Hastings Science and Technology Law Journal

Volume 8
Number 1 *Winter 2016*

Article 4

Winter 2016

Spotting Software Innovation in a Patent Assertion Entity World

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Table of Contents

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I. Introduction

Young innovating companies constitute risky investments because they lack the necessary track record and often lock their capital in intangibles.[1] Entrepreneurs wish to secure some financial backing in order to grow their business; but, while they know their business inside-out, potential investors must be convinced to invest. To defeat information asymmetries,[2] entrepreneurs and potential investors must rely on observable characteristics or other manufactured signals to make investment decisions.[3]

While these innovative startups are ill-suited for bank loans,[4] they are prime candidates for venture capital (VC) fund investments.[5] To elect their investments targets, VCs rely on characteristics and signals that can be observed before and during the negotiations. For instance, before the negotiations, potential investors valorize the prior experience and education of a fund-seeking entrepreneur;[6] or during negotiations, an entrepreneur can

1. Bronwyn H. Hall, *The Financing of Innovative Firms*, 1 R. ECON. & INSTITUTIONS 1, 2–5 (2010) (discussing how innovative companies have most of their assets in research and development (R&D) and this R&D constitute an intangible asset, mostly in the form of human capital).

2. *Id*. at 7. Information asymmetries were first formally discussed by George A. Akerlof in *The Market for "Lemons": Quality Uncertainty and the Market Mechanism*, 84 QUARTERLY J. ECON. 488 (1970) where he describes how market with information asymmetry may lead to good investments to not enter the market.

3. Hall, *supra* note 1, at 8 (using the example of R&D expenditure as a signal around the information asymmetry problem).

4. "Low salvage values relative to the original investment makes these [intangible assets created by innovation investment] unsuitable for debt finance in spite of the tax advantage, so that firms whose investments are mostly intangible will rely more heavily on retained earnings and equity." *Id.* at 10. Citing previous empirical studies, Hall, supra *note* 1, argues that young innovative companies are often cash strapped, this lack of cash affects R&D, and they rely more on venture financing because they are more willing to take risks. *Id.* at 21–22.

5. ANDREW METRICK & AYAKO YASUDA, VENTURE CAPITAL & THE FINANCE OF INNOVATION, 10–13 (2d ed. 2011) (discussing the type of companies in which venture capital funds invest).

6. David H. Hsu, *Experienced Entrepreneurial Founders, Organizational Capital, and Venture Capital Funding*, 36 RESEARCH POL'Y 722 (2007), David H. Hsu empirically tests whether prior experience and education affect the fund receives through direct ties as well as the valuation of the venture. He finds that prior experience has a statistically significant effect on the likelihood of receiving funds through direct ties as well as increases the pre-investment valuation of the company. He finds, however, that education has mixed and sometimes inconclusive effects; yet, in the Internet industry, holding a doctorate increases the likelihood of receiving funds through direct ties as well as increases preinvestment valuation in a statistically significant way.

reveal her company's potential if she is willing to accept staged financing[7] or relinquish some corporate control.[8]

When investing, VCs also consider company characteristics such as its innovative potential. Investors seek innovative companies because innovations can help them profit based on Schumpeterian principles.[9] These principles argue that innovation helps generate profits in one of two ways: innovation helps create differentiated products or innovation helps produce the same product but at a lower cost.[10]

Investors struggle to assess innovation potential.[11] First, investors do not fully observe this potential because inventors do not wish to disclose their innovation.[12] Second, even if inventors clearly disclose their ideas, entrepreneurs also have an incentive to exaggerate their potential.[13]

7. Ronald J. Gilson, *Engineering a venture capital market: lessons from the American experience*, 55 STAN. L. REV. 1067 (2003). Ronald J. Gilson explains how contracts between venture capital firms and startup entrepreneurs can be used to alleviate some of the risk, uncertainties, information asymmetries, and agency cost linked with the investor-investee relationship including using staged financing, control, monitoring, etc. Stage financing falls within this category. *Id*. at 1080.

8. *Id*. at 1091.

9. "[T]he bulk of private fortunes is, in capitalist society, directly or indirectly the result of the process of which innovation is the 'prime mover.'" Joseph A. Schumpeter, BUSINESS CYCLES, A THEORETICAL, HISTORICAL AND STATISTICAL ANALYSIS OF THE CAPITALIST PROCESS, 104 (1939).

10. *Id*. at 85–86. Innovations shift the innovator's cost curve and allow innovators to capture some of the demand.

11. This issue does not refer to the difficulties measuring innovation or innovation potential because innovation is an abstract concept. This issue refers to the observation of innovation potential because innovators know more about their inventions than outside observers.

12. Disclosing innovation makes it available to potential competitors because ideas and innovations are non-rival and can be reproduced. The "non-rival character of knowledge . . . means that once an invention is known, everyone can use it with no additional R&D cost." David Encaoua, Dominique Guellec & Catalina Martínez *Patent systems for encouraging innovation: Lessons from economic analysis*, 35 RESEARCH POL'Y 1423, 1424 (2006). This issue is referred as the Arrow's information paradox where disclosing the information destroys its value. KENNETH J. ARROW, *Economic Welfare and the Allocation of Resources for Invention*, THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 615 (Nat'l Bureau of Econ. Research ed., 1962) (explaining the paradox that the information's "value for the purchaser is not known until he has the information, but then he has in effect acquired it without cost"). The investors may not copy the information herself but the innovator may not be able to prevent its reproduction after disclosing it. The initial inventors may still enjoy a first-mover advantage and hence benefit from her invention, but she might not be able to benefit as much as she would have, had she not disclosed.

13. Mattew Beacham & Bipasa Datta, *Who becomes the winner? Effects of venture capital on firms' innovative incentives: a theoretical investigation*, Univ. of York, Working Paper (2013). Mattew Beacham and Bipasa Datta present a two-period theoretical model explaining the incentive that entrepreneurs have to put high amounts of efforts in the first period in order to obtain venture capital financing in the second period.

Therefore, investors struggle to forecast the market potential especially at the early innovations stages.

Fund seeking companies and investors rely on selection criteria that address information asymmetries and separate companies according to their potential. In the software industry, entrepreneurs and investors have arguably used patent portfolios to separate companies according to their potential.[14]

Patents are perceived as incentivizing innovation by granting the holder a monopoly in exchange for disclosing information about the invention;[15] however, in the software industry, patents do not seem to fulfill this function.[16] The software industry moves too fast for the patent system and for the innovator to profit on her monopoly power. This is because a patent takes on average of almost three years to be granted,[17] while most software users would have changed software at least once during that time period.[18] Even if software patents remain relevant, its holders have hardly enforced them.[19]

Software patents instead are often used as innovation-potential signals. Software startups rarely hold patents.[20] This scarcity makes them good

14. Ronald J. Mann, *Do Patent Facilitate Financing in the Software Industry?*, 83 TEX. L. REV. 961 (2005).

15. Catherine M. Cottle & Robert P. Greenspoon, *Don't Assume a Can Opener: Confronting Patent Economic Theories with Licensing and Enforcement Reality*, 12 COLUM. SCI. & TECH. L. REV. 194, 205 (2011) (discussing the reward theory of patents that "argues that patents incentivize innovation by increasing the benefits associated with obtaining a patent" because it creates a monopoly market that the innovator can exploit).

16. *Id*. at 209–10 (discussing the prospective theory and how patents disseminate information such as declaring to competing firms of successful research and allowing holders to exchange information).

17. *Performance Accountability Report* 190 Table 4 (2013), USPTO, http://www.uspto.gov/about/stratplan/ar/USPTOFY2013PAR.pdf. This table shows that the average pendency for a Computer Architecture, Software & Information Security was 2 years and 8 months.

18. The lifespan of software has been dropping quickly. A survey from 1992 cites a 10.1 year lifespan for software in Japan. Tetsuo Tamai & Yohsuke Torimitsu, *Software Lifetime and its Evolution Process over Generations*, SOFTWARE MAINTENANCE PROC. 63 (1992). "Another survey in Germany from the year 2000 claims that more than seventy-five percent of customers are replacing their software each year and almost fifty percent are replacing them every six months." Sylvain Perchaud, *Software Patents and Innovation*, 1 J. OF INFO. L. & TECH. (2003).

19. Mann uses his interview with IBM to explain how some companies have a more "lenient enforcement of their IP rights." IBM offers nonexclusive licenses and does not wish to enforce its intellectual property through litigation. Mann, *supra* note 15, at 1005–06. This seems to indicate that the cost of enforcing patents outweighs the benefits in the software industry. Software innovators often prefer to cross-license their patents.

20. For instance, in a 2005 survey, a minority of software startups held patents by the time they received their first round of venture capital financing. In comparison, in the biotech industry the majority of companies held a patent before receiving their first investments. In *Patents,*

signals. Software companies often file patent(s) later in their lifecycle to differentiate their products, to facilitate cross-licensing, and to signal expertise and knowhow.[21] First, this paper analyzes whether patents have been used as innovation-potential signals as well as how they help investors select which projects to finance. This paper argues that VC funds have indirectly encouraged the proliferation of software patents.

Patent scarcity also makes startups vulnerable to potential claims. A 2013 report by the U.S. Government Accountability Office noted an increase in patent infringement litigation with multi-defendants between 2007 and 2011 and 89 percent of this increase was attributable to software patent litigation.[22] Second, this paper analyzes how the impact in the increase in patent litigation affected the software industry and the signaling value of patents. The second section also discusses how Patent Assertion Entities (PAEs) have proliferated, how PAE litigations have increased, and how they impact the value of patents.

Both VCs and PAEs rely on patents in different ways. By using patents in an unexpected way, PAEs have complicated VCs' company valuation. Indirectly, VCs have fed into the patent assertion entity problem. This paper presents empirical evidence that PAEs have impacted the behavior of VCs. Finally, this paper discusses how VCs have been impacted by PAEs and the role that VCs play to hinder the PAE phenomenon. This paper argues that VCs can do more to hinder the impact of PAEs.

II. Are Patents Good Signals for Investors?

On the demand side, most young companies rely on inside finance to start their businesses but in order to grow and flourish, they turn to outside financing.[23] To gain access to outside finance, innovators need to convince

Venture Capital, and Software Startups, Ronald J. Mann and Thomas W. Sager compare the biotech industry to the software industry. Ronald J. Mann & Thomas W. Sager, *Patents, Venture Capital, and Software Startups*, 36 RESEARCH POL'Y 193 (2007). In *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, Stuart J.H. Graham, et al., compared the biotechnology, medical device, software/internet, and IT hardware industries. While Graham et al., also find that VC backing correlated with patenting and that the software industry behave differently than the biotech industry, they report higher patent numbers than Mann et al. Stuart J.H. Graham et al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255 (2009).

21. Mann, *supra* note 14, at 985–96.

22. U.S. GOV'T ACCOUNTABILITY OFF., GAO-13-465, ASSESSING FACTORS THAT AFFECT PATENT INFRINGEMENT LITIGATION COULD HELP IMPROVE PATENT QUALITY 14 (2013).

23. *See e.g.* Metrick, *supra* note 5, at 17, exhibit 1-6; Valérie Revest & Alessandro Sapio, *Financing Technology-Based Small Firms in Europe: What Do We Know?*, 39 SMALL BUS. ECON. 179 (2012) (showing that high-tech European companies rely on internal funds at the early

outsiders to invest. To convince outsiders, innovators can resort to sending the "correct" signals.

