional, Scientific, and Technical Services" "Management of Companies and Enterprises"

[21]Specifically, following Chien (2008, p. 1595), we identify litigated software patents as those in U.S. Patent Classes 703, 717, 324, 369, 700, 701, 709, 704, 711, 713, 710, 345, 715, and 707.

[22]Another complication is that the Transitional Program for "Covered Business Method Patents" applies from 2012, but our do not cover the post-implementation period.

investment begins to decrease with additional litigation, occurs at a significantly lower level of instances of litigation than does the tipping point of instances of all other types of patents litigated.

As the time span of our data finishes in 2012, and as we focus on the product sector that the patent is initially tied to rather than the industry of the defendant in the case, we are not able to evaluate claims of harm to Main Street businesses and service providers, a topic which has recently featured in policy discussions. These cases span a variety of industries, though often featuring a piece of reasonably ubiquitous technology. For example, White Castle, a fast food chain, was targeted by a lawsuit over its use of Quick Response (QR) codes.[23] Similarly, businesses such as Panera Bread, Caribou Coffee, Marriott Hotels, and Dunkin' Donuts were recently targeted by a lawsuit over free provision of WiFi on their premises.[24]

Table 5: Investigating variation by sector

	Traditional	Financial	Technology	Software	All
	(1)	(2)	(3)	(4)	(5)
Total instances of a Patent being litigated	-0.0913	3.371	5.557***	20.40***	
	(0.124)	(2.879)	(1.656)	(3.192)	
Total instances^2 of a Patent being litigated	-0.0000785	-0.394	-0.00960***	-0.0774***	
	(0.00169)	(0.315)	(0.00301)	(0.0150)	
Total instances of a Software Patent being litigated					13.91***
					(2.997)
Total instances^2 of a Software Patent being litigated					-0.0593***
					(0.0138)
Total instances of a Non-Software Patent being litigated					4.769***
					(0.699)
Total instances^2 of a Non-Software Patent being litigated					-0.00699***
					(0.00140)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
District Court Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	6480	1620	4860	37260	37260
R-Squared	0.141	0.470	0.408	0.259	0.289

Ordinary Least Squares Estimates. The dependent variable is VC investment ($ Mil) in a region-industry-year from 1995-2012. Robust standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6.5 Effect of Frequent Patent Litigator Litigation

We next turn to investigate whether the effects of patent litigation on our measures of entrepreneurial activity vary by whether or not the litigation involved an entity which was a frequent patent litigator, our proxy measure for a PAE.

[23] http://www.insidecounsel.com/2014/02/14/patent-trolls-target-white-castle.
[24] http://www.rcrwireless.com/article/20131114/wi-fi/hotels-ask-congress-for-help-with-wi-fi-lawsuits/.

Table 6 presents results of a specification where we distinguish the effect of patent litigation that involved a frequent litigator and litigation that did not on VC investment. Column (1) repeats our earlier estimation from Table 2 to provide a baseline for comparison. Column (2) splits this up between litigation that involves a frequent litigator plaintiff and litigation that does not. It is evident that there is a direct negative effect on VC investment from patent litigation that involved one of these frequent litigators. This contrasts with litigation that involves a non-frequent litigator, which exhibits an inverted U-shaped pattern. The coefficient on "Total instances of a Patent being litigated by frequent litigator" implies that, for each patent litigated by frequent litigators in a district, holding other factors constant, VC investment in the district will decrease by $2.7 million. Column (3) repeats the same specification as Column (2), but this time splits the data again, using the alternative definition of a PAE where we identified a subset of PAEs by name in our data. Again, we see a similar negative effect on VC investment for litigation that involves a frequent litigator. Though our point estimates suggest a similar-sized negative effect for the identified PAE, the effects are not significant - perhaps because of our inability to identify such firms due to their policy of using different shell companies for each suit. Columns (4) and (5) investigate the robustness of our results to different thresholds for identifying frequent litigators. In both cases our results are similar in size and in direction, though the estimates in Column (5) are no longer statistically significant - the p-value for the negative linear term is now 0.13. One explanation for this lack of precision at higher thresholds is that 76% of observations of patent litigation by frequent litigators are now zero, meaning that there is less variation to identify the estimates precisely.

