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Patent Trolls: Evidence from Targeted Firms

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Abstract. We provide the first large-sample evidence on the behavior and impact of nonpracticing entities (NPEs) in the intellectual property space. We find that, on average, NPEs appear to behave as opportunistic "patent trolls." NPEs sue cash-rich firms and target cash in business segments unrelated to alleged infringement at essentially the same frequency as they target cash in segments related to alleged infringement. By contrast, cash is neither a key driver of intellectual property lawsuits by practicing entities (e.g., IBM and Intel) nor of any other type of litigation against firms. We find further suggestive evidence of NPE opportunism: targeting of firms that have reduced ability to defend themselves, repeated assertions of lower-quality patents, increased assertion activity nearing patent expiration, and forum shopping. We find, moreover, that NPE litigation has a real negative impact on innovation at targeted firms: firms substantially reduce their innovative activity after settling with NPEs (or losing to them in court). Meanwhile, we neither find any markers of significant NPE pass-through to end innovators, nor of a positive impact of NPEs on innovation in the industries in which they are most prevalent.

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Clearly defined property rights are a hallmark of well-functioning markets. In the case of intellectual property (IP), however, property rights are complex to define as, unlike ownership of physical assets, the space of ideas is difficult to delineate. The United States and many other countries protect inventors' IP through *patents*, property rights granting inventions' owners sole rights of commercialization or exclusion—the right to block the use or sale of equivalent inventions by others—for a period of time. In the United States, the legal system is the arbiter of patent infringement; hence, legal action (or the threat of legal action) is the main lever by which patent holders challenge alleged infringers.

A new organizational form, the *nonpracticing entity* (hereafter, *NPE*), has recently emerged as a major driver of patent litigation. NPEs amass patents not for the sake of producing commercial products, but to claim license fees and/or litigate against infringement. The rise of NPEs has sparked a debate regarding NPEs' value and impact on innovation: Proponents argue that NPEs serve a key financial intermediary role, policing infringement by well-funded firms that could otherwise infringe upon small inventors' IP without consequence. Opponents argue that NPEs simply raise the costs of innovation by exploiting the fact that the costs of the legal process, together with the risks that imperfect courts may rule in NPEs' favor even if no infringement has actually occurred (or if the asserted patents would not survive a validity test), mean that the credible threat of a legal process can yield rents from producing, innovative firms.[1] In part reflecting the debate on NPEs, in the last few years there have been more than a dozen bills introduced in congress proposing to regulate the licensing and assertion of patents.[2]

In this paper, we provide the first large-sample evidence on precisely which corporations NPEs target in litigation, when NPE litigation occurs, and how NPE litigation impacts targeted firms' innovative activity.[3]

We develop a parsimonious model of an innovative economy in which a large firm must decide whether to innovate and—conditional on innovating—must also decide whether to reduce the costs of innovation by infringing upon a small inventor's IP. NPEs help small inventors litigate in response to infringement by the

large firm but can also bring nuisance lawsuits when no infringement has occurred.[4] The theory illustrates that the key question for assessing NPEs' welfare impact concerns lawsuit targeting behavior: do NPEs, on average, police against true infringement, or do they primarily behave opportunistically, bringing lawsuits irrespective of whether infringement has occurred? It is impossible for us to directly measure whether targeted firms were actually infringing, especially given that most NPE lawsuits are settled before even early stages of pretrial discovery occur. However, we can—and do—look to see whether the empirical evidence suggests opportunistic behavior on the part of NPEs.

We work with two independent sources of data on NPE litigation activity: proprietary data from RPX Corporation and hand-coded, finely classified public data assembled by Cotropia et al. (2014). Together, these data sources cover the complete universe of NPE lawsuits from 2005 to 2015; we combine this data on NPE lawsuits with external data on publicly traded firms.

Using our linked data, we show that NPEs appear to behave opportunistically: they target firms that are flush with cash (controlling for all other characteristics) and firms that have had recent, positive cash shocks. NPEs even target firms that earn their profits from business segments having nothing to do with the allegedly infringing segments. Our findings suggest, for example, that an NPE would likely sue a firm regarding alleged information technology infringement even if the firm is earning all its revenue from a lumber division entirely unrelated to the information technology division and even if the information technology division is unprofitable. Indeed, a one standard-deviation increase in cash level increases the probability of being sued by an NPE by 7.40% ($t = 4.25$)—a twofold increase—and cash holdings in unrelated business segments are almost as predictive of NPE litigation as are cash holdings in segments related to the alleged infringement.

Meanwhile, we find direct evidence that NPEs may not be policing infringement. The cash targeting we observe is mostly the behavior of large "patent aggregator" firms; small inventors' lawsuits show a different targeting pattern, in which defendants' cash holdings are not a significant factor. There is also some evidence that NPEs bring lower-quality lawsuits, as well as evidence that NPEs are actively forum shopping.

In theory, our finding that cash/profitability is a first-order determinant of NPE litigation could simply be picking up a general characteristic of IP litigation or of litigation more generally. However, our results show otherwise: *practicing entities* (*PEs*), such as IBM and Intel, do not behave in the same way as NPEs. We hand-collected the universe of patent infringement cases brought by PEs against PEs in our sample period and found that, if anything, PEs are slightly *less* likely to sue firms with high cash balances.[5] Similarly, we found that cash is not a significant determinant of other (non-IP) forms of litigation: tort, contract, securities, environmental, or labor; this comparison suggests that our results on NPE litigation behavior do not just reflect general characteristics of litigation. Rather, our findings are consistent with agent-specific motivations for NPEs in targeting firms flush with cash.

Using several different empirical measures, we also find that NPEs target firms against which they have a higher ex ante likelihood of winning. First, we show that NPEs are significantly more likely to target firms that are busy dealing with other, non-IP-related litigation. Being tied up with outside litigation is associated with a roughly 19% ($t = 2.38$) increase in the probability of being sued by an NPE. Moreover, we show that, controlling for all other characteristics, firms with smaller legal teams have a significantly higher probability of being targeted by NPEs. Additionally, echoing and amplifying findings of prior work, we find evidence that NPEs frequently forum shop and assert patents that appear to be broader, wordier, and closer to expiry than those asserted by PEs.