On the supply side, VC funds provide finances to startups. Since most VC funds have a short lifespan,[24] they rely on selling their stakes to profit (instead of collecting dividends).[25] A successful sale involves an initial public offering (IPO) where the VCs' stakes are sold to a public or to another company in case of an acquisition.[26] To profit, a VC needs to successfully convince a public or another company about the investment's soundness. As a result, sending signals can help convince outsiders.

Over its lifetime, a company might send signals to VCs to get initial financing and to the public to get further financing. Patents can serve as a signal on both occasions. This section investigates how startups use patents as signals. The section concludes by discussing whether these signals work in the software industry.

A. From Patenting to Investments

Investors are less interested in defining and measuring innovation and more interested in profiting from innovation.[27] VCs want the companies they fund to innovate because innovation lead to higher profits according to Schumpeterian principles. Scholars have debated over the role of VC funds in the innovation process: Do VC funds encourage innovation?[28] Or

stage and outside financing at a later stage); William B. Gartner, Casey J. Frid, & John C. Alexander, *Financing the Emerging Firm*, 39 SMALL BUS. ECON. 745 (2012) (estimating the most common source of financing for young firms).

24. VC funds are a limited partnership built to usually last ten years. They are extendable under certain circumstances. See e.g., William A. Sahlman, *The structure and governance of venture-capital organizations*, J. FIN. ECON. 473 (1990); Paul Gompers & Josh Lerner, *The Venture Capital Revolution*. 15 J. ECON. PERSPECTIVES 145 (2001).

25. Metrick, et al., *supra* note 5, at 178–80. Profiting upon exit contrasts with other investors who profit from collecting interest on loan repayments like banks or dividends like long-term entrepreneur-investors.

26. *Id*. at 179.

27. *See e.g.*, Zvi Griliches, *R&D and Productivity: The Econometric Evidence*, NAT'L BUREAU OF ECON. RESEARCH 315–19 (1998) (discussing how stock market prices respond to changes in patent filings and reporting mixed evidence about this impact); James Bessen, Jennifer Ford, and Michael J. Meurer, *The Private and Social Costs of Patents Trolls*, 34 REGULATION 26 (2011-2012) (discussing the reaction of investors and the stock market to filing patent suits and showing that investors may overreact).

28. What constitutes an innovation is beyond the scope of this paper. For simplicity, a "product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses." OECD & EUROSTAT, OSLO MANUAL 48 OECD PUBLISHING (3d ed. 2005). "This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics." *Id.* Beside product innovation, the OECD and Eurostat identify three

do they accurately spot innovative companies?[29] The truth is probably somewhere in between these two views.[30]

This section analyzes these innovation selecting and the innovation inducing hypotheses. Because innovation is difficult to measure, scholars have used patents as a proxy for innovation.[31] This section argues that patents seemingly play such a proxy role for investors as well.

On the one hand, if investors can only spot but cannot encourage innovation, investors must carefully select the companies. They must find ways to separate companies with high innovative potential from companies with low innovative potential, and to invest in the former.[32] This task can, however, prove difficult.

First, entrepreneurs cannot directly exhibit their innovativeness because disclosing their content can destroy its potential value.[33] Second, innovative potential can be faked: if a fund-seeking entrepreneur knows how investors select companies, he or she will try to exhibit the sought-out characteristics, which includes innovativeness.[34] These two problems force inventors to indirectly signal their innovativeness. A good signal is costly enough to separate individuals with low and high potential,[35] and cheap enough to allow recipients to access it.[36]

types of innovation: process innovations, marketing innovations, and organizational innovations. *Id.* at 47. These last three types of innovation are beyond the scope of this paper.

29. *See* Masayuki Hirukawa & Masako Ueda, *Venture Capital and Innovation: Which is First?*, 16 PAC. ECON. REV. 421 (2011).

30. "Firms that seek venture-funding appear to be patenting more actively prior to the funding event (and for the purpose of securing funding), and venture-capital investors appear much less willing to fund companies that hold no patents." Graham et al., *supra* note 20, at 1280.

31. Patents are legal title to a monopoly over the innovation. Griliches, *supra* note 27, at 289. Companies may decide to not protect their innovation or use another form of protection (e.g., trade secret) or the innovation may simply not be patentable. *Id.* at 296. Thus, patents may constitute an imperfect proxy. *Id.* at 301 (discussing the validity of using patent as a measure of inventive output). Griliches argues that patents may provide a good indicator when comparing behavior across firms and across industry but is a less accurate indicator within firms. *Id*. The size of the company (as measured by R&D expenditure) impacts the relationship between R&D and patent filings. *Id.* at 303. The propensity to file a patent for invention differs according to industries as well. *Id.* at 308.

32. *See* Metrick & Yasuda, *supra* note 5, at 123–35 (highlighting the different failure rates VC funds experience depending on the stage of financing involvement). VC funds that invest at earlier stages often face higher failure rate. *Id.*

33. *See* Arrow, *supra* note 12, at 615 (discussing the information value paradox).

34. *See* Matthew Beacham & Bipasa Datta, *Who Becomes the Winner? Effects of Venture Capital on Firms' Innovative Incentives – A Theoretical Investigation*, 7–10 (Univ. of York, Working Paper No. 13/33, 2013) (building a theoretical model to show the different incentives of companies with high or low skillsets).

35. Michael Spence, *Job Market Signaling*, 87 Q. J. ECON. 355, 358 (1973) (discussing the role that signal costs play in effectively defeating information asymmetries and using the example

Patents have served as an efficient signal because they are costly to produce, verifiable, and costless to access.[37] First, patents are often quite costly to obtain,[38] and they generally are costly to retain.[39] If an innovator is rational, she will only file a patent if she expects the benefits to outweigh the costs. Signaling the innovative potential to outsiders constitutes such a benefit. A patent that signals her innovative potential may even justify the patenting cost[40] when she may have otherwise used other means to protect her innovation — such as trade secrets.

Second, patents are verifiable and verified. The government verifies patents in two principal ways. A patent office must first verify and approve that the patent fulfills certain criteria before a patent becomes valid.[41] The

of education as a costly and time consuming signal that job seekers may elect to signal to employers their worth); Clarissa Long, *Patent Signals*, 69 U. CHI. L. REV. 625, 655–660 (2002) (discussing the importance of making the signal costly enough to avoid multiple equilibria). A good signal should also reflect the underlying quality being signaled. *See id.* at 671.

36. Long, *supra* note 35, at 644 ("The strategy of firms will thus be to convey in-formation about their positive attributes in a way that presents low acquisition and verification costs to the intended recipients."). The issue is twofold: Outsiders cannot directly observe innovation potential and they cannot trust what they are told. An outsider may not be able to directly observe the innovative potential because innovators wish to keep it secret and young companies may not have yet realized this potential. An outsider may not trust an entrepreneur to directly express the truth about the company's innovative potential because of the distorted incentive to exhibit the sought-out characteristics. Of course, an entrepreneur knows more about her company than outsiders and this unequal knowledge creates information asymmetries that have been usually resolved through signaling. IPO and investment literature focused on the signal theory. *See, e.g,.* James C. Brau, & Stanley E. Fawcett, *Initial Public Offerings: An Analysis of Theory and Practice*, 61 J. FIN. 399 (2006) (performing a survey of company officers to determine what signals are important for a successful IPO).

37. Carolin Haeussler, Dietmar Harhoff & Elisabeth Müller, *To Be Financed or Not: The Role of Patents for Venture Capital Financing* (Munich Sch. of Mgmt., Working Paper No. 2009-02, 2009) (investigating, empirically, whether patent filing and patent quality impact the likelihood of receiving financing in the German and British biotechnology industry). Haessler et al., found that having patent applications increased the likelihood of receiving funding, and that the changes in the patent application stock provided results that were more statistically significant. *Id.* at 22. Patent quality also increased the likelihood of receiving funding in a statistically significant way. *Id.*

38. For instance, AM. INTELLECTUAL PROP. LAW ASS'N, REPORT OF THE ECONOMIC SURVEY 2013 27 (2013) cites $10,000 patent fees for electronic/computer in 2012.

39. For more information on the fee schedules, see *USPTO Fee Schedule,* U.S. PATENT AND TRADEMARK OFFICE (USPTO), http://www.uspto.gov/web/offices/ac/qs/ope/fee010114.htm (last visited Dec. 15, 2014).

40. Long, *supra* note 35, at 627, argues that, "[P]atents can serve as a means of reducing informational asymmetries between patentees and observers. The ability to convey information credibly to observers at low cost is a highly valuable function of patents. . . ." Using a model, she later argues the information cost reducing role of patents can explain why patents may be worth the cost, aside from the rent they produce. *Id.* at 644.

41. The criteria are different in most jurisdictions. For instance, the USPTO verifies that the invention is: (1) useful, 35 U.S.C § 101 (2015); (2) novel, 35 U.S.C § 102 (2015); and (3)

courts also legitimize any patents that have successfully been litigated and upheld.[42] Similarly, industry participants can signal the value of a patent through citations[43] because subsequent patents must cite patents which they rely on.[44] In conclusion, even if an investor does not have the required expertise, she can still easily access this signal and its value because other entities (whether governmental or other industry participants) vouch for the patent's quality.

However, an investor does not have to rely solely on these entities to assess the signal's value because she can research the patent's content. To obtain a patent, innovators must disclose the contents of their invention.[45] An investor can access the patent office's records and read the documents relating to the patent. Because VC fund managers specialize in an economic sector, they often possess the expertise required to evaluate patents.[46] Patent disclosure helps dispel some information asymmetries without destroying the information's (and innovation's) value.[47] Empirical evidences support that VCs use company portfolio when deciding whether

non-obvious, 35 U.S.C § 103 (2015). Long, *supra* note 35, at 667-68, argues at that "[t]he PTO is an imperfect mechanism . . . for assuring that information contained in a patent is credible" because the evaluation can be rushed and incomplete.

42. During a patent litigation, a court can decide on the validity of the patent along the same criteria used by the patent office to grant a patent. Furthermore, the court must decide whether infringement occurred; hence, the court decides upon the boundaries of the patent. Patent enforcement is an even more costly signal because it involves more actions: monitoring infringements and costly litigating court. GAO Study, *supra* note 22, at 9–11 (discussing the enforcement of patents).

43. Haeussler et al., *supra* note 37, at 16 (discussing the value of patents as signal to obtain financing. They investigate as well the quality of the signal sent by patents: they estimate patent quality using patent citations because patents that receive citation are considered prior art. They find that "companies with highly cited patents receive VCs financing faster than firms with infrequently cited patent applications.").

44. Long, *supra* note 35, at 652. Investors can also look at the original patent to look at what patents it cites and benchmark this patent with respect to previous patents; Samuel Kortum & Josh Lerner, *Assessing the Contribution of Venture Capital to Innovation*, 31 RAND J. ECON. 674, 689–90 (2000) (arguing that citations and litigations are two indicators of a patent's value).

45. This disclosure is the quid pro quo for gaining an enforceable legal monopoly. The patent holder can exploit this monopoly power or outsource the exploitation through licensing or selling agreements or refuse to exploit it as well.