Table 6: Distinguishing between the effect of frequent and non-frequent litigators on VC Funding

	(1)	(2)	(3)	(4)	(5)
Total instances of a Patent being litigated	6.341***				
	(0.800)				
Total instances^2 of a Patent being litigated	-0.00831***				
	(0.00153)				
Total instances of a Patent being litigated by non-frequent litigator($<$ 20)		11.30***			
		(1.583)			
Total instances^2 of a Patent being litigated by non-frequent litigator($<$ 20		-0.0143***			
		(0.00549)			
Total instances of a Patent being litigated by frequent litigator ($>$ 20)		-2.744**			
		(1.135)			
Total instances^2 of a Patent being litigated by frequent litigator($>$ 20)		0.00172			
		(0.00307)			
Total instances of a Patent being litigated (Non-NPE, Freq)			-3.184***		
			(1.213)		
Total instances of a Patent being litigated (NPE)			-2.130		
			(7.380)		
Total instances of a Patent being litigated (Non-NPE, Not Freq)			11.96***		
			(1.740)		
Total instances^2 of a Patent being litigated (Non-NPE, Freq)			0.00289		
			(0.00293)		
Total instances^2 of a Patent being litigated (NPE)			0.0223		
			(0.0789)		
Total instances^2 of a Patent being litigated (Non-NPE, Not Freq)			-0.0158**		
			(0.00629)		
Total instances of a Patent being litigated by non-frequent litigator($<$ 15)				12.53***	
				(1.788)	
Total instances^2 of a Patent being litigated by non-frequent litigator($<$ 15				-0.0143**	
				(0.00707)	
Total instances of a Patent being litigated by frequent litigator ($>$ 15)				-2.538**	
				(1.044)	
Total instances^2 of a Patent being litigated by frequent litigator($>$ 15)				0.000505	
				(0.00315)	
Total instances of a Patent being litigated by non-frequent litigator($<$ 25)					9.538***
					(1.413)
Total instances^2 of a Patent being litigated by non-frequent litigator($<$ 25					-0.0117***
					(0.00389)
Total instances of a Patent being litigated by frequent litigator ($>$ 25)					-2.225
					(1.469)
Total instances^2 of a Patent being litigated by frequent litigator($>$ 25)					0.00145
					(0.00333)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
District Court Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	37260	37260	37260	37260	37260
R-Squared	0.270	0.306	0.305	0.318	0.288

Ordinary Least Squares Estimates. The dependent variable is total VC investment at the district court-product level in each year. The sample spans 1995-2012. Robust standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6.6 Instrumental Variable Estimates