Finally, we examine the real impacts of NPE litigation on targeted firms' innovative activity. Using a difference-in-differences approach, we find evidence that firms losing to NPEs (either in court or through settlement) reduce their research and development investment by roughly 20% going forward relative to ex ante identical firms. Thus, our evidence suggests that NPE litigation may lead to a real decrease in innovation at targeted firms. Of course, when NPEs win lawsuits, some of the losses to the targeted firms—part of the settlement or damage awards but not the legal costs—should eventually flow back to end inventors. The best available estimates suggest, however, that only a small fraction of the damages won by NPEs are actually paid back to innovators (Bessen et al. 2011, Bessen and Meurer 2014). Moreover, we show empirical evidence consistent with the view that pass-through from NPEs has not significantly increased innovation by small inventors.

Taken as a whole, our evidence appears most consistent with the view that NPEs, on average, behave as patent trolls. NPEs chase cash and have a real negative impact on targeted firms' innovative activity. Alternative interpretations simply do not seem to explain the entire body of evidence. For instance, NPEs' empirically documented level of cash targeting—which does not appear in PE patent litigation or in other types of litigation—suggests that the scope and implementation of cash targeting we see is unique to the NPE organizational form in the IP space. Furthermore, our results on cash targeting might be consistent with the possibility that targeted firms are knowingly infringing and are stockpiling cash in anticipation of litigation; however, this alternate explanation is at odds with our finding that NPEs are especially likely to target firms

that have had cash shocks and/or are embroiled in non-IP-related lawsuits. Meanwhile, the idea that NPEs solely target firms that profitably infringe on NPEs' intellectual property is inconsistent with our finding that cash holdings in related and unrelated operating segments are almost equally predictive of suit.

The remainder of the paper is organized as follows. Section 1 provides background and a literature review. Section 2 describes our data sources. Section 3 presents our empirical results on NPE targeting. Section 4 shows evidence on the real impacts of NPE litigation behavior on innovation. Section 5 provides a discussion, and Section 6 concludes. We develop our formal model of the impact of NPEs on innovation and intellectual property litigation in Appendix A. We present supplementary tables and robustness checks in the online appendix.

1. Background

A U.S. inventor's patenting process begins with an application to the U.S. Patent and Trademark Office (USPTO), which assigns the application to a patent examiner. The examiner's job is to compare the filed patent's claims to prior art to determine whether the claimed invention is patentable, novel, and nonobvious.[6] If the examiner decides to grant the claims in an application, then the USPTO issues a patent to the applicant.[7] The patentability of a patent's claims can be challenged in administrative proceedings. Patent validity can be challenged in one of the 94 federal district courts by presenting prior art that may have been overlooked by USPTO examiners. Since 2012, it has also been possible to challenge patent validity via administrative proceeding at the Patent Trial and Appeal Board.

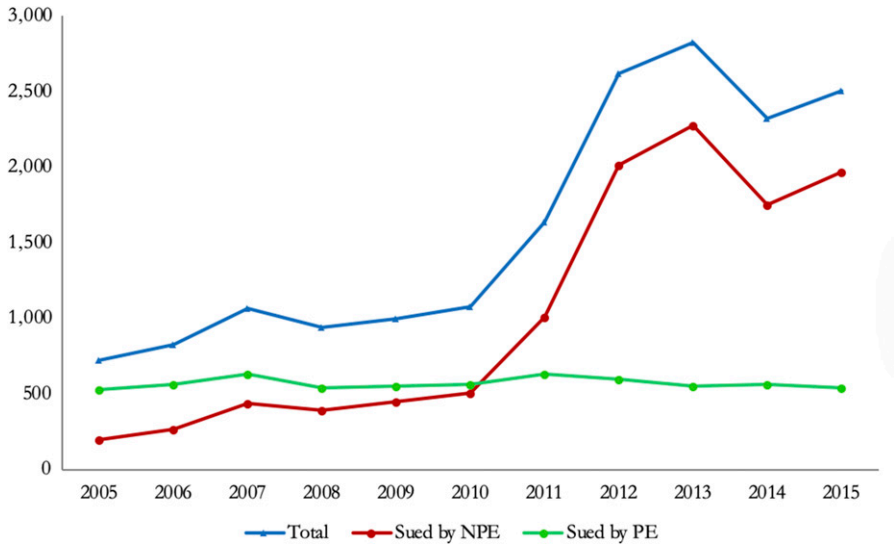
Because a patent confers the right to exclude others from "practicing" an invention, patent owners can sue anyone who uses, makes, sells, offers to sell, or imports their inventions without legal permission. If a patent infringement lawsuit is not dismissed in its initial stages, it proceeds to the *discovery* phase, in which both the accused infringer (defendant) and the patent owner (plaintiff) supply documents and depositions intended to demonstrate how the allegedly infringing product is made. If a party does not make or sell products or provide services based on the patented invention, then it is likely to have far fewer documents to disclose. Consequently, as NPEs do not produce products, the discovery phase can be far less costly for NPE plaintiffs than for defendants.

If an infringement suit is not settled or dismissed, then a court interprets the parties' claims, making determinations as to whether both the patent is valid and infringement occurred. A judge or jury who rules in favor of the patent owner can award monetary damages and/or issue an injunction to prohibit further infringement.[8]

The amount of patent-related litigation has increased threefold since 2005 (see Figure 1).[9] According to a recent U.S. Government Accountability Office (2013) report, three factors contributed to the rise in IP litigation: (1) the number of patents (especially software-related patents) with unclear scope has increased, (2) courts have been granted large monetary awards in infringement lawsuits even for ideas that make only small contributions to a product, and (3) markets place a larger valuation on patents than they did before.