46. Long, *supra* note 35, at 666 (discussing the cost of evaluating signals like patent and requiring the intervention of experts); George G. Triantis, *Financial Contract Design in the World of Venture Capital*, 68 U. CHI. L. REV. 305, (2001) (discussing the importance of intermediaries like venture capital funds and banks because they provide specialized knowledge and can evaluate projects); Olav Sorenson & Toby E. Stuart, *Syndication Networks and the Spatial Distribution of Venture Capital Investments*, 106 AM. J. SOCIOLOGY 1546, 1577 (2001) (empirically testing the impact of industry experience and finding that industry experience have a statistically significant on the likelihood of financing a company).

47. Haeussler et al., *supra* note 37.

to invest,[48] even if patents constitute a problematic proxy for innovative potential.[49]

On the other hand, if VCs can encourage companies to innovate,[50] they will encourage innovation only if they can profit from it. To encourage profitable innovation, investors must align their incentives with the company managers or inventor's incentive. Realigning incentives can, however, prove to be difficult because, by investing, VCs separate control from capital and dis-align these incentives; hence, VCs inadvertently create an agency problem.[51]

To overcome this agency problem, VCs have mostly relied on two solutions.[52] First, investors can realign their incentives with the innovator's through financial inducements.[53] For instance, investors can request a stage financing clause, which specifies that an entrepreneur and its VC agree on installment investments that are disbursed only if the entrepreneur reaches certain milestones (e.g., prototype, mass production, etc.).[54] This method assures that an innovator-entrepreneur remains motivated to develop an innovation along a VC-selected timeline.

Second, investors can realign incentives through direct intervention. By this way, VCs can monitor and control some activities. For instance, investors can demand that the innovator-entrepreneur yields some positions

48. *See e.g.* Dirk Engel and Max Keilbach, *Firm-level Implications of Early Stage Venture Capital Investment – An Empirical Investigation,* 14 J. EMPIRICAL FIN. 150 (2007) (empirically testing and finding that German venture-capital-backed startups have more patent filing than comparable non-venture-capital-backed startups but they are already filing more application before the engagement of venture capital funds, which means that funds invest in companies that patents instead of encouraging patenting).

49. *See supra* note 31.

50. Kortum & Lerner, *supra* note 44 (attempting to estimate the impact of venture capital activity on patent filing controlling for R&D investment). They find a positive relationship between venture capital investment and patenting. They further test the casual direction of the relationship. They use the liberalization of investment rules, which only impact venture capital funding, to control for the causality of the effects. They find that increasing venture financing increases patenting.

51. Eugene F. Fama & Michael C. Jensen, *Separation of Ownership and Control,* 26 J. OF L. & ECON. 301 (1983) (discussing the issues associated with control, which makes the decision, from separating ownership, which bears the consequences of decisions because transaction costs lead incomplete contracts).

52. Gilson, *supra* note 7, also discusses the use of compensation schemes involving performance incentives and exit call option at 1083–85.

53. *Id*. at 1079 ("Staged financing aligns the interests of the venture capital fund and the entrepreneur by creating a substantial performance incentive. If the portfolio company does not meet the milestone whose completion was funded in the initial round of financing, the venture capital fund has the power to shut the project down by declining to fund the project's next round.").

54. *Id*.

of control in the company. VCs often request seats on the company's board of directors[55] to remain involved and monitor the company's activities. Relinquishing too many seats (and control) may, however, signal a poor investment because it can indicate that an entrepreneur has little leverage through outside opportunities.[56] Investors would then need to screen companies for the appropriate level of malleability.[57]

Even under this VC-inducing innovation hypothesis, patents can be used as signal. Since VCs profit from exiting companies, they must send the proper signal to attract outside investors.[58] VCs can signal before exiting through patenting the company's innovative and profit potential. This hypothesis has been verified empirically.[59]

Under both the selecting and inducing hypothesis, patenting plays a role as signal. While this section examined the general signaling value of patents, their value varies from industry to industry. The following section discusses the role of patents in the software industry.

B. The Software Industry

Software patents continue to create a debate. In the United States, software innovators can patent and/or copyright their software innovations.[60] Patenting software protects processes and against reverse

55. *Id*. at 1082-83.

56. In *Contracts and Exits in Venture Capital Finance*, 21 REV. FINANCIAL STUDIES, 1947 (2008), Douglas Cumming estimates that venture capital fund managers who exercise more control are more likely to exit via an acquisition than IPO or a write-off using a sample of European venture capital backed companies. He argues that more VCs' control rights are usually associated with less promising companies. *Id.* at 1950.

57. VCs need to balance the need to exercise control to encourage innovation without stifling or wrongly steering innovation. The VC's expertise becomes important in this context because she may be able to understand the industry specific difficulties.

58. "Because entry and exit is more difficult for investors in a privately held firm, such investors can be expected to place a higher marginal value on gaining information about each firm's attributes than would investors in publicly held firms." Long, *supra* note 36, at 673.

59. "This finding suggests that patents cast an important signal not only to VC audiences but also to investors in public equity markets." David H. Hsu & Rosemarie H. Ziedonis, *Patents as Quality Signals for Entrepreneurial Ventures*, Academy of Management Proceedings 25 (2008) (estimating the impact of patent as signal at different stages of a startup financing cycle and finding that patent application stock is strongly correlated with the likelihood of a venture's final funding was through an IPO).

60. *See e.g*. Philip J. Weiser, *The Internet, Innovation, and Intellectual Property Policy*, 103 COLUM. L. REV. 534, 539 (2003) (stating that "computer programs are eligible for protection under both copyright – as creative works of authorship — and patent — as items of functional utility").

engineering.[61] Patenting grants an innovator protection over the software's innovative sections.[62] Copyrighting software grants longer protection[63] at a lower cost.[64] Copyright protects against literal copying.[65] This option between patenting and copyrighting makes software unique. Software patent and copyright have their upsides and downsides, which are beyond the scope of this paper.

Patents can serve to incentivize innovators by granting them a right to exclude others to use their innovation. However, in the software industry, patents have arguably been used to signal potential. First, the software patent granting process and lifecycle support that patents are more of a signal than an asset: a software patent takes on average almost three years to be granted whereas users update or change software on average once in that period.[66] Hence, by the time a software innovator can take advantage of her monopoly, users have moved on.

Second, VCs backing is correlated with higher patenting levels. A 2008 study reports that software startups backed by VCs applied or hold 5.9 patents on average as compared to 1.7 for the software startup general population; and that 67 percent of VCs backed software startups held at least one patent while only 24 percent of the software startup general population.[67] While VCs backed companies may be more innovative (selection hypothesis), non-VCs backed companies may simply not wish to patent because they do not have a need for it.

More particularly, software companies generally delay patenting[68] and this delay supports the signaling argument. While budget constraints may

61. Julie E. Cohen and Mark A. Lemley, *Patent Scope and Innovation in the Software Industry*, 89 CALIF. L. REV. 1 (2001) arguing that patenting should not protect reverse engineering efforts.

62. *Id*.

63. Patents are valid for up to 20 years from the date of filing (35 U.S.C. § 154(a)(2)) while copyright protection are valid for up to "the life of the author and 70 years after the author's death" (17 U.S. Code § 302).

64. American Intellectual Property Law Association, *Report of the Economic Survey 2013*, (2013) cites $350 copyright fees and $10,000 patent fees for electrical/computer in 2012. For more information on the fee schedules, see U.S. Copyright Office http://copyright.gov/docs/fees.html; United State Patent and Trademark Office (USPTO), http://www.uspto.gov/web/offices/ac/qs/ope/fee010114.htm (last visited Dec. 15, 2014).

65. "In the language often used by courts interpreting the Copyright Act, this issue boils down to the protectibility of literal copying of 'non-literal' elements of a software program." Weiser, *supra* note 60, n. 13.

66. *See* footnote *supra* note 17 & 18.

67. Graham et al., *supra* note 20, Table 1.

68. *See e.g.,* the discussion in Mann and Sager, *supra* note 20 (estimating the differences between the biotechnology industry and the software industry and finding lower patenting rates

dictate this delay,[69] VC funds invest millions into software companies[70] and can afford to file a patent. If software patents are mainly viewed as a valuable asset, a rational VC should not delay patenting (to protect their investments) because of value discounting[71] and knowing the speed of the industry.[72] VCs must delay because software patent value is affected overtime.[73] If software patents are mainly viewed as a valuable signal, patents only become valuable when VCs prepare to exit.[74]

Finally, as one study reports, software patents have traditionally not generated revenue streams or been heavily enforced prior to 2005 as reported by one study.[75] This trend has changed and a GAO study reveals

and a large gap between both industry before the first investment rounds) and Mann, *supra* note 21 (arguing on the differences of patenting in the software industry).

69. GAO Study, *supra* note 22, reports that "a few representatives of venture capital and software startup firms told [GAO] that they do not always apply for patents until their companies are well established because patent attorneys are expensive, and the process is time consuming." *Id*. at 34–35. Graham et al., *supra* note 20, find that software startups patent less often and with lesser intensity than biotechnology, medical device, and IT hardware startups. *Id*. at Table 1. And Table 2 shows that the most cited reason for not seeking patent protection is the cost of patenting in the software industry.

70. *See infra* Section IV. A. (explaining that between 2005 and 2012, VCs invested on average $5.6 million into each software company according to a dataset from Dow Jones).

71. *See generally*, *What is the Formula for Calculating Net Present Value?*, INVESTOPEDIA.COM, http://www.investopedia.com/ask/answers/021115/whatformulacalculating netpresentvaluenpvexcel.asp. The present value of a patent is the sum of the marginal profits received from filing a patent over the life of a patent as compared to not filing a patent. This value is higher today than it is tomorrow based on the future value discount/present value calculation of economics since people discount the future because of its uncertainties, inflation, and other factors such as preferences. However, because a competitor may be able to file a similar patent, filing a patent tomorrow may be worthless if someone else filed it. In other words, rational individuals value the present more than the future.

72. *See generally What is the Formula for Calculating Net Present Value?*, INVESTOPEDIA.COM, http://www.investopedia.com/ask/answers/021115/whatformulacalculating netpresentvaluenpvexcel.asp. The implicit assumption is that the value of a patent diminishes because of present value discounting of future value, inflation, and because of competing researcher willing to patent the same idea. In other words, assets are more valuable today than in the future.

73. *See generally Inefficient Market*, INVESTOPEDIA.COM, http://www.investopedia.com/ articles/05/032905.asp?rp=i. The discussion assumes that VCs can sell patents. If the market for patent is efficient, then patenting an exploiting the innovation itself or patenting and selling the patent should be worth the same. While markets for patent are likely inefficient because information asymmetries and search cost to find a buyer, a VC should likely be able to recoup the cost of patent filing.

74. Delaying patenting — instead of patenting or not patenting — does not seem rational, unless the value of patent as a signal changes over time because its value as an asset should not. A priori, startups may be as innovative as incumbent companies; a nonestablished company seeking a path may not need to signal its potential while an established one seeking further fund may need to signal its potential.

75. *See* discussion *supra* note 19.

that software patent litigation has increased more rapidly than non-software litigation not involving software between 2007 and 2011.[76] The next section discusses software patent litigation and particularly PAEs, which have been playing a central role in this change in philosophy. Seemingly, to gain access to funds, VCs have incentivized software entrepreneurs to seek funding through patents. Accordingly, VCs have indirectly fed into the litigious changes.