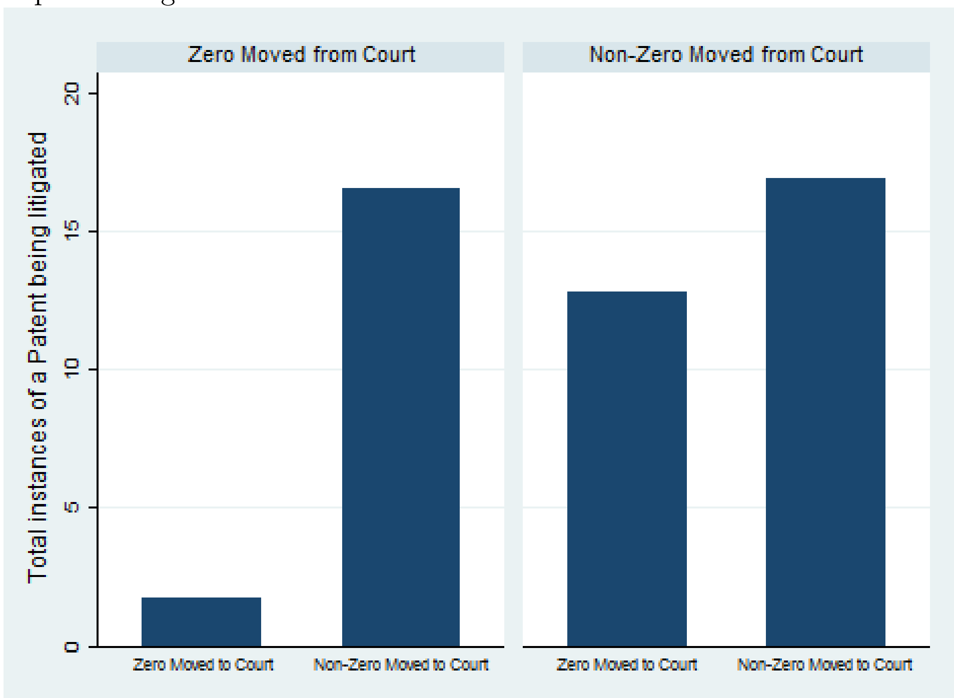
One concern in a paper that uses panel data is that there may be unobserved time-varying heterogeneity that can provide an alternative explanation for the finding. For example, in our setting, we may worry that a pattern of excessive patent litigation could also be linked with worsening economic conditions in that region which drives firms to try to obtain more revenues from existing assets, and in turn these worsening economic conditions may lead to decreased VC investment. To deal with such concerns, we turn to an instrumental variables approach. An ideal instrumental variable in this setting will drive the volume of patents involved in court cases being heard in a court system for a particular industry each year, but not be directly related to the provision of VC investment or the motivation of those who provide VC investment, except through the channel of how it affects the volume of patent litigation.

For our instrument, we use the number of patent litigation cases that were moved into that particular court in that year, and the patent court cases that were moved out of that district court in that year. As shown by Figure 4, these are both variables which are highly positively correlated with instances of patents being litigated. Though, as the figure shows, both instruments work in a similar positive direction, the two instrumental variables only exhibit a 0.0092 correlation with each other. This represents the fact that it seems likely they affect the volume of patent litigation for different reasons.

If a court sees many patent cases transferred from it, then this might suggest that it has established a reputation as either being friendly to defendants or plaintiffs. This potential perceived bias leads those involved in the litigation to make efforts to move the case from that court's jurisdiction. It also affects the volume of cases seen at the court, simply because the favored side has more incentives to bring a case to trial. However, crucially for meeting the exclusion restriction, there is no reason to think that this potential for different legal leanings should affect the VC process directly.

By contrast, if a court sees many patent cases transferred to it, this may reflect the expertise of the judges in patent law or the convenience from the legal perspective of trying the court in that jurisdiction. Again, it seems likely that this expertise or legal convenience will affect the volume of patent law cases without generally affecting the environment for VC investment.

Figure 4: No. of instances of patents being litigated for a product-court pair by whether that court had non-zero patent litigation cases transferred to it or moved from it.



Source: LexisNexis CourtLink

Table 7 reports results of our instrumental variable estimation. In all specifications, we use the same court-industry fixed effects as reported in Column (5) of Table 2. We use this more saturated specification as our instrumental variable at the court-level is somewhat collinear with court fixed effects. Column (1) reports our results without year fixed effects, and Column (2) reports the results with year fixed effects. In both cases, our estimates are similar. We note that relative to the magnitude of the reported effect in Column (5) of Table 2, both estimates are larger, perhaps reflecting the fact that we are now estimating a local average treatment effect. This local average treatment effect only measures the effect of patent litigation that is directly motivated by the attractiveness of that specific court system. In Column (3), we examine the robustness of the negative general slope of VC investment with patents litigated by frequent patent litigators that we observed in Table 6. As we only have two instruments, we do not have enough exogenous variation to explore the squares of the instances of a patent being litigated. However, it is noticeable that we do see a large, linear, and negative effect for patents involving a frequent litigator which supports the results we observed in Table 6.