The growth in large-scale NPE patent litigation is a recent development; consequently, the associated empirical literature on NPEs is limited but growing

Figure 1. Time Series of NPE, PE, and Total Patent Litigation



Notes. This figure shows the number of unique dockets in PACER (Public Access to Court Electronic Records) classified as patent cases (PACER code 830) in which at least one of the defendants is a public firm. We use RPX's classification of plaintiffs to split dockets according to whether the plaintiff is an NPE or a PE.

rapidly.[10,11] Our paper contributes to this literature by providing the first large-sample evidence about which public corporations NPEs choose to litigate, when NPEs bring litigation, and how NPE litigation impacts innovative activity at targeted firms.

Our paper is also related to literature in economics that examines innovation and patents, suggesting that the impact of patent rights on innovation is highly heterogeneous (Galasso and Schankerman 2015); in particular, patents may discourage valuable follow-on innovation (Williams 2013; see also Sakakibara and Branstetter 2001, Lerner 2009, and Williams 2015).[12] Consequently, the law and policy literature have begun to sort out potential deficiencies in the patent system more broadly (see, e.g., Lemley and Melamed 2013, Budish et al. 2015, and U.S. Patent and Trademark Office 2015) while proposing potential reforms (see Lemley and Shapiro 2006, Schwartz and Kesan 2014, and especially the work of Helmers et al. 2013, which hints at how policy lessons from the United Kingdom could be used to reduce patent trolling in the United States).

Finally, our work is also related to the literature that examines the choice between settlement and the pursuit of a court decision. Spier (2005) provides an excellent review of the economics of litigation.[13] Although we focus solely on intellectual property, our paper is also related to the well-developed literature on the effect of litigation risk on firm activities.[14]

2. Data

We obtain information on NPEs from RPX Corporation, a company that tabulates information on NPE behavior, including data on patent litigation.[15] RPX Corporation has collected data going back to 1977, capturing from Public Access to Court Electronic Records (PACER) every lawsuit filed by more than 4,000 NPEs (approximately 850 parent companies and 3,300 affiliates); the data are, thus, systematic and not based on self-reporting.[16,17] We replicate all of our analysis—and find nearly identical results in magnitude and significance—using the hand-coded, publicly available NPE activity data collected by Cotropia et al. (2014) for the years 2010 and 2012 (see Section 3.9.1 and Table B4 in the online appendix).

Demand letters and other informal patent assertions by NPEs do occur. Informal patent assertions are unreported by nature, so there is, unfortunately, no comprehensive data set of these actions. However, it is widely believed that informal patent assertions have been in decline recently and are projected to decline further. The two biggest factors driving this decline are the decreasing credibility of patent assertions (given the availability of the formal legal channel)[18] and the rise of legislation (both state and federal) to hold entities liable for unsubstantiated demand letters.[19] Furthermore, as many more NPEs are now suing (see Table 1, panel B), non-legally binding letters simply alleging infringement (and asking for money) are becoming less credible signals. The equilibrium result is that the economically large alleged IP infringements appear to be addressed through lawsuits (all of which are in our data), and this is becoming increasingly true over time.[20] We thus feel that RPX Corporation's systematic and exhaustive collection of NPE lawsuit data likely captures the economically important (and increasingly dominant) component of NPE behavior even though it does not capture patent assertions not backed by litigation (see also Feldman and Lemley 2015 for supporting survey evidence). In Table 1 (panel A), we present summary statistics on the firms included in our analysis.[21]

According to RPX Corporation, roughly 69% of NPEs' patents were acquired externally (purchased) by NPEs and their subsidiaries, whereas 19% were originally assigned to NPEs.[22,23] Panel B of Table 1 shows the time series of NPE litigation through our sample period, 2005–2015. The data clearly indicate that there has been a sharp rise in NPE lawsuits over the past decade.

In total, the data provide detailed information on 21,300 litigation actions by NPEs (i.e., in which an NPE is the plaintiff) and 19,621 litigation actions by PEs. RPX's definition of an NPE includes the following organizational forms: (1) *patent asserters*, entities that earn revenue predominantly through asserting patents; (2) *small inventors*; (3) *noncompeting entities* (NCEs), operating companies asserting patents outside their areas of products or services; and (4) *universities* (and *research institutions*). In our study, we exclude NCEs and universities, which make up less than 3% of the sample. In the last column of panel B of Table 1, as a further data check, we compare RPX's data on NPEs to that of another frequently used independent data provider, Lex Machina. A comparison of the cases in the RPX and Lex Machina data sets indicates that there is little difference between the two data sources, with the correlation between RPX and Lex Machina annual data series in the final two columns of panel B of Table 1 being 99.95%.

We focus on the cases in which the defendant firm is publicly traded as, for these defendants, we can obtain rich, detailed characteristic data for which reporting is required by the Securities and Exchange Commission (SEC). In Figure 1, we graph the number of NPE and PE case dockets in which at least one of the defendants is a public firm. By 2015, 11.25% of all publicly traded firms were sued by an NPE. This rise in IP litigation is also depicted in Figure 1, which first shows the total rise in patent litigation over our sample period (consistent with findings of Bessen and Meurer 2013) and then separates the rise into the cases brought by NPEs and the cases brought by PEs. From Figure 1, it is apparent that the rise in overall IP litigation is entirely driven by NPE

Table 1. Summary Statistics, 2005–2015

Panel A: Summary statistics on firm characteristics

	Mean	Median	Standard deviation	P05	P25	P75	P95
Total assets	13.991	0.719	108.401	0.023	0.165	3.075	32.143
Market value	3.815	0.454	16.389	0.019	0.112	1.866	15.483
B/M	2.965	0.599	66.765	0.117	0.339	1.000	3.787
Past return	0.139	0.065	0.706	−0.622	−0.191	0.325	1.077
R&D expense	0.077	0.000	0.510	0.000	0.000	0.011	0.184
Number of patents	55.62	0.000	540.80	0.000	0.000	0.000	97.00
Cash	0.579	0.040	4.272	0.001	0.010	0.167	1.776
Sued by NPE	0.086	0.000	0.280	0.000	0.000	0.000	1.000
Sued by PE	0.046	0.000	0.209	0.000	0.000	0.000	0.000