III. Patent Assertion Entities Impacting the Software Industry

The previous section has showed that software patents play a role as a signal; yet, they remain a potential asset. Still, VCs may prefer companies with large patent portfolios because these portfolios may guarantee larger profits through patent-granted monopolies. These portfolios can also be sold in case of failure.[77]

Moreover, patents can be strategically used to increase the competitor's costs. For instance, through a patent, its holder gains an associated right to exclude others from using her patented innovation.[78] Patents can be strategically used to defend against competitors' claims. For instance, a company can use its patents as defense during an infringement lawsuit or leverage their patents to instigate counter-claims.[79]

Recently, some entities have disrupted the software patent ecosystem. These entities enforce but do not utilize patents. Their activities have changed how market participants value patents as assets. This section discusses non-practicing entities. It argues that these entities help as well

76. *See* GAO Study, *supra* note 22, at Figure 5.

77. *See, e.g.*, John E. Dubiansky, *An Analysis for the Valuation of Venture Capital-Funded Startup Firm Patents*, 12 B.U. J. SCI. & TECH. L. 170 (2006) (discussing the issues venture capitalists face valuing patent before their sell and give the example of VC firms who specialized in reselling intellectual property of failed startups).

78. Holders enforce this right of exclusion through litigation: litigating may conclude in an injunction ordering the infringer to not use the patented innovation or in royalty damages transferring funds from the infringer to the patent holder; however, the court may also hold that the alleged infringer did not infringe or that the patent is invalid. Injunctions are more difficult to obtain: "In the 2006 *eBay* decision, the Supreme Court ruled that district courts should not assume an injunction was automatically needed in patent infringement cases and instead should use the same test used in other cases to determine whether to award the plaintiff an injunction. eBay, Inc. v. MercExchange, L.L.C., 547 U.S. 388 (2006). According to several legal commentators we spoke with, this decision has generally made it more difficult for NPEs to obtain injunctions in the courts and has led them to pursue exclusion orders at ITC — although there may have been other reasons for the increase in filings, including the relative speed of proceedings at ITC." GAO Study, *supra* note 22, at 11 n.26.

79. Graham et al., *supra* note 20, at 1300–02.

as hinder innovation and concludes by looking at the software industry and the impacts of these entities have on the financing of innovation.

A. Patent Assertion Entities Impacting the Innovation Ecosystem

Non-practicing entities encompass a multitude of entities. These entities live along a spectrum. At one end of the spectrum are inventors who do not exploit their patents. Universities and research centers often perform research and file a patent based on their research, but do not develop products or services that utilize these patents (but may license them).[80]

At the other end of the spectrum are entities that exploit patents but do not invest in R&D or invent. For instance, some organizations have developed a business model that relies on purchasing patents and licensing them or enforcing them for revenues.[81] These organizations have been credited with driving the increase in patent litigation at a large cost to society.[82]

In other words, these entities monetize patents but do not utilize patents: they profit either by acquiring and licensing patents[83] or by litigating infringers.[84] The companies, "whose business model primarily focuses on purchasing and asserting patents,"[85] are often referred to as patent monetization entities or patent assertion entities (PAE),[86] to

80. GAO Study, *supra* note 22, at 2.

81. *Id.* at 19.

82. James Bessen & Michael J. Meurer, *The Direct Costs from NPE Disputes*, 99 CORNELL L. REV. 387, 389 (2014) (estimating that non-practicing entities cost accrued $29 billion of direct costs in 2011.) This figure however, has been criticized for being overinflated, David L. Schwartz & Jay P. Kesan, *Analyzing the role of non-practicing entities in the patent system*, 99 CORNELL L. REV. 425, 433, 440 (2014) (arguing that this figure is biased upward because it includes litigation that may have been brought regardless and because monetary transfers between entities differ from costs to economists.)

83. Thought, Inc. v. Oracle Corp., No. 12-cv-05601-WHO (N.D. Cal. 2014).

84. Pragmatus AV, LLC v. Facebook, Inc., 769 F. Supp. 2d 991, 995 (E.D. Va. 2011) (stating that the plaintiff is a "'non-practicing entity,' meaning that it does not research and develop new technology but rather acquires patents, licenses the technology, and sues alleged infringers. [Plaintiff]'s main line of business is enforcing its intellectual property rights, and a large part of that task involves threatening to file lawsuits.").

85. FTC, *The Evolving IP Marketplace: Aligning Patent Notice and Remedies with Competition*, at 94–103 (Mar. 2011), https://www.ftc.gov/sites/default/files/documents/reports/evolving-ip-marketplace-aligning-patent-notice-and-remedies-competition-report-federal-trade/110307patentreport.pdf.

86. "Some NPEs simply buy patents from others for the purpose of asserting them for profit; these NPEs are known as patent monetization entities (PME)." The GAO study, *supra* note 22, at 2. But "[t]he Federal Trade Commission uses the related term 'patent assertion entities' to focus on entities whose business model solely focuses on asserting typically purchased

distinguish them from other nonpracticing entities (NPEs) like university and research institutions, which develop technologies.[87] PAEs are sometimes also referred as patent trolls.[88]

PAEs have developed three different types of business models:[89] They sue and hope for a big jury award; they sue and negotiate quickly for a low-value settlement (leveraging high litigation costs); or they accumulate large quantities of patents and license this portfolio (under the threat of suing nonlicensed alleged infringers).[90] Regardless of their business model, these entities present major upsides and downsides.

On the one hand, PAEs provide inventors with the opportunity to raise more funds from their patented innovation. PAEs transfer funds through licensing or sales from technology users to patent holders.[91]

Since innovators receive more funds, PAEs should incentivize inventors to innovate more.[92] Assuming that an innovator is rational and

patents. As such, the PME term also encompasses entities that might use third-party NPEs to assert patents for them." The GAO study, *supra* note 23, at n. 6.

87. For an in-depth definition of nonpracticing entities and patent trolls, see for example Mark A. Lemley & A. Douglas Melamed, *Missing the Forest for the Trolls*, 113 COLUMB. L. REV. 2117 (2013); Schwartz et al., *supra* note 22.

88. *See, e.g.*, In re Qimonda AG, 462 B.R. 165, 174 (Bankr. E.D. Va. 2011) ("'non-practicing entity' or 'NPE' (sometimes disparagingly referred to as a 'patent troll')."). "Not all NPEs are referred to as 'patent trolls.' For example, research universities may develop patented technology but not practice the patents." Cascades Computer Innovation LLC v. RPX Corp., No. 12-CV-01143 YGR, 2013 WL 316023, at *1 n.3 (N.D. Cal. Jan. 24, 2013).

89. Executive Office of the President, *Patent Assertion and U.S. Innovation*, THE WHITE HOUSE, http://www.whitehouse.gov/sites/default/files/docs/patent_report.pdf (last visited Jan. 23, 2015). The Executive Office of the President has identified seven characteristics for these kinds of patent assertion entities: "1. They do not "practice" their patents; that is, they do not do research or develop any technology or products related to their patents; 2. They do not help with "technology transfer" (the process of translating the patent language into a usable product or process); 3. They often wait until after industry participants have made irreversible investments before asserting their claims; 4. They acquire patents solely for the purpose of extracting payments from alleged infringers; 5. Their strategies for litigation take advantage of their non-practicing status, which makes them invulnerable to counter-claims of patent infringement; 6. They acquire patents whose claim boundaries are unclear, and then (with little specific evidence of infringement) ask many companies at once for moderate license fees, assuming that some will settle instead of risking a costly and uncertain trial; 7. They may hide their identity by creating numerous shell companies and requiring those who settle to sign non-disclosure agreements, making it difficult for defendants to form common defensive strategies (for example, by sharing legal fees rather than settling individually)."

90. Lemley et al., *supra* note 87, at 2126; The GAO study, *supra* note 22, at 14 ("some stakeholders . . . said that they experienced a substantial amount of patent assertion without firms ever filing lawsuits against them."). These licenses have been referred as stick licenses, where the potential infringer takes a license under threat of litigation.

91. Lemley et al., *supra* note 87, at 2124–25.

92. *See* Cottle et al., *supra* note 15, at 215 (discussing how "NPEs also introduce liquidity into technology markets" because "when acquiring rights to an individual's or a company's patent

risk neutral, she invests in innovating only if her expected benefits from innovating outweigh her expected costs. This innovator forms expectations about the value of her innovation. This valuation is based upon either exploiting the innovation or licensing or selling it.

An innovator may opt to license her patent because she cannot exploit it or simply because she prefers to let others exploit it. First, an innovator may struggle to exploit her innovation because of budget constraints (e.g., costly product development or manufacturing), or because she lacks necessary supporting patents, or because she lacks the clout to maximize profits.[93] Second, an innovator may simply specialize in R&D and prefer to license instead of exploiting her innovation.

Regardless of her reasons, an innovator may struggle to license her patent due to the licensing-related transaction costs. One study found[94] that a minority of companies licenses out their patents,[95] but companies often wish to license more.[96] Companies mostly cite identifying licensing partners as the most important problem — above issues surrounding licensing fees, negotiation costs, and technology advances.[97]

Innovators can benefit from an intermediary. Such an intermediary has proven useful for small and medium enterprises in Korea.[98] These enterprises have used the services of the Korean Integrated Contract Manufacturing Service to enhance their collaborative efforts and help them "diffuse their innovative technologies."[99]

or portfolio, the NPE acts as a technology broker and facilitates a robust technology marketplace.").

93. For instance, even if an innovator could exploit her patent, she may not profit because she might not even have the resources to enforce her patent and exploit her monopoly. "[P]atent enforcement has become financially undoable for small startup companies. NPEs provide an avenue to protect assets that would otherwise be lost due to financial constraints." Colleen V. Chien, *Patent Assertion and Startup Innovation*, NEW AM. FOUND., OPEN TECHN. INST. WHITE PAPER 18 (2013).

94. Maria Pluvia Zuniga & Dominique Guellec, *Who Licenses Out Patents and Why? Lessons from a Business Survey* (OECD Sci., Tech. and Indus. Working Papers, Working Paper No. 2009/05, 2009), *available at* http://dx.doi.org/10.1787/224447241101.

95. Twenty-seven percent of Japanese companies declared to license patents to nonaffiliated partners while the corresponding figure for European companies is twenty percent. Zuniga & Guellec, *supra* note 94, at 12.

96. Forty-five percent of European companies and eighty percent of Japanese companies that already license want to license more. Zuniga & Guellec*, supra* note 95, at 20.

97. Zuniga & Guellec*, supra* note 94, at 21.

98. Sungjoo Lee, Gwangman Park, Byungun Yoon & Jinwoo Park, *Open Innovation in SMEs—An Intermediated Network Model*, 39 RESEARCH POL'Y 290, 296–99 (2010).

99. Lee et al*., supra* note 98, at 296–99.

PAEs can play this intermediary role and provide middlemen services.[100] PAEs, by definition, must repeatedly and profitably purchase patents; therefore, they have the required skillset to price the patents correctly. PAEs can use these interactions to build a network to identify viable partners, to help innovators sell[101] and price their innovation.[102] As such, they can serve as a hub for patents or market places.

By creating opportunities for licensing and sale revenues, PAEs incentivize patenting innovation.[103] Basic economics dictate that if the innovation market functions efficiently, the presence of PAEs shifts the patent demand curve. In the long term, the equilibrium supplied quantity of patents should increase whereas the impact on the equilibrium price of patent is ambiguous.