Table 7: Instrumental variable estimates: The relation between VC investment and patent litigation

	(1)	(2)	(3)
Total instances of a Patent being litigated	4.298***	4.296**	9.752*
	(1.664)	(2.002)	(5.302)
Total instances^2 of a Patent being litigated	-0.00802**	-0.00792**	
	(0.00335)	(0.00394)	
Total instances of a Patent being litigated by frequent litigator (> 20)			-10.96*
			(6.141)
Year Fixed Effects	No	Yes	Yes
Court-Industry Fixed Effects	Yes	Yes	Yes
Observations	37260	37260	37260
R-Squared	0.162	0.168	0.227

Instrumental Variable Estimates. The dependent variable is total VC investment ($ Mil) in a region-industry-year. Endogenous variables are total instances and total instances^2 of patents being litigated. Instruments are the number of patents moving into and out of a court system by year. Equation is exactly identified. F-test for significance of first-stage regression is highly significant - $p - value < 0.001$ across all columns. The data spans 1995-2012. Standard errors reported in parentheses below. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

7 Cost Estimates of "Excess Litigation"

In this section, we provide some back-of-the-envelope calculations about the likely economic implications of our various findings.

7.1 VC Investment

We use our estimates from Table 6 to provide some rough estimates of the effect of different types of patent litigation on VC investment.

When we look at patent litigation conducted by non-frequent litigators that is past the tipping point based on estimates from Column(2) of Table 6, we find that VC investment in new innovations and startups over the past five years would likely have been $109 million higher than it would have been but-for excess patent litigation.[25]

Since our analysis suggests a negative and linear relation between the proportion of patent cases involving frequent litigators and VC investment, our estimates from Column (2) of Table 6 suggest that VC investment would have likely been $21.772 billion higher over the course of five years but-for litigation brought by frequent litigators. This is relative to the baseline of $130.979 billion that was invested in start-ups and innovation over the course of these five years. Since our estimates represent a reasonably large proportion of the baseline, we also followed a bootstrap procedure to try to estimate the 95% confidence interval for this estimate, which was between $8.1 billion and $41.8 billion. [26]

These estimates are also supported by recent anecdotal evidence of the effect of frequently litigated patents on entrepreneurial activity. Feldman (2013) conducted a survey of 200 venture capitalists and found that 100% of respondents indicated that an existing patent demand against a potential portfolio company could be a major investment deterrent. Feldman also found that the

[25]This is estimated by employing a bootstrap procedure wherein we re-sample the data with replacement 1,000 times, estimate the model on the re-sampled data from each iteration, and recalculate the loss in VC investment due to litigation by non-frequent litigators that is past the tipping point using the coefficient from each iteration. These estimates exclude industries in the Eastern District of Texas and the District of Delaware.

[26]This 95% interval was estimated by employing a bootstrap procedure wherein we re-sample the data with replacement 1,000 times, estimate the model on the re-sampled data from each iteration, and recalculate the loss in VC investment using the coefficient from each iteration. The estimates exclude industries in the Eastern District Court of Texas and the District Court of Delaware.

majority of venture capital firms believe that patent demands have a negative effect on the venture-backed community. Further, as reported in Chien (2013), venture capitalist Brad Burnham could not continue to raise capital for a portfolio company after it was hit by two successive patent lawsuits. Ultimately, Burnham's firm chose to reduce the portfolio company to a fraction of its former size. Also profiled in Chien (2013), one venture capitalist concluded that the activities of frequent litigators are"creating friction in the acquisition process [and] buyers are warier because they are worried about buying a company and getting sued," after having witnessed two portfolio companies become targets of frequent litigators (p. 50).

7.2 Comparison of Direct and Indirect Costs

We believe that our research sheds new light on the indirect costs of patent litigation on innovation. For purposes of comparison, in this section we use exiting estimates for some of the direct costs of litigation to allow a comparison of the relative magnitudes of our estimates and those in the existing literature.

We calculate these direct costs by building on prior research which has estimated the average total cost of a patent lawsuit involving PAEs, including settlements and legal fees, at between $1.75 million per lawsuit for firms with revenues less than $1 billion and $8.79 million per lawsuit for firms with revenues greater than $1 billion (Bessen and Meurer, 2014). Reflecting their methodology, these estimates include direct legal costs as well as the value of settlements paid or damages awarded. We used the count of how many cases were brought by the frequent litigators we identified in our data (which our estimates in Table 6 suggested had a universally negative effect on VC funding) to estimate that the separate costs of litigation, as identified by Bessen and Meurer (2014), attributable to litigation brought by frequent litigators was between $3.77 to $18.9 billion in 2012. Though, we recognize that such litigation costs may only be a fraction of the costs imposed by patent lawsuits, this provides an initial idea of the order of magnitude of the indirect costs that we estimate relative to more direct forms of costs that have received the focus of prior academic work.