Panel B: Sample description

	RPX						Lex Machina
	NPE				PE		NPE & PE
	PAE	INV	NCE	University	Practicing entity	Total	Total
2005	381	172	11	12	1,917	2,493	2,523
2006	499	143	16	11	1,914	2,583	2,581
2007	658	173	16	11	1,831	2,689	2,775
2008	618	222	8	15	1,651	2,514	2,573
2009	633	197	12	16	1,634	2,492	2,547
2010	787	174	19	17	1,693	2,690	2,770
2011	1,520	183	16	14	1,813	3,546	3,575
2012	3,319	161	107	31	1,764	5,382	5,455
2013	3,831	230	9	71	1,873	6,014	6,114
2014	2,881	245	63	22	1,722	4,933	5,070
2015	3,613	152	3	8	1,809	5,585	5,818

Notes. Panel A of this table presents summary statistics on the firms included in the tests. Table B1 in the online appendix contains the definitions of the variables we use. *Total assets*, *market value*, *R&D expense*, and *cash* are reported in billion USD. In panel B, we tabulate number of dockets reported in the RPX database by year. RPX records information on cases in which the plaintiff is an NPE or an operating company (PE). According to RPX, an NPE is an entity that derives or plans to derive the majority of its revenue from the licensing or enforcement of patents and for which RPX has been unable to obtain verifiable evidence that the entity sells products or services that would make it vulnerable to patent counterassertion. NPEs contain the following organizational forms: (1) patent assertion entities (PAEs), entities believed to earn revenue predominantly through asserting patents; (2) individual inventors (INV); (3) noncompeting entities (NCEs), operating companies asserting patents outside their areas of products or services; and (4) universities and research institutions. In the last column of panel B, we tabulate the number of observations in a different database, Lex Machina, that provides IP litigation information.

lawsuits. PEs' patent litigation has remained constant over the sample period. We revisit and examine more systematically the differences between NPEs' and PEs' patent litigation behaviors in Section 3.2.

We obtain firm-level patent information from the database used by Kogan et al. (2017).[24] This database contains utility patents issued by the USPTO between January 1, 1926, and November 2, 2010, along with citation data on those patents.[25] We obtain information on the in-house legal counsels and law firm associations of public firms from ALM Legal Intelligence, which searches public records to find outside counsel used by companies for corporate, contract, labor, tort, and IP litigation.

To identify involvement in litigation events not related to IP, we use the Audit Analytics Litigation database, which covers the period from 2005 to 2013 and reports information on litigation for Russell 1000 firms from legal disclosures filed with the SEC. Audit Analytics collects details related to specific litigation, including the original dates of filing and locations of litigation; information on plaintiffs, defendants, and judges; and, if available, the original claim amounts and the settlement amounts.

To create our final data set, we merge firm-level litigation and patent information with firm-level stock-return and financial statement data. We use stock-return data from the Center for Research in Security Prices (CRSP) database. For each firm, we calculate its monthly market value of equity as the product of its shares outstanding multiplied by the firm's common stock price at the end of month t. For

each stock-month (i,t), we also calculate the firm's past 12-month stock returns $(i,t,t-11)$. We drop observations if a stock does not have price, return, or share outstanding information or if the stock does not have more than two month observations in a year.

We obtain firm-level accounting measures (total assets, components of book value of equity, R&D expense, cash level) from the Compustat database maintained by S&P Global. Specifically, we download all annual financial statements from the CRSP-Compustat Merged Annual Database whose fiscal years ended between 2002 and 2014 and whose total assets were not missing or 0. We calculate each firm's book value of equity following Fama and French (1993); we measure book equity as stockholder equity plus balance sheet deferred taxes (Compustat annual item TXDB if available) and investment tax credit (item ITCB if available) minus the book value of preferred stock. Depending on data availability, we use redemption (item PSTKRV), liquidation (item PSTKL), or par value (item PSTK) to represent the book value of preferred stock. The explanatory variables are defined using the financial statements with fiscal year ending one year prior to litigation-filing year. Our main variable of interest, *CashLevel*, is the amount of cash held by the firm as reported in its audited annual financial statement. We add 1 and then apply log transformations to all variables except the dummy variable *CashShock*, which is set equal to 1 if a firm's change in cash in the prior fiscal year is among the top 5% of cash changes in the firm's industry cross-section in that year. Additionally, we construct our main dependent variable—*SuedByNPE* (*SuedByPE*)—as equal to 1 if a given publicly traded firm was litigated by an NPE (PE) in a particular year and 0 otherwise. For matching litigation files to Compustat GVKEY identifiers, we use a CapitalIQ-Compustat GVKEY concordance file provided by CapitalIQ-Compustat. The final data set contains 50,965 firm-year observations and spans the years 2005 to 2015.

3. Results

3.1. Cash Targeting

We begin by examining the determinants of NPE litigation behavior. As a start, we parameterize a central concern of opponents to NPEs, namely that NPEs bring nuisance suits and that their prime driver is the ability of targeted firms to pay large damages or royalties. We use both levels of cash balances on the balance sheet (*CashLevel*) and changes in cash holdings (*CashShock*) as proxies for the potential proceeds of a suit.[26] We include several firm- and time-level control variables, such as the firm's market value, book-to-market ratio,[27] the prior year's stock market performance, and the number of recent patents issued to the firm, *R&D*, along with time and firm fixed effects. In Table 2, we report ordinary least squares (OLS) regression results of the following specification:

$$SuedByNPE = f(CashLevel, TotalAssets, MVE, B/M, R\&D, PastReturn, PatentStock, CashShock).$$

We include industry or firm fixed effects to capture unobserved industry- or firm-level time-invariant factors that are correlated with NPE targeting. Likewise, we include time fixed effects to control for variation in litigation activity specific to a given year and for any time trends in litigation propensity. We report various specifications to show the incremental value of each covariate on overall model fit. Column (5) of Table 2 represents our preferred specification, which includes firm-level characteristics (market value, book-to-market ratio, asset size, research and development expense, prior stock performance of equity), time and firm fixed effects, and our cash variables. We use a log transformation of all variables to minimize the effect of outliers.[28] We cluster our standard errors at the firm level to broadly allow for any time-series dependency in the probability of being sued over the course of the sample period.