PAEs may encourage innovators to patent innovations that would not have otherwise been patented; or they may also encourage innovators to innovate more than they would otherwise have. Assuming that PAEs encourage innovation, it is also ambiguous whether the incentivized innovations are socially efficient innovations.[104] On the one hand, the PAEs that use the first business model[105] rely on acquiring valuable patents and enforcing them; these PAEs should encourage patenting valuable innovations. On the other hand, second and third business-model PAEs do not necessarily encourage socially efficient innovations and their patenting

100. *See generally* Colleen Chien, *From Arms Race to Marketplace: The Complex Patent Ecosystem and Its Implications for the Patent System*, 62 HASTINGS L.J. 297, 315–17 (2010) (discussing the role of intermediaries in the patent system, including the PAEs).

101. *See generally* Linus Dahlander & David M. Gann, *How Open Is Innovation?*, 39 RESEARCH POL'Y 699 (2010). Linus Dahlander & David M. Gann perform a review of the literature on Open Innovation, a business model which relies on bringing inside a company outside innovation and sending outside a company innovation. They highlight the literature that discusses the issues with selling (or licensing) innovation. *Id* at 704. They highlight the issues with disclosure, valuation, and technology transfer costs.

102. *See generally* James F. McDonough, *The Myth of the Patent Troll: An Alternative View of the Function of Patent Dealers in an Idea Economy*, 56 EMORY L.J. 189, 190 (2006) (NPEs can then license or collect fees for these patents: they act as intermediaries and decrease transaction costs for innovators who do not have the expertise to license their patent, to negotiate fees, or enforce their patent. "These trolls act as a market intermediary in the patent market. Patent trolls provide liquidity, market clearing, and increased efficiency to the patent markets — the same benefits securities dealers supply capital markets.").

103. *See generally* Schwartz et al., *supra* note 82, at 434 ("By creating options to generate rewards for innovators otherwise shutout of the marketplace . . . [t]ogether with contingency fee lawyers whose business models depend on choosing the right patents and the right patentees, NPEs can create important avenues for appropriating rewards for valuable patent rights that are owned by non-market players.").

104. A socially efficient innovation is an innovation whose social benefit from innovating outweighs the social cost of innovating.

105. Executive Office of the Present, *supra* note 89.

because they rent-seek based on nuisance demands/suits and scale leveraging for revenues.[106]

Finally, first business model PAEs also provides a public good because, through litigation, they challenge patents and establish their boundaries.[107] If an innovation is cumulative,[108] then knowing the patent boundaries helps subsequent innovators assess the innovation added value. If a court validates a patent and sets its boundaries, a follow-on innovator also knows whether to negotiate a license from the original patent holder.[109] When second and third business model PAEs intervene, courts never have a chance to assess a patent's validity or boundaries.

On the other hand, PAEs disrupt innovation systems because they impose additional costs upon innovators. First, they enforce patents that may not have been enforced otherwise. For instance, the original patents may not have been enforced because the original holder could not afford to enforce. Some industries also have a culture of cross-licensing;[110] hence, putting patents in the hand of PAEs disrupts such culture.

Second, these entities have been heavily criticized in recent times as a tax on innovation[111] because they use their superior bargaining position to

106. Since the PAEs that deploy the third business model rely on acquiring a large portfolio and leveraging them, they encourage patenting any innovation regardless of their added value.

107. *See generally* Joseph E. Stiglitz, *Economic Foundations of Intellectual Property Rights*, 5 DUKE L.J. 1693, 1715 (2008) ("When a firm gets a patent, it encloses the commons, making private what would otherwise be public . . . But when a firm challenges a patent, it creates a public good, because if it successfully challenges a patent, that piece of knowledge enters the public domain, where anybody can use it. Thus, challenging a patent is a public good. The result, of course, is that there will be an underinvestment in fighting bad patents, and an overinvestment in trying to get bad patents.").

108. For a broad discussion of cumulative innovation and the associated issues, see for example Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, 5 J. ECON. PERSP. 29 (1991). In general, more frequently cited patents are more valuable because their innovator-declared and implied value (using patent renewal as proxy) is positively correlated to the number of citations. Dietmar Harhoff, Francis Narin, Frederic M. Scherer & Katrin Vopel, *Citation Frequency and the Value of Patented Inventions*, 81 REV. ECON. & STAT. 511 (1999).

109. This has lead different countries to approach this issue differently. "For example, in the United States, patent holders do not have a duty to license and their licensing actions are limited only by antitrust law, but in the United Kingdom, France, and Germany, compulsory license statutes require patent holders to license their products." T. R. Beard, George S. Ford, Thomas M. Koutsky & Lawrence J. Spiwak, *Quantifying the Cost of Substandard Patents: Some Preliminary* Evidence, 12 YALE J.L. & TECH 240, 249 (2010).

110. Colleen V. Chien, *Reforming Software Patents*, 50 HOUS. L. REV. 325, 341 (2012) (discussing the culture of cross-licensing among patent holders, which can become difficult with the presence of PAEs).

111. Robin Feldman & Mark A. Lemley, *Does Patent Licensing Mean Innovation?* (Stan. L. & Econ. Olin Working Paper No. 473, 2015).

impose costs on innovators without providing added value. Their superior bargaining position rests on their nonparticipation in the industry: Innovators/alleged infringers have a product at stakes; they can be locked into a technology with high switching cost; and they may have invested in second-generation innovation, whereas PAEs are immune to cross-claims because they have no products at stake.[112] PAEs can leverage this position and extract more rent from alleged infringers who fear large damages or an injunction, which would prevent innovators from producing their products.[113]

PAEs also burden the judicial system.[114] Second business model includes PAEs filing suits and negotiating low-value settlement; hence, they require court intervention and clog dockets. Even though third-business-model PAEs rely on threats, they may need, from time to time, to carry out their threats and file out a suit in order to substantiate these threats.[115] Under both business models, PAEs leverage litigation costs to gain more profits.[116]

PAEs likely discourage socially efficient cumulative innovations because they create uncertainties. They encourage innovators to patent their inventions through financial incentives, some of which might not have been patented otherwise. Therefore, PAEs feed into the system and make it more difficult to see patent boundaries. This behavior of patenting more innovations leads to patent thicket, "a term used to describe 'a dense web

112. Only a small number of companies opt to switch products. Colleen Chien, *Startups and Patent Trolls*, 17 STAN. TECH. L. REV. 461 (2014) (explaining that faced with NPEs litigation 9% of respondents decided to change their product). NPEs can exploit the switching cost from the adopted technology to any alternative technology.

113. "The Federal Circuit focused on the high costs for defendants to defend, the burden of complying with discovery, and the minimal risk to non-practicing entities because they have no actual products at stake." Summit Data Sys., LLC v EMC Corp., No. 10-749-GMS, 2014 WL 4955689, at *4 (D. Del. Sept. 25, 2014).

114. These entities have been associated with large social welfare impact. Bessen & Meurer, *supra* note 82 (estimating that NPEs accrued $29 billion of direct costs in 2011).

115. "The typical scenario begins with an NPE contacting a targeted company through a cease and desist letter accusing the company of infringing one or more of its patents. Soon after, the NPE sends a request for royalty payments to the targeted company leaving the attached entity with three options: (1) stop using the technology (and incur switching costs if alternatives are available); (2) pay royalties to the NPE; or (3) face litigation." Stefania Fusco, *Markets and Patent Enforcement: A Comparative Investigation of Non-Practicing Entities in the United States and Europe*, 20 MICH. TELECOMM. & TECH. L. REV. 439, 444 (2014).

116. Awarding attorney's fees may solve some but not all problems because defendants would still need to go through the court system. Christian Helmers, Brian Love & Luke McDonagh, *Is There a Patent Troll Problem in the U.K.?*, 24 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 509, 541–544 (2013) (arguing that the U.K. and the U.S. are similar in many respects but the U.K. experience fewer PAE activities because the U.K. system shifts the litigation costs onto the loser instead of each party paying for their own litigation costs).

of overlapping intellectual property rights.'"[117] Patent thickets impose a cost upon innovators because innovators must check for possible infringements or need to guess and estimate the boundaries of numerous patents.[118] PAEs, by indirectly encouraging patent thickets, increase the cost and diminish the likelihood of subsequent innovations.[119]

"NPEs make innovation more expensive while, at the same time, creating a secondary market for inventors with an uncertain beneficial effect."[120] The overall theoretical impact of PAEs on patenting incentives and, by proxy, on innovation incentives remains unclear.[121] Survey evidence has pointed out, however, that PAEs are not an efficient middleman first, because PAEs usually sue before issuing a license[122] and second, because if a license is issued, it leads to no knowledge transfers,[123] or only marginal improvements to products.[124] The overall impact of PAEs on innovation seems more negative than positive.

The relationship between PAEs and patenting is intricate: PAEs need patents to thrive and they encourage patenting whether by providing a market for innovation or by creating the need for practicing entities to defend themselves. Patents have proliferated as shown by Figure 1: The left axis shows the number of newly granted patents per year; the right axis shows the number of patent suit filed and the number patent suits involving

117. Jaffe v. Samsung Electronics Co., Ltd., 737 F.3d 14, 17 (4th Cir. 2013).

118. Ass'n for Molecular Pathology v. U.S. Patent & Trademark Office, 653 F.3d 1329 (Fed. Cir. 2011).

119. Lemley et al., *supra* note 85, at 2125 (arguing that "[b]y increasing the costs of using technology, [NPEs] would . . . create deadweight, welfare-reducing loss by decreasing the use of patented technologies and the manufacture and sale of products using patented technologies. In addition, by increasing the costs of using patented technologies, they would reduce the use of those technologies in research and development (R&D) and in follow-on inventions and thereby reduce innovation.").

120. Fusco, *supra* note 115, at 449.

121. Fiona M. Scott Morton & Carl Shapiro, *Strategic Patent Acquisitions*, 79 ANTITRUST L. J. 463 (2014) (presenting a stylized model that describe under which conditions NPEs promote innovation and benefit consumers and under which conditions they deter innovation and harm consumers; concluding that, under anecdotal evidence, NPEs are more likely to deter innovation and harm consumers).

122. Feldman & Lemley, *supra* note 111, at 23.

123. Feldman and Lemley argue that the traditional markers of knowledge transfer (technical knowledge, personnel transfer, and joint venture creation) are not exhibited by these relationships. Feldman & Lemley, *supra* note 111, at 25–28. Their survey also shows that relationship with NPEs like universities also do not exhibit these markers. Feldman & Lemley, *supra* note 112 at 30–36.

124. "100% of respondents in both the computer & other electronics category and the combined life sciences category reported that when licensing or settlement requests led to licenses, the technology they licensed resulted in adding new products or features 0-10% of the time." Feldman & Lemley, *supra* note 111, at 38.

PAEs. Between 2004 and 2013, inventors have filed patents at a faster pace. Figure 1 also shows that patent suits have increased at an even faster pace. The portion of patent suits that involve NPEs has also increased dramatically over the period and seems to drive the increase in patent suit filings.