8 Conclusions

8.1 Possible Policy Approaches to Patents

Given this negative empirical relation between excessive patent litigation and our measures of entrepreneurial activity, what should be done?

To help provide guidance to policymakers, we empirically investigated what appears to be driving the high levels of patent litigation we observe. Table 8 investigates the relation between patent litigation and the number of patents granted. We regress the number of patents involved in litigation in each year, in each U.S. patent class, on the cumulative number of patents granted in the prior ten years from each class, fixed effects for each year, and fixed effects for the patent class. The results in Table 8 suggest that as more patents are granted in the U.S., the amount of patent litigation also increases.

The results in Columns (1) - (4) of Table 8 suggest that mechanically, one way to reduce litigation would be to decrease the number of patents granted.

The obvious question, however, is what kind of criteria should be used to identify the patents which, if granted, lead to excessive patent litigation. One possibility is that because not all patents are for equally innovative inventions, a reduction in patent grants could be achieved by increasing the threshold of what is considered patentable. Inventions that are also patented in the E.U. and Japan generally have to meet a higher threshold for innovation than patents registered only in the U.S. To investigate this further, we define as "triadic patents" in our data those that have been approved by the U.S. Patent and Trademark Office, the European Patent Office (EPO), and the Japanese Patent Office (JPO). Triadic patents are more likely to be "relatively important" and considered to be of higher quality, because as noted by Beard et al. (2010) they are "generally regarded as 'valid' patents." Given that the EPO is considered to be "the most stringent in its requirements and evaluations," triadic patents are "less likely to be substandard patents." As shown by Figure 5, such patents form a decreasing percentage of patents granted in the U.S.

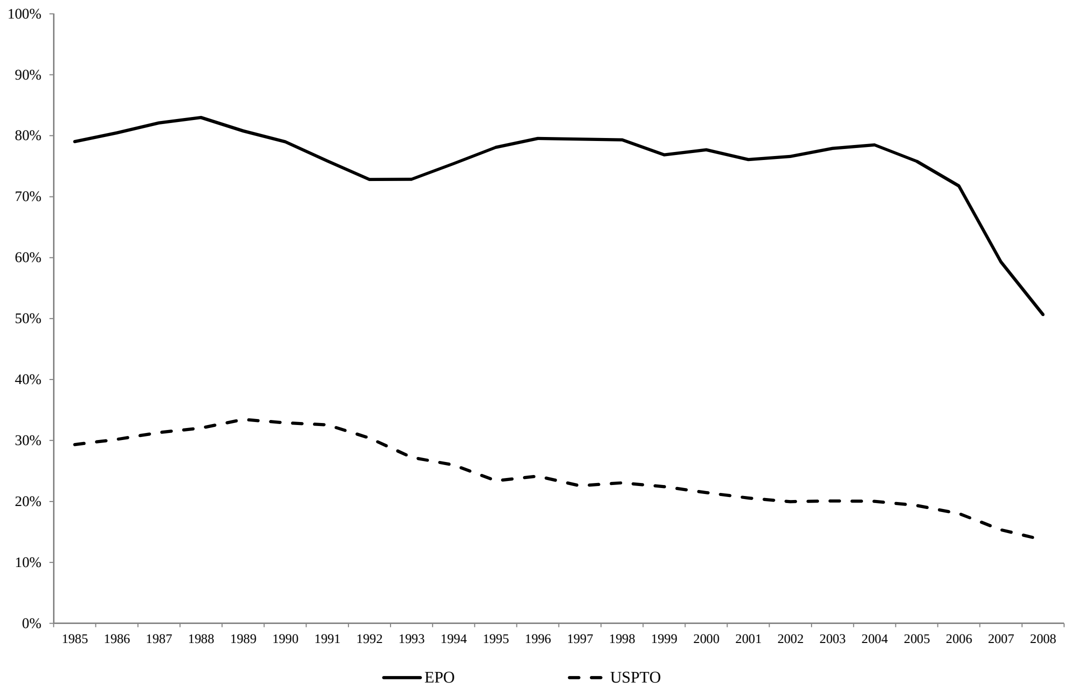
In Columns (5) - (6) of Table 8, we regress the number of patents involved in litigation in each year from 1995 to 2008 on both the number of patents granted and the number of patents