Table 2 uncovers a strong and consistent pattern: firms with larger cash balances and firms with positive shocks to their cash holdings are more likely to be targeted by NPEs. Controlling for other determinants and for firm and time fixed effects, the *CashLevel* coefficient in column (5) is 0.0565 ($t = 4.25$), which is large and significant as is the *CashShock* coefficient 0.0167 ($t = 2.06$). To get an idea of the magnitudes, we use the coefficient estimates in the full specification in column (5). With the average firm-level cash holding of \$579 million, the 0.0565 coefficient on *CashLevel* implies that a one standard-deviation increase in cash balance increases the chances of being sued by 7.40%. Given that the unconditional probability of being sued for patent infringement is approximately 8.60%, this is nearly a twofold higher probability of being targeted (16.00% versus 8.60%). An alternate way to view the economic magnitude is looking at the interquartile change. From Table 1, we see that the interquartile change implies a more than 14 percentage point increase in the probability of being sued by an NPE—again an economically large magnitude.

In sum, Table 2 reveals the strong impact of cash on NPEs' targeting decisions. In particular, in column (4), both of these effects are estimated, including firm and time fixed effects, along with fine controls for firm size, past returns, R&D spending, and patent portfolio size. Thus, the large coefficients can be interpreted as showing that a firm is likely to be targeted by NPEs when it has an abnormally high cash level (or a shock to that cash level) relative to all other firms' cash levels (and shocks).

We have run a number of robustness checks exploring the relationship between cash and NPE litigation. First,

Table 2. Cash and Probability of Being Sued

	(1) *Sued by NPE*	(2) *Sued by NPE*	(3) *Sued by NPE*	(4) *Sued by NPE*	(5) *Sued by NPE*
Cash level	0.2073***	0.1021***	0.0994***	0.0581***	0.0565***
	(0.0117)	(0.0119)	(0.0119)	(0.0113)	(0.0133)
Total assets		–0.0161***	–0.0149***	0.0130**	0.0199**
		(0.0057)	(0.0056)	(0.0059)	(0.0084)
Market value		0.0740***	0.0720***	0.0610***	–0.0125
		(0.0075)	(0.0075)	(0.0066)	(0.0083)
B/M		–0.0045	–0.0081*	–0.0133***	–0.0150**
		(0.0048)	(0.0049)	(0.0048)	(0.0061)
Past return		–0.0063***	–0.0072***	–0.0070***	–0.0006
		(0.0021)	(0.0023)	(0.0022)	(0.0025)
R&D expense		0.1394***	0.1398***	0.1368***	0.1220**
		(0.0342)	(0.0342)	(0.0295)	(0.0483)
Number of patents		0.0139***	0.0146***	0.0149***	0.0006
		(0.0026)	(0.0026)	(0.0024)	(0.0038)
Cash shock		0.0199*	0.0163	0.0147*	0.0167**
		(0.0106)	(0.0105)	(0.0089)	(0.0081)
Firm fixed effects	No	No	No	No	Yes
Industry fixed effects	No	No	No	Yes	No
Year fixed effects	No	No	Yes	Yes	Yes
N	50,965	50,965	50,965	50,965	50,965
R^2	0.11	0.17	0.18	0.28	0.55

Notes. In this table, we use a linear probability model to estimate the probability of being sued by an NPE. The outcome variable, *Sued by NPE*, is a dummy equal to 1 if the firm was litigated by an NPE in a given year. RPX data allows us to observe the type of the NPE. We focus on cases in which the NPE is classified as a patent assertion entity (PAE) or a small inventor (INV). Table B1 in the online appendix contains the definitions of the variables we use. We use log transformation for total assets, market value, B/M, patent stock, past return, R&D expense, and cash level. The sample contains firm-year observations between 2005 and 2015. Standard errors, clustered by firm, are reported in parentheses.

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

in robustness tests reported in Section 3.9, we consider specifications identical to those of Table 2 but using logit and probit estimation as opposed to OLS. The coefficients on cash remain large and significant with the implied magnitudes even slightly larger in point estimate. Furthermore, we replace the dummy dependent variable *SuedByNPE* with its continuous counterpart *TimesSued*, measuring the number of times a given firm is sued by NPEs in any given year. We estimate the model in OLS (and Tobit) and find that *CashLevel* remains a large and significant predictor of the intensity with which firms are sued by NPEs. Next, in Table B3 in the online appendix, we test for any impact of multicollinearity on the estimates. From Table B3, we see that multicollinearity does not appear to be an issue with regard to the magnitude or significance of the estimated impact of cash on NPE suits. In particular, the coefficients on *CashLevel* and *CashShock* remain large, significant, and—importantly—stable irrespective of the addition or deletion of any given control variable. Additionally, we estimate specifications with industry (as opposed to firm) fixed effects with a number of definitions of industry. In addition, to control for an industry life-cycle explanation (e.g., an industry plateaus with respect to innovation and investment opportunities, and its technology becomes more complex and technical and potentially easier to target), we also run specifications with industry-by-year fixed effects. We find nearly identical magnitude estimates and significance on the *CashLevel* and *CashShock* coefficients (Table B3, panel B). Finally, in our main tests, we impute zero if an R&D expense is not explicitly reported in the income statement. Results reported in panel C of Table B3 show that excluding R&D expense from the specification or including a dummy variable for observations with missing R&D values does not affect our results.