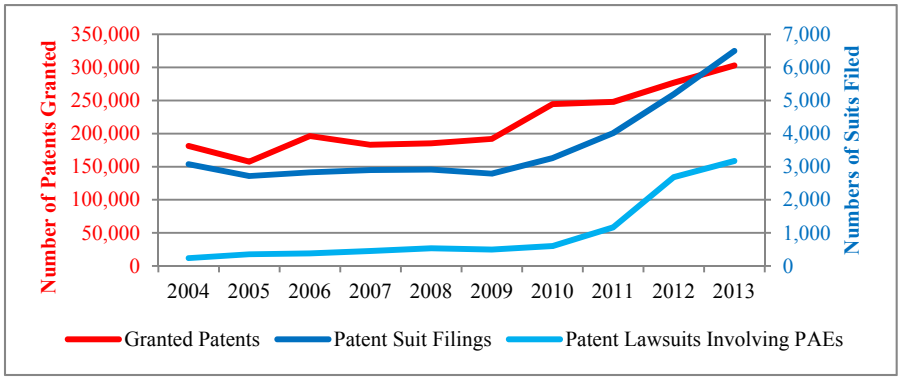

Figure 1: Patents Granted and Patent Suits Filed between 2004 and 2013.
(Source: USPTO; Annual Report of the Director: Judicial Business of the United States Courts, Patent Freedom)

The growth of patents and PAE activities is hard to disentangle. On the one hand, a PAE can only file a suit after an inventor files a patent and sells it to them; hence, patent filings influence the likelihood of patent suits and PAE's activities. On the other hand, a PAE encourages patent filing for defensive purposes and by doing so provides innovators with financial alternatives. The next section discusses how this can have an impact on startups and how innovation incentive affects their financing and VC funding. It investigates in more detail the impact of PAEs on patenting activities.

B. Spotting Innovation in the Software Industry

PAEs have operated in many industries, but they have concentrated in the Information and Communication Technology (ICT).[125] The ICT industry and in particular the software industry have been heavily impacted

125. Bessen, Ford, and Meurer use industry codes (SIC) and estimate that 22 percent of NPE cases involved a defendant in the electronics industry, 15 percent in machinery and computer equipment, 14 percent in software, and 9 percent in communications between 1990 and 2010. Bessen, Ford & Meurer, *supra* note 27, at 29. From surveys, Chien reports that 88 percent of IT VCs received demands of their portfolios as compared to biotechnology/pharmaceutical/medical device VCs of whom only 13 percent received demands. Chien, *supra* note 93, at 11.

by the rise of PAEs:[126] since 2005, the majority of PAE suits have come from high-tech industry and about 42 percent of the litigated patents by PAEs come from the ICT industry.[127]

PAEs can take advantage of the software industry's characteristics: broad patents and patent abundance. First, patents in the ICT industry and particularly in the software industry tend to be broad because software patents use functionality language (what something does) instead of descriptive language (what it is).[128] A broad patent leads "to a lack of understanding of patent claims and, therefore, what constitutes infringement."[129] In some instance, patents could even overlap.

Second, the abundance of patent increases the costs and decreases the benefits of patent searches for innovators. This abundance leads to patent thickets,[130] which complicates identifying the relevant patents.[131] Figure 2 shows on the left axis the number of newly granted patents for all USPTO categories and on the right axis the number of newly granted software patents.[132] This figure shows that the number of software patents has increased at a faster rate than the total number of patents.

126. "As many as 55% of all patent defendants and 82% of PAE ("patent troll") defendants have been sued on the basis of a software patent." Colleen Chien & Aashish Karkhanis, *Software Patents & Functional Claiming*, Presentation to the 2/12/13 Software PTO Roundtable at SLS (2013) http://www.uspto.gov/patents/init_events/software_ak_cc_sw.pdf (last visited Jan. 23, 2015).

127. Patent Freedom, an organization that gathers data on NPE activities, reports in *Exposure by Industry* that in each year from 2005 to 2012, over 51 percent of NPE suits are from high-tech industry. Aggregating the computer hardware, software, services, media and telecom, and semi-conductors show that ICT accounted for 42 percent of litigated patents by NPEs. https://www.patentfreedom.com/about-npes/industry/ (last visited Jan. 19, 2015).

128. Executive Office of the President, *supra* note 89, at 8.

129. The GAO study, *supra* note 22, at 28–30.

130. Timo Fischer & Philipp Ringler, *The Coincidence of Patent Thickets – A Comparative Analysis*, TECHNOVATION, December 2014, at Fig. 3 and Table 1.

131. "[T]he sheer volume of patents makes searching for relevant patents before developing new products particularly difficult, especially for products that combine many patented technologies." The GAO study, *supra* note 22, at 30–31.

132. Software patents include patents granted by USPTO under 14 different classifications according to the methodology provided by Stuart J.H. Graham & David C. Mowery, *The Use of Intellectual Property in Software: Implications for Open Innovation*, in OPEN INNOVATION: RESEARCHING A NEW PARADIGM 184 (Henry Chesbrough et al., eds., 2006): 324 (Electricity: Measuring and Testing), 345 (Computer Graphics Processing and Selective Visual Display Systems), 369 (Dynamic Information Storage or Retrieval), 700 (Data Processing: Generic Control Systems or Specific Applications), 701 (Data Processing: Vehicles, Navigation, and Relative Location), 703 (Data Processing: Structural Design, Modeling, Simulation, and Emulation), 707 (Data Processing: Database and File Management or Data Structures), 709 (Electrical Computers and Digital Processing Systems: Multicomputer Data Transferring), 704 (Data Processing: Speech Signal Processing, Linguistics, Language Translation, and Audio Compression/Decompression), 710 (Electrical Computers and Digital Data Processing Systems:

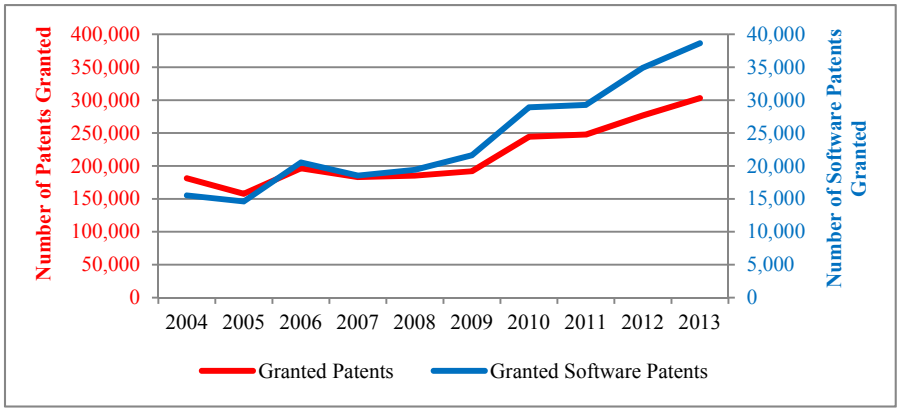

Figure 2: Patents Granted for Software and All Category Patents between 2004 and 2013.
(Source: USPTO)

VCs invest in this patent ecosystem of broad, unclear, and abundant patents. Not only patents lose value as an asset, they also lose their value as a signal: VCs will struggle more and more to assess patent value and innovation potential in the software industry. VCs might wish to perform patent searches to assure that the companies in which they invest do not repeat patented innovation and do not infringe on existing invention. However, patent searches are expensive and having to perform searches nullifies some of the patent signaling value because its value can no longer be readily assessed at no cost.

VCs might request that innovators perform searches before investing but innovators have little incentive to perform patent searches before innovating. If an innovator encounters a relevant patent, during their search, on which they may infringe, then, during litigation, this knowledge may support a willful infringement theory and lead to higher damages.[133] Even if an innovator performs a search, she may struggle to find the patent owner because the PTO does not register transfers. This is also true if PAEs hold these patents because, by definition, PAEs purchased their portfolio from innovators.[134]

Input/Output), 711 (Electrical Computers and Digital Processing Systems: Memory), 713 (Electrical Computers and Digital Processing Systems: Support), 715 (Data Processing: Presentation Processing of Document, Operator Interface Processing, and Screen Saver Display Processing), and 717 (Data Processing: Software Development, Installation, and Management).

133. *Id.*

134. *Id.*

PAEs that file nuisance suits or leverage their portfolio[135] can thrive in this software patent ecosystem because an alleged infringer is less likely to take a risk and challenge patents whose identities and boundaries are uncertain.

In effect, software innovators are caught in a vicious circle: broad software patents lead to patent thickets; patent thickets lead to less pre-invention patent searches; fewer searches increases infringement likelihood. PAEs feed into this equation: they encourage patenting and broad software patent; and they increase search cost for patent owners. VCs also feed into this equation: They encourage patenting and selling these patents for scrap.

For VCs, patents should become more of a shield against suits than a proof of innovativeness or even an asset to sell in case of failure. The correlation and possibly the causation between patent lawsuits, PAE activities (observed in Figure 1) and patenting activities (observed in Figure 2) seems to point out that: with more patents comes more opportunity to file lawsuits; as PAEs accumulate more patents over the years, they have more opportunities to file lawsuits; and as they become more active, they create a higher cost on the system. The relationship between PAEs and VCs lies through the patents they respectively purchase and sell, and through the companies they respectively sue and finance. The next section attempts to answer how VCs have reacted to PAEs activities.

IV. The Impact of Patent Assertion Entities on Venture Capital Funds

VCs and PAEs are repeat players targeting the same type of companies. VCs traditionally invest in very small companies and PAEs target small as much as large companies, if not more. One study reports that "companies with less than $10M of annual revenue represented at least 55% of unique PAE defendants, bringing 26% of PAE defenses."[136]

135. As discussed previously, PAEs use three essential business models: litigation for large jury award; leveraging high litigation costs for quick and low-value settlement; large portfolio leveraging to induce licenses. Lemley, et al., *supra* note 87, at 2126.

136. Chien, *supra* note 112, at 471; Morton et al., *supra* note 121, found that in 2013 defendants earning less than $10 million in revenues constituted 55 percent of unique defendants and 35 percent of total defendants. *Id*. at Figure 3. In 2015, Feldman et al., *supra* note 111, reported that in their sample of 102 companies, 71 percent of companies that received request had over $100 million in revenues. *Id.* at 18; Chien, *supra* note 93, reports that from a survey of 307 venture capital or investors and startups, 35 had received demands and 75 percent of the companies reported revenue under $10 million. *Id*. at 10. NPEs do not spare small companies nor wait for them to become large in order to exercise pressure.

Unsurprisingly, a survey of 114 VC showed that "75% responded that NPEs had made demands of their portfolio."[137]

PAEs may target VC backed startups. By definition, VC backed companies receive funds; hence, PAEs know that their demand can be honored. PAEs can also strategically time their demand for further gains.[138] Some startups' funding events (e.g., obtaining seed money, doing later stage rounds of financing, or going through an IPO) receive publicity.[139] Because litigations can impact their valuation,[140] fund seeking companies will yield to PAE demands more easily — even if they are unfunded.

A. Empirical Evidence

According to the previous argument, PAEs should impact VC activities. In this section, I test the relationship between PAE activities, patenting activities, and VC activities at a macro level. I collected data on: the number of patents granted annually sorted by category from the USPTO;[141] patent suits from the yearly United States Courts statistics;[142] PAE activities from Patent Freedom;[143] and venture capital funding from the Dow Jones database.[144] Some of this data was used to graph Figure 1 and Figure 2. The data covers the period from 2004 to 2013.