Table 8: Patent litigation as a function of number and type of patents granted

	USPTO Data		OECD Data		Combined Data	
	(1)	(2)	(3)	(4)	(5)	(6)
Rolling 10-yr Cumulative Patents Granted (000)	4.120***	4.136***	2.712***	2.528***	4.314***	3.916***
	(0.351)	(0.343)	(0.236)	(0.207)	(0.429)	(0.390)
Rolling 10-yr Cumulative Triadic Families (000)					-8.394***	-6.975***
					(1.149)	(1.094)
Year Fixed Effects	No	Yes	No	Yes	No	Yes
Observations	4080	4080	112	112	112	112
R-Squared	0.190	0.207	0.723	0.781	0.782	0.818

For USPTO Data: Each observation is an aggregated U.S. Patent Class from 1995 - 2012. For OECD Data: Each observation is aggregated to a One-Character IPC Section from 1995 - 2008. For Combined Data: Each observation in the combined data is aggregated to a One-Character IPC Section from 1995 - 2008. Ordinary Least Squared Estimates. The dependent variable is the level of patent litigation for that patent class for that year. Regressions are run with robust standard errors. $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 5: Triadic Patent Families as percentages of EPO and USPTO patent grants (1985-2008)



Note: Triadic Patent Families as a percent of grants is calculated by dividing the number of new Triadic Patent Families each year by the number of new patents granted each year by either the USPTO or EPO. Source: OECD.

that are triadic, and find that patent litigation is decreasing in the percentage of triadic patents. We caution the reader that this is predominantly identified from cross-sectional variation between different patent classes - for example, pharmaceutical patents are far more likely to be triadic and also are far less likely to be litigated, while technology patents are far less likely to be triadic but more likely to be litigated. The statistical relation identified in Table 8 does suggest, however, that one approach to stemming excessive litigation could involve the U.S. adopting some of the EPO's and JPO's more stringent approaches toward reviewing patents.

In general, the results in Table 6 imply that litigation launched by frequent patent litigators has an immediate negative effect on VC investment. This suggests that another policy implication of this research is that policies directed at repressing the activities of PAEs or frequent litigators may increase the funding available for entrepreneurial activity. This provides support for several policies under consideration by policymakers which attempt to address the asymmetries of costs faced by PAEs and those who they launch litigation against. As described in Chien (2009), since PAEs do not actually manufacture anything, they bear fewer costs in terms of discovery and preparing for trial.

8.2 Summary

This study investigates the empirical relation between rising patent litigation and the entrepreneurial economy. We find evidence that both at the regional level and at the product sector level, high levels of patent litigation have a statistically negative relation with VC investment, and more weakly with the creation of small new firms.

There are of course limitations to our findings. First, we identify our effect of interest by using a panel data approach. Though we present instrumental variable estimates as a robustness check, there is still the potential that there is an unexplained source of unobserved time-varying heterogeneity which would provide an alternative explanation of our findings. Second, we rely on a relatively simple parameterized model. We do this to increase the ease of interpretation of our estimates; however, there are other ways of specifying the functional form of the relation between patent litigation and entrepreneurial activity. Third, the results for small businesses are smaller than those for VC investment, which perhaps reflects the fact that the employment effects take longer to materialize. Last, when discussing policy implications, we focus our estimates of the economic effects of litigation by non-frequent litigators on regions which are past our estimated tipping point, rather than attempting to estimate an equilibrium effect. Notwithstanding these limitations, we believe that this research provides important new empirical evidence for policymakers about the relation between excessive patent litigation and entrepreneurial activity.

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