3.2. Patent Litigation Behavior of PEs and Litigation Behavior Against Firms More Generally

A reasonable response to the results in Table 2 is to expect that cash targeting should be the behavior of *any* profit-maximizing litigant. It makes little sense to sue a firm—incurring potentially sizable legal costs along with the opportunity costs of foregone suits—if the target firm has no ex ante ability to pay.[29] To examine this more formally, we compare the determinants of NPE IP litigation to those of PE IP litigation and to the determinants of litigation activity more broadly. Generally, we find that NPEs are unique in the extent to which cash is a first-order determinant of targeting in litigation.

3.2.1. Patent Lawsuits Brought by PEs. NPEs do not have a monopoly on IP litigation. PEs such as Apple, General Electric, and Intel also sue each other for patent infringement. If our results were simply picking up general characteristics of IP litigation, then we might expect to see PEs behaving in much the same way as NPEs. To compare PE and NPE behavior, we collect the time series of patent infringement cases brought by PEs and compare their determinants with those brought by NPEs over our time period. From Figure 1, we see that the rise in IP litigation is driven by NPE litigation. Although NPEs have an exponential-type rise in IP litigation over the sample period, PEs' IP litigation has remained essentially constant. Thus, in an aggregate time-series sense, we do see a difference between the litigation behavior of the two groups.

Turning to a more formal analysis of the determinants of PE lawsuits, we use an identical setup to that used for NPEs in Section 3.1. We replicate the specifications used in Table 2, but this time, we use *SuedByPE* as the dependent variable.[30] The results of this analysis are in column (1) of Table 3. We see that PEs behave very differently from NPEs. Nearly all of the predictors of NPE litigation behavior have a small and insignificant impact on PE litigation behavior. Moreover, the impact of cash goes mildly in the *opposite* direction (in point estimate).[31]

Of course, PEs likely have motivations for IP litigation beyond those of NPEs (e.g., competitive responses, defensive tactics, retaliatory litigation); these differing motivations could lead PEs to utilize different litigation tactics, in terms of both intensity and target set (for example, PEs are likely to target their competitors). However, this comparison does suggest that the results on NPE litigation behavior do not simply reflect general characteristics of IP litigation over time or within the cross-section. Rather, they are consistent with agent-specific motivations for NPEs in targeting firms flush with cash.[32]

3.2.2. Other Litigation Behavior. We next move on to a more general setting, considering *all* lawsuits filed against publicly traded firms. If the cash targeting in NPE IP litigation is a general feature of litigation—as we might think—then cash targeting should show up in other litigation categories. From Audit Analytics, we collected the entire slate of material legal actions taken against publicly traded firms. Audit Analytics covers the 2005–2013 period and reports information on litigation against Russell 1000 firms, recording legal disclosures filed with the SEC.[33]

We run specifications identical to those of Table 2 for all other litigation categories. The results are shown in Table 3. From columns (2)–(6) of Table 3, we see that large amounts of cash are not positively related to non-IP litigation actions (tort, contract, securities, environment, and labor).

So what drives non-IP litigation? The results suggest that the main determinant of non-IP cases is the infraction itself (e.g., polluting a local waterway in the case of an environmental suit). Importantly, these other cases often have more concrete and provable actions taken by the defendant as opposed to IP infringement, in which the property right is itself more amorphously defined (and so infringement is more subjectively determined). The extra range of uncertainty in IP cases makes IP a potentially good candidate for opportunistic, purely profit-driven legal activity.

The sum of the evidence in Tables 2 and 3 shows that NPE IP litigation is unique in its cash-targeting nature in comparison with other forms of litigation and even within the fine space of IP litigation. In the following sections, we explore more closely the behavior of NPEs and examine whether NPE litigation behavior appears to be, on average, opportunistic.

3.3. Targeting Unrelated Profits

In this section, we examine whether NPEs go after profits *unrelated* to alleged infringement. Using finely reported business segment-level disclosures, we are able to extract and separate profits in the business segments related to the alleged infringement from those profits in unrelated segments.

As of 1976, all firms are required by statement of financial accounting standards (SFAS) 14 (financial reporting for segments of a business enterprise, 1976) and SFAS 131 (reporting desegregated information about a business enterprise, 1998) to report financial information for any industry segment that accounts for more than 10% of total annual sales. Using these segment-level filings, we extract information on industry classification, sales, and cost of goods sold for each segment of each conglomerate between 2005 and 2015. We then use the concordance between international patent classification (IPC) codes and four-digit U.S. standard industrial classifications (SICs) to identify the conglomerates' segments associated with the NPE-litigated patents.[34]

We split each NPE-targeted firm's segments into *related segments* and *unrelated segments*. A firm's related segments are those segments that could potentially use the asserted patent in regular operations; its unrelated segments are those that could not. We compute each segment group's gross profits by subtracting cost of goods sold from segment group sales.[35]

We note that not all conglomerates report segment-level information in the same format. For example, a conglomerate may report information on one segment only, or it may report cost of goods sold for only

Table 3. Is Cash Targeting a General Feature of Litigation?

	(1) *Sued by PE*	(2) *Tort*	(3) *Environment*	(4) *Securities*	(5) *Contract*	(6) *Labor*
Cash level	−0.0016	−0.0228*	−0.0078	−0.0261**	−0.0343***	−0.0004
	(0.0111)	(0.0122)	(0.0067)	(0.0125)	(0.0127)	(0.0036)
Total assets	0.0127*	−0.0158*	0.0016	0.0354***	0.0059	−0.0012
	(0.0065)	(0.0084)	(0.0028)	(0.0097)	(0.0098)	(0.0031)
Market value	0.0093	0.0158**	−0.0019	0.0280***	0.0265***	−0.002
	(0.0073)	(0.0079)	(0.0026)	(0.0087)	(0.0095)	(0.0031)
B/M	−0.0012	0.0100**	0.0004	−0.0023	0.0143***	0.0001
	(0.0042)	(0.0042)	(0.0015)	(0.0052)	(0.0048)	(0.0016)
Past return	−0.0013	−0.0022	0.0005	−0.0048*	−0.0039	−0.0008
	(0.0020)	(0.0017)	(0.0007)	(0.0027)	(0.0024)	(0.0008)
R&D expense	−0.0108	−0.1590**	−0.0019	−0.0573	−0.2343***	−0.0211
	(0.0494)	(0.0701)	(0.0158)	(0.0424)	(0.0538)	(0.0143)
Number of patents	−0.0079**	0.0056*	0.0017**	−0.0003	−0.0018	0.0001
	(0.0036)	(0.0034)	(0.0008)	(0.0028)	(0.0034)	(0.0005)
Cash shock	−0.0037	−0.0055	0.0017	0.0096	0.0221***	0.001
	(0.0070)	(0.0073)	(0.0035)	(0.0080)	(0.0082)	(0.0029)
Number of employees						0.0033
						(0.0031)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	50,965	42,209	42,209	42,209	42,209	41,213
R^2	0.42	0.31	0.23	0.25	0.24	0.24