I test the following relationship:

$$VC\ Activity = \alpha + \beta Legal\ Activity + \gamma Patenting\ Activity + \delta Economic\ Shocks$$

VC activities are represented by three variables: the number of software companies who receive funds; the total VC-funds invested in

137. Chien, *supra* note 112, at 471.

138. Morton et al., *supra* note 121, at 474–75.

139. Graham et al., *supra* note 20, at 1320.

140. Bessen, Ford, & Meurer, *supra* note 27, estimate that NPEs have led to a trillion dollars of lost wealth from NPEs suing public traded companies.

141. *Patent Counts By Class By Year January 1977—December 2014,* U.S. PATENT & TRADEMARK OFFICE, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cbcby.htm (last visited May 28, 2015).

142. *Annual Report of the Director: Judicial Business of the United States Courts,* U.S. COURTS, http://www.uscourts.gov/statistics-reports (last visited May 28, 2015).

143. RPX CORPORATION, https://www.patentfreedom.com/about-npes/litigations/ (last visited May 28, 2015).

144. VENTURESOURCE DOW JONES, https://www.venturesource.com (last visited May 28, 2015). The dataset contained 8,777 companies; after removing companies that did not have an industry affiliation, and did not have an amount funded, the dataset yield 15,800 transactions — as some companies received more than one round of funding.

software companies; and the average VC-funds invested in software companies.

Legal activities are represented by two variables: number of patent lawsuits; and the number of NPE lawsuits. Patenting activity is represented by the number of patents granted.

Since the period covers the financial crisis, financial shocks are likely. To control for these economic shocks, the estimation will include same variables for non-software companies. The underlying assumption is that software and non-software companies were impacted in the same way by economic shocks.

Since I would like to test whether PAE activities impacted VC funding, I must address the following two issues. First, the discussion above highlighted that PAE activities, patenting, and VC funding show signs of simultaneity as well as feedback loops. To address these potential endogeneity problems, the relationships are tested through fixed effect estimations, which focus on the impact of the change in the independent variables onto the change in the dependent variable.[145] Second, I test the impact of the lagged legal activity and the lagged patenting activity because I hypothesize that VC activities are impacted by legal and patenting activities after these activities are observed. Thus, I hypothesis that: in year one, VCs observe the level of legal and patenting activity and fundraise;[146] and in year two, they invest these funds.

The reason for using one-year lag for patenting activity is twofold. First, VC funds often base their funding upon patent applications and not necessary on patents granted because USPTO takes on average three years to grant patents at which point startups already need and receive funding. Looking at patent granted more than a year prior to funding would arguably not reflect the actual VC decisions. Therefore, having older granted patents should not improve the results.[147] Second, econometrically, adding more lagged software is problematic because of the sample size; it decreases the

145. Fixed effect estimations focus on the change in a variable or more precisely on how a variable differs from its average value. Using the first difference provides a similar result but since only eight years of data are available, fixed effect avoids losing a variable. To avoid complicating the text unnecessarily, I write, for instance, that PAE activities impact VC activities whereas I am actually testing whether deviating from the mean PAE activity impacts deviating from the mean VC activity. As such, α is not computed because it is the average activity.

146. VC funds invest their money after they raised the whole fund, which may take up to a year. One study reports that the investment duration period, time between the first investment and the last investment, lasts between one to two years. Douglas J. Cumming, *The Determinants of Venture Capital Portfolio Size: Empirical Evidence*, 79 J. BUS. 1083 (2006).

147. Assuming that VCs base their funding decisions upon older patent portfolio, patent lawsuits may be. In other words, the number of patents granted beyond the previous year may impact the number of software companies receiving financing.

accuracy of the results. For completeness, I attempted to add more lag years for patents but it did not improve the results and the results did not lead to statistically significant effects.

When the VC activity is measured by the number of software companies who receive funds, I expect this number to decrease as more lawsuits are filed and more PAEs are active because VC-backed software companies are prime targets and become less attractive as investments as compared to other opportunities that are not targeted by PAEs. If VC funds are not deterred from investing, litigation activities may also increase the number of companies in which VC funds are invested because they want to diversify their risk and invest in more companies in case a lawsuit destroys their investment.

When the VC activity is measured by the total VC-funds invested in software companies, I expect this number to either increase or decrease. It may decrease if VC funds are deterred from investing in these companies because of the fear of losing their investments. It may increase if they are not deterred because in spite of this "innovation tax" VCs still profit from their investment but must pay part of the profits to this innovation tax.

When the VC activity is measured by the average VC-funds invested in software companies, I expect this number to either increase or decrease for the same reasons. The results of these fixed effect estimates are presented in Table 1.

In the first specification, the number of patent lawsuits in year one has a positive and statistically significant effect at the 10 percent level on the number of software companies in year two. The number of patents granted in year one does not have a statistically significant effect on the number of software companies in year two.

In the fourth specification, PAE filings in year one do not have a statistically significant effect on the number of software companies in year two. The impact of patents granted in year one does not have a statistically significant effect.

In the second specification, patent lawsuits in year one have a positive and statistically significant effect on the total funds software companies receive in year two. The number of software patents granted in year one has a negative and statistically significant effect the VC-funds software companies receive in year two.

In the fifth specification, patent lawsuits and PAE filings in year one has a positive and statistically significant effect on total funds software companies receive in year two. The number of software patents granted in year one has a negative but not statistically significant effect on the average funds software companies receive in year two.

	Number of VC-backed software companies	Total VC amount invested in software companies	Average VC investment in software companies	Number of VC backed software companies	Total VC amount invested in software companies	Average VC investment in software companies
Lagged patent lawsuits	0.14*	1.07**	0.0005			
Lagged PAEs lawsuits				0.20	1.87*	0.003*
Lagged software patent granted	-0.01	-0.202**	-0.00006	.0008	-0.12	-0.002**
Number of VC-backed non-software companies	0.25*			0.08		
Total VC amount invested in non-software companies		0.42**			0.25	
Average VC investment in non-software companies			0.27			0.47
Number of Observations	*8*	*8*	*8*	*8*	*8*	*8*
R^2	*0.94*	*0.95*	*0.21*	*0.90*	*0.95*	*0.52*

* the coefficient is significant at the 10 percent level

** the coefficient is significant at the 5 percent level

Table 1: Fixed Effects Regressions of the Macro-Level Impact of PAE Activities

In the third specification, patent litigation in year one does not have a statistically significant effect on the average amount received by company in year two. In the sixth specification, PAE activities in year one have a positive and statistically significant effect on the average amount received by company in year two at the 10 percent level. In these two specifications, the explanatory power of the fixed effects estimates is much lower than under other specifications.

In general, lawsuits and PAE have impacted VC activities. First, as expected, PAEs have a greater impact than lawsuits in general when comparing specifications 1 and 4, 2 and 5, and 3 and 6. While the coefficients of these legal activities are consistent, they do not always produce statistically significant effects. PAE activities impacted the total and average amount invested in software companies in a statistically significant way whereas lawsuits impacted the number of software

companies that received VC funds and the total amount VC funds invested in a statistically significant way.

Second, these results are probative of some correlation but not causation. PAE activities spur VC to invest more into software companies and this can be interpreted in two ways: On the one hand, VCs end up paying part of the rent raised by PAE and much like a tax, these rent is passed on to all market participants including investors like VCs; on the other hand, VCs may invest more into software companies because now if the companies fail, VCs can sell the patents to VC funds.

However, I would argue that this second explanation does not hold because the number of software patent granted has a negative effect on the total and average amount received by VC-backed software companies (which is statistically significant in specification 2 and 6). In other words, since granted software allows companies to protect themselves against demand, these companies require fewer funds. This overall, supports the hypothesis that VCs infuse funds to pay for PAE demands.[148]

In other words, VC funds seem to finance the litigious activities of their investments. The extra funds invested might also be later transferred to PAEs. Not only do VC funds indirectly pay a part of the PAE burden, they act like an insurance company by spreading the risk of PAE activities across all their investments and increasing the pool of companies in which they invest.

The data provides some level of detail about who receive the VC funds: the funds can be divided according to the timing to the investment or investment rounds: seed round, first round, second round, and later round. This nomenclature parallels the development stages during which the company fundraises. After dividing the data according to the investment stage and focusing on PAE activities, the relationship between the variables are further investigated. Table 2 summarizes the results of these investigations.

The seed round results show that PAE activities in year one do not have a statistically significant effect on VC behavior in year two at the seed round. VC funds may not be reacting to PAE activities at the seed round because PAE do not focus on seed companies. Seed software startups receive on average $630,000 (and non-software seed startups receive $780,000) as compared to companies in the first round who receive on average $4 million (and $5.5 million respectively), in the second round who receive $6.2 million (and $7.9 million respectively), in the later stages

148. VC funds invest fewer funds because patents can be used as shield against litigation and hence patent protection decreases the VC investment's exposure to suits whereas if patents were valuable assets, as more patents are granted, VC should invest more.

who receive $8.5 million (and $11.5 million respectively). Thus, the relatively small amount that seed startups receive may not attract PAEs and explains why their activity does not have a statistically significant effect on VC funding activities.

The first round results show that PAE activities only have a positive and statistically significant effect on the total amount invested by VC into software companies. Taking all three results together seems to imply that overall VCs have invested more money because of PAE activities but the increase per company is only marginal. From year to year, the average amount software companies receive at the seed stage has oscillated around the $4 million without much deviation.

The second round results show that PAE activities in year one had a positive and statistically significant effect on the change in the total amount invested by VC into software companies in year two and on the total amount invested by VC into software companies in year two; but, it did not have a statistically significant effect on the average amount invested by VC into software companies in year two.

These results seem to imply that VCs have increased the amount they invest overall in companies at the second round of financing but also they have invested in more companies at this investment round. These results support that VC funds seem to diversify their risk while paying part of the innovation tax.

The later round results show that the change in PAE activities in year one had a positive and statistically significant effect on all three dependent variables in year two. These correlations support the assertion that VC funds observed PAE activities and reacted in response to their increased activities by increasing the amount invested overall and on average as well as spreading the funds invested to more companies.

Investment Round	Seed Round			First Round			Second Round			Later Rounds		
	Number of VC-backed software companies	Total VC amount invested in software companies	Average VC investment in software companies	Number of VC backed software companies	Total VC amount invested in software companies	Average VC investment in software companies	Number of VC-backed software companies	Total VC amount invested in software companies	Average VC investment in software companies	Number of VC-backed software companies	Total VC amount invested in software companies	Average VC investment in software companies
Lagged PAEs lawsuits	0.025	0.03	0.0002	0.05	0.50**	0.001	0.07**	0.58*	0.002	0.04**	0.69**	0.005**
Lagged software patent granted	-0.002	-0.002	0.000005	0.007	0.007	-0.0001	0.001	-0.003*	-0.00005	-0.003**	-0.11**	-0.0001
Number of VC-backed non-software companies	0.54			0.03			-0.05			0.22**		
Total VC amount invested in non-software companies		0.61			0.05			0.02			0.35**	
Average VC investment in non-software companies			1.26*			-0.25			0.56			0.046**
Number of Observations	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*
R^2	*0.91*	*0.89*	*0.58*	*0.86*	*0.93*	*0.46*	*0.84*	*0.76*	*0.37*	*0.99*	*0.99*	*0.88*

* the coefficient is significant at the 10% level
** the coefficient is significant at the 5% level

Table 2: Fixed Effects Regressions of the Macro-Level Impact of PAE Activities by Investment Round

VC activities have been most affected by PAE activities in the second and later round the most. First, from a cost benefit analysis standpoint, PAEs may focus their activities where they may profit the most. PAEs may have targeted companies that are in later rounds of fundraising because these companies receive more funds and can afford to pay demands. These companies also have more (financial backing) to lose; hence, they may be more willing to settle. If PAEs had targeted seed and first stage startups who cannot defend themselves or do not know how, the effect has not been statistically significant at the macro level. Anecdotal evidence discussed above shows that PAEs have made demands from all companies; hence, PAEs may have had a disparate effect.