Notes. In Column (1) of this table, we define *Sued by PE* to be equal to 1 if a firm faces IP lawsuits from practicing entities (PEs) in a given year. The PE litigation information is obtained from RPX. We obtain litigation information on other types of cases from the Audit Analytics database, which includes material federal civil litigation and class action claims disclosed to the SEC by the SEC registrants. Case disclosure comes from the firm, which is responsible for determining whether the case is material for the company. Given the severe penalties involved in not disclosing information that is already public (through PACER), a dominant strategy for a CEO is often to disclose not only material information, but also potentially nonmaterial information that could later be assessed as being within disclosure guidelines. Furthermore, because our interest lies in the public firms (which are SEC registrants by definition), Audit Analytics provides a comprehensive database for cases we are interested in. In columns (2)–(6), we utilize case classifications reported in Audit Analytics to investigate whether the relation between firm characteristics and NPE litigation differ for different case types. Specifically, in column (2), we first define the dependent variable to be 1 if the firm is involved in a case related to tort. The other categories include environment, securities, contract, and labor—as defined by PACER. Table B5 in the online appendix outlines the specific case codes used to identify these cases. We define the dependent variable to be 1 if the firm is sued in the case type specified in the column heading. We use the baseline specification used in Table 2 to facilitate comparison of coefficients across case types. Standard errors, clustered by firm, are reported in parentheses.

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

one of the segments in which it operates. Therefore, our final sample contains only conglomerates for which we have both cost and revenue data on at least one related segment and one unrelated segment.

We estimate a model to test whether the probability of being sued by an NPE is correlated with profits obtained from unrelated segments even after controlling for the profitability of related segments. In this model, we include conglomerate fixed effects to control for conglomerate-level unobserved litigation probability. We also control for industry-wide shocks to profitability by including a variable measuring the average profitability of the segment's industry.

The results of our segment-level analysis are shown in Table 4. Column (1) of Table 4 shows the basic model, and column (2) includes conglomerate fixed effects. Both columns tell the same story. Consistent with the results in Table 2, *RelatedSegmentProfitability* is a large and significant predictor of NPE targeting, but so is *UnrelatedSegmentProfitability*. In other words, NPEs seem not to care where their proceeds come from; an NPE's probability of suing a firm increases with the firm's profits even if those profits are derived from segments unrelated to the patent under litigation. In column (2) of Table 4, we see that the coefficient on *UnrelatedSegmentProfitability*, 0.0265 ($t = 1.99$), implies that, controlling for the profitability of a segment related to the patent allegedly being infringed, a one standard-deviation increase in a completely unrelated segment's profitability increases the chance of being sued by 0.58% (relative to a mean of 3.18%). This compares with an increase in probability of 0.71% for the same size increase in a related segment's profitability ($t = 2.18$). In contrast, when we run the analog of columns (1) and (2) for PE firms, we see that *UnrelatedSegmentProfitability* is not related to PE litigation activity.

In sum, the results in Table 4 provide additional, finely measured evidence that NPEs behave opportunistically by targeting cash indiscriminately: NPEs target related cash and unrelated cash at essentially the same rate.

Table 4. Probability of Being Sued: Related vs. Unrelated Cash Flows

	(1) *Sued by NPE*	(2) *Sued by NPE*	(3) *Sued by PE*
Related segment profitability	0.1457**	0.0569**	0.0388**
	(0.0623)	(0.0260)	(0.0181)
Unrelated segment profitability	0.0835***	0.0265**	0.0213
	(0.0246)	(0.0133)	(0.0135)
Industry profitability	–0.0039***	0.0008*	0.0002
	(0.0009)	(0.0005)	(0.0003)
Conglomerate fixed effects	No	Yes	Yes
N	29,405	29,405	29,405
R^2	0.02	0.44	0.39

Notes. In this table, we use a linear probability model to estimate the probability that a conglomerate is sued by an NPE as a function of the gross profitability of related and unrelated segments. The unit of observation is a conglomerate-segment-year. *Sued by NPE* is a dummy variable equal to 1 if the conglomerate was sued by an NPE that year. To identify which conglomerate's segments that are related to litigated patents, we use the IPC-to-SIC concordance developed by Silverman (2003). We use the Thompson Innovation database to identify IPC classification of each asserted patent. We use financial statements disclosed in segment filings at the end of each year to collect segment-level information on sales and cost of goods sold and calculate segment gross profitability as the difference. Industry profitability is the average profitability of all firms in the same four-digit SIC. Standard errors, clustered by conglomerate, are reported in parentheses.

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

3.4. Which NPEs Are Driving Cash Targeting? Patent Assertion Entities vs. Small Inventors

NPEs take many organizational forms. We thus explore whether the cash-targeting behavior seen in Tables 2 and 4 varies by NPE type. As mentioned in Section 2, we exclude universities and NCEs from the sample. This leaves essentially two main categories of patent asserters in our data: patent assertion entities (PAEs) and small inventors. In our sample, 87.98% of the 21,300 cases have a patent assertion entity as a plaintiff, and small inventors bring 9.63% of cases.[36] Detailed information on plaintiff types as well as comparison with other samples is provided in Table B4 in the online appendix.