Second and late stage startups are older startups, which are more likely to have been granted a patent. Thus, they are more likely to bse able to defend themselves against demands. VC funds could have perceived these type of companies as safer investments and decide to invest more into these later stage ventures in year two once they observe more PAE activities in year one.

Some VCs specialize in rounds and only invest in seed or late stage startups whereas others invest in a balanced portfolio. Since I cannot control for the origin of the funding, it is impossible to determine whether PAEs may have led to a shift in the behavior for VCs with a balance portfolio.[149]

Over the period, VC funds have invested more in later stage startups overall and on average (a 53 percent increase in the average amount received by later stage software companies and 16 percent increase for non-software companies). In comparison, between 2005 and 2012, seed startups received fewer funds on average (a 7 percent decrease in the average amount received by software startups and 24 percent for non-software startups).

This increase may also be due to the financial crisis. The non-software VC investment variables all have a statistically significant effect on the dependent variables for the late stage estimations. More mature companies may have received more funds during the period because they were viewed as more likely to survive.

Once more, VC funds do not seem to invest more because PAEs purchase patents: the number of granted patents by the USPTO has a negative effect on VCs investment when statistically significant. This

149. Round specialized VCs may no change their behavior without important switching cost linked to the partnership agreement when the VC was set up.

supports the notion that VC funds have valorized patents as a mean to protect against PAE activities.

However, these estimations have limitations. I can only use eight years of macro-level data. Data on individual companies and the PAE demands they receive may help further answer these questions particularly because numerous demands may not take the form of a suit. As such, a micro-level investigation may provide a better understanding of VC behavior in the face of PAE demands.

Even with these limitations, these estimations support the notion that VC funds may have impacted their financing behavior because of PAE activities. Further investigations of these issues may be required to draw a more accurate conclusion about the actual micro level impact.

B. What can VCs do?

PAEs are active in the software and tech industry and VCs invest in these industries.[150] As repeat players, VCs need be aware of PAEs and adjust their business model accordingly[151] because small companies and startups hardly benefit from PAEs through patent sales.[152] The VC adjustments come at three stages: preinvestment, during investment, and post-investment.

Preinvestment VCs may wish to stop valorizing patent as signal. This approach feeds into the PAE problem. Since innovators who patent are more likely to receive funds, this added incentive leads to more patents, which may later be sold to PAEs. More patents also increase the likelihood of patent thickets, where PAEs thrive.

VCs need to realign their cultural approach to patents and possibly more in line with startup innovators. "While most surveyed VCs were positive about patents, startup survey respondents tended to express more anti-patent sentiments."[153] VCs need not rely on patents for investing because they can use other metrics or tools. In the software industry, VCs have used software downloads, network size, and other performance measures to invest.[154] VCs should eliminate their reliance on patents

150. From 66 VC funds, 88 percent responded that PAEs made demands of companies in their portfolios. Chien, *supra* note 112, at 471–72.

151. Some market participants have expressed certainties about PAE demands showing that companies and VCs are aware of their presence. Chien, *supra* note 112, at Table 1.

152. Larger companies benefit from selling their patents to PAE as "50% of PAE patents come from companies with under $200M in annual revenue." Chien, *supra* note 112, at 469.

153. Chien, *supra* note 93, at 21–22.

154. *See* Mario Schaarschmidt & Harold von Kortzfleisch, *Examining Investment Strategies of Venture Capitalists in Open Source Software*, 11 INT'L J. INNOVATION AND TECH.

altogether. The information gained through using patents is only marginal from the information a VC could gain through a nondisclosure agreement with a fund-seeking venture. Furthermore, they may pass by socially and privately efficient innovation that may not be patentable.

Pre-investment, VCs should create an environment where PAE demands should not become taboo. A rational VC expects PAE demands and accounts for them *ex-ante*. By penalizing fund-seeking companies if they receive PAE demands, VCs encourage companies to hide these demand, which lead to further information asymmetries and also companies to yield to PAE demands to hide them. In other words, VCs indirectly incentivize their companies to yield to demands. Without precise information, VCs will spread the cost of PAEs over its entire portfolio and act as insurance companies for their portfolio innovative startups.[155] This phenomenon spreads the PAE innovation tax beyond the concerned company and industry.

Once they have invested, VCs can help their startups to anticipate PAE demands. First, VCs can encourage their portfolio companies to exercise more caution to perform patent searches at the onset. VC backed companies already perform more patent searches than the general population of companies.[156] In the IT industry, VCs need to double their efforts: even though PAEs are more active in ICT, IT innovators perform fewer patent searches than other industries;[157] and VC-backed companies only perform marginally more patent searches than non-VC backed companies.[158]

MANAGEMENT 1 (2014). The authors discuss how VCs have invested in Open Source Software. *Id*. They discuss how by definition those VCs do not rely on intellectual property to profit but instead of other business model (e.g., sale of complementary services) and have relied on other performance indicators and methods to select ventures. *Id*.

155. In equilibrium, since VCs expect a certain level of PAE demands, they have already adjusted on all their offers to all their ventures. Because these costs remain inaccurate without disclosure between entrepreneurs and VCs, the venture capitals will on average overestimate the demand than underestimate. Thus, this PAE tax affects venture more than necessary because of these information asymmetries. As a tax, PAEs deter investments in seemingly lower-innovative-potential ventures because high-innovative-potential ventures remain attractive investments.

156. "A substantial share of the respondents to this question reported regularly doing patent searches. . . . Among the venture-backed sample, searching was substantially more common." Graham et al., *supra* note 20, at 1321.

157. Graham et al., *supra* note 20, at 1321. The authors found that nine in ten biotechnology and medical devices companies perform patent searches whereas only six in ten IT companies and three in ten software companies amongst VC backed companies. *Id*.

158. "[S]lightly less than one-quarter of software companies reported doing regular patent searches . . . [and] nearly three in ten venture-backed software startups." *Id*. *See* GAO Study, *supra* note 22, at 30 (anecdotally comparing the search cost technology industry and pharmaceutical industry).

VCs need to further encourage patent searches as best practices; but, VCs should also request these patent searches to be performed as soon as possible.[159] Patent searches have a real cost, which will partially be passed on to innovation users and will decrease the overall innovation value. However, search costs avoid larger litigation costs later. Furthermore, patent searches have positive externalities because companies do not inefficiently repeat existing research: If an innovation exists, the startup can try to obtain a license. These best practices, once implemented, benefit startups now and in the future.[160]

Aside from avoiding demands, VCs can play a role in countervailing PAE unreasonable demands. As an industry repeat player, VCs know the reputation of PAEs better than new innovators; hence, they can mentor innovators to deal with these demands.[161]

VCs value patents as a shield against demands. Individual rationality dictates that VCs push for patenting instead of trade secret because trade secrets do not protect them against attacks.[162] However, having a software patent does not protect against PAE demands because the PAE-offensive and the startup-defensive patents still need to be compared, contrasted, and litigated in court. PAEs' second and third business model gamble on startups being cash-strapped and thus challenge patents in court — regardless of the claim validity.

Post-investment, VCs should, however, avoid selling their portfolio companies' patents to PAEs. The majority of startups, particularly software startups, do not have patents; if they do, they only sell them

159. Graham et al., *supra* note 20, at 1322-23. The authors discuss the timing of the patent search and argue that companies "put off costly searching until they are more certain of the economic value of a technology." *Id*. A startup may need to perform some research before they can identify the problems needing solving; hence, a patent search many be impossible until later in the innovation process. *Id*.

160. Annalisa Croce, José Martí & Samuele Murtinu, *The Impact of Venture Capital on the Productivity Growth of European Entrepreneurial Firms: 'Screening' or 'Value added' Effect?*, 28 J. BUS. VENTURING 489 (2013) empirically test and find that VC-backed companies have higher level of productivity than comparable non-VC backed companies once VC invest and that these VC investments have a long term effect on the company's productivity: the VC exit has no negative impact on labor, capital, and total factor productivity. *Id*. They conclude that VCs have an imprinting effect (performance persistence after the exit) because VCs provide value-adding services like coaching and mentoring. *Id*.

161. Chien describes in Appendix C a number of patent defense service providers and offerings and as repeat players, VCs are better placed to encourage the user of these services. Chien, *supra* note 93, at 52 app. c.

162. Patents also provide some monopoly power for their portfolio companies but these startups can find it too costly to enforce their own patents.

during transition or distressful times.[163] This decision to refuse to sell to PAEs is socially and individually rational: in the future, their portfolio companies are likely to receive demand from PAEs. And because VCs operate in a given industry, the patents they sell to PAEs can come back and haunt them.

VCs can benefit from keeping the patents of their failed companies to pass on to future startups, or putting them into a patent pool on behalf of their portfolio companies, or selling them to practicing entities. For instance, Google has recently attempted to purchase the patents of distressed companies and innovators to circumvent them selling to PAEs and reappearing as a threat later.[164]

V. Conclusion

PAEs' demands do not create the same impact on larger companies as they do on smaller ones.[165] These demands unsettle the operation of small companies, whose responses vary from product changes to fighting the issues in court.[166] VC funds operate within the realm of these small companies. They have a chance to diminish the impact of PAEs.

Even though a company's profit potential is hard to assess *ex-ante*, investors must stop putting such an emphasis on patents in their decision-making. Such emphasis becomes detrimental to innovation because innovators are over-incentivized to invest in patents instead of investing in innovations.

These issues are exacerbated in the software industry. VC funds and PAEs have constant run-ins. VCs pressure their portfolio companies to patent, which feeds even further into the PAE problem: More patenting leads to more patent thickets and more patenting opens the door to more patents available for sale to PAEs if the startup fails. Therefore, VCs indirectly put their future investment at a competitive disadvantage.

163. Chien, *supra* note 93, at 479–80. Note that selling should be distinguished from monetizing via licensing here because a previous OECD research found that smaller and larger companies had a higher propensity to license than medium size companies as measured by employees. Zuniga, *supra* note 94, at 13 tbl.2. However, age of the companies did not seem to play an important factor. *Id.* at 15 tbl.6.

164. Allen Lo, *Announcing the Patent Purchase Promotion*, GOOGLE PUB. POL'Y BLOG (Apr. 27, 2015), http://googlepublicpolicy.blogspot.com.es/2015/04/announcing-patent-purchase-promotion.html.

165. Chien explains that "The smaller the company, the less able it was to absorb the impact of a lawsuit without a significant impact: the smallest companies reported the highest rate, while companies over $100M in revenue reported no impact from troll suits, even though they were sued at a much higher frequency than small companies in the sample." Chien, *supra* note 112, at 475.

166. Chien, *supra* note 112, at 473 tbl.1.

The software industry lends itself to the proliferation of PAEs. Their proliferation makes assessing the value of innovations even more difficult. As a result, VC fund activities have been in part affected by PAE activities and VCs are paying for the activities of PAEs. In the future, VCs should aim to decrease the chances of having to respond to PAEs' demands.