In Table B8 in the online appendix, we decompose the results shown in Table 2 by NPE type. In column (1) of Table B8, the regressand takes a value of 1 if the firm is sued by a PAE. In column (2), we reestimate the same specification with the regressand defined as 1 when a firm is sued by a small inventor.

From Table B8, we see that the entire cash-targeting effect is driven by patent assertion entities. Column (1) of Table B8 shows that in cases in which a patent assertion entity is involved, *CashLevel* and *CashShock* are large and significant predictors of litigation action. In contrast, in cases involving small innovators, neither *CashLevel* nor *CashShock* are significant predictors of targeting, and both have coefficients that are close to 0. Consequently, we see that patent assertion entities are responsible for nearly the entire magnitude of the coefficients on both cash variables shown in Table 2.[37]

3.5. Comparing the Types of Patents Asserted by NPEs and PEs

Allison et al. (2017) compared the NPE and PE lawsuits that reach decisions, finding that NPEs are significantly more likely than PEs to have their patents invalidated

- through summary judgment,
- based on prior art, and
- for inadequate disclosure.[38]

Unfortunately, we cannot directly assess the validity of the full universe of patents that NPEs (or PEs) assert, as validity determinations are not made for cases that are settled prior to judgment.[39] However, we can follow Allison et al. (2017) in looking for systematic differences between the patents NPEs and PEs assert and attempting to understand how those differences relate to patent quality.[40]

There are many ways to parameterize patent similarity; we use a number of different measures of patent quality in comparing the patents asserted by NPEs with those asserted by PEs.

First, following Love (2014), we examine whether NPEs disproportionately assert patents just before those patents' expiration dates (that is, 20 years from filing). We show the breakdown of patent age between NPEs and PEs in Table B9 in the online appendix. In panel A of Table B9, we see that NPE-asserted patents are significantly older than PE-asserted patents. From the first row of Table B9, we see that NPEs assert patents that are 25% older than those PEs assert ($t = 20.91$); because proximity to patent expiration should be orthogonal to patent quality, we take this as indicating a quality difference between NPE and PE patent assertions.[41]

Next, we attempt to test whether cash-rich firms are working with different technologies than non–cash rich firms, and if so, whether technology differences could be driving the apparent cash targeting we observe from NPEs. In panel B of Table B9, we see that there are no significant differences between cash-rich and non–cash rich firms' patent holdings within industry. Even within the set of cash-rich firms (within industry), we show that those firms that are targeted have identical patent portfolios to those that are not. Overall, we do not see any markers that technology differences are driving the association between cash and NPE litigation.[42]

Relative to PEs, NPEs are also much more likely to sue many times on any given asserted patent. In the second row of Table B9, for instance, we see that NPEs litigate each patent they assert 4.5 times as frequently as PEs do (13.02 times for NPEs versus 2.84 times for PEs ($t = 59.76$)).

Using a recently assembled data set that contains information on the number of issued, pending, and abandoned patents by NBER technology group for each month (Marco et al. 2015), we see that patents asserted in NPE cases are more likely to be issued at times when the USPTO issues more patents compared with total pending and abandoned applications ($t = 13.74$), that is, at times when the USPTO is especially busy. Furthermore, and consistent with NPEs asserting broad patents, we also find that patents asserted by NPEs have a significantly higher number of associated technology classes.[43]

When we compare the textual content of the claims in patents asserted by NPEs and PEs, we find striking differences. Consistent with the previous finding that NPE patents are broader than PE patents, evidence suggests that NPE patents contain significantly more independent claims than PE patents do (4.86 versus 3.80 ($t = 21.11$)) and more dependent claims (29.98 versus 21.19 ($t = 22.92$)). Moreover, the descriptions of patents asserted by NPEs contain more words, both in dependent and independent claims, than are found in patents asserted by PEs. For instance, an average patent asserted by an NPE contains 802 words in its independent claims, whereas an average patent asserted by a PE contains 531 words in its independent claims (with the difference of 271 words highly significant ($t = 26.54$)). The same holds true for more lengthily worded dependent claims with a difference of 361 words ($t = 26.54$)—802 for NPEs versus 531 for PEs.

Collectively, our results suggest that NPEs assert patents that are significantly different from those of PEs. In particular, NPEs assert patents that are broader in scope and wordier; in addition, they assert these broader patents significantly more aggressively and closer to the expiration of patent rights.[44]

3.6. Geography of NPE Litigation

Even if NPEs target lawsuits opportunistically, this need not show up in outcomes, as courts remain the ultimate arbiters of patent infringement. Thus, for NPEs to target cash successfully, they would—at minimum—need a credible threat of having courts rule in their favor sufficiently often.

Figure 2 shows the geography of NPE patent litigation in the United States. Unsurprisingly, some well-known innovation hubs (e.g., Silicon Valley) have large amounts of NPE IP litigation. However, validating common anecdotal accounts, we see that the preponderance of NPE patent litigation (43% of *all* cases) takes place in the eastern district of Texas (Marshall, Texas). Eastern Texas is not a major innovation center; rather, its courts are favored by NPEs because they are perceived to be plaintiff-friendly (both anecdotally and because of specific rules regarding judgment (Leychkis 2007)).

The practice of "forum shopping" (i.e., "choosing the most favorable jurisdiction or court in which a claim might be heard" (Garner and Black 2004, p. 770)) is not unique to IP litigation. However, again, even within the space of IP litigation, we see that NPEs seem to forum shop a uniquely large amount. NPE cases and PE cases have very different geographic patterns. As noted, NPEs litigate 43% of their cases in the eastern district of Texas, and only 7% of PE cases are litigated there. When we run a Wilcoxon test comparing the geographic distributions of NPE and PE litigation, we see a significant difference between the two ($z = 3.91$, $p < 0.001$).[45,46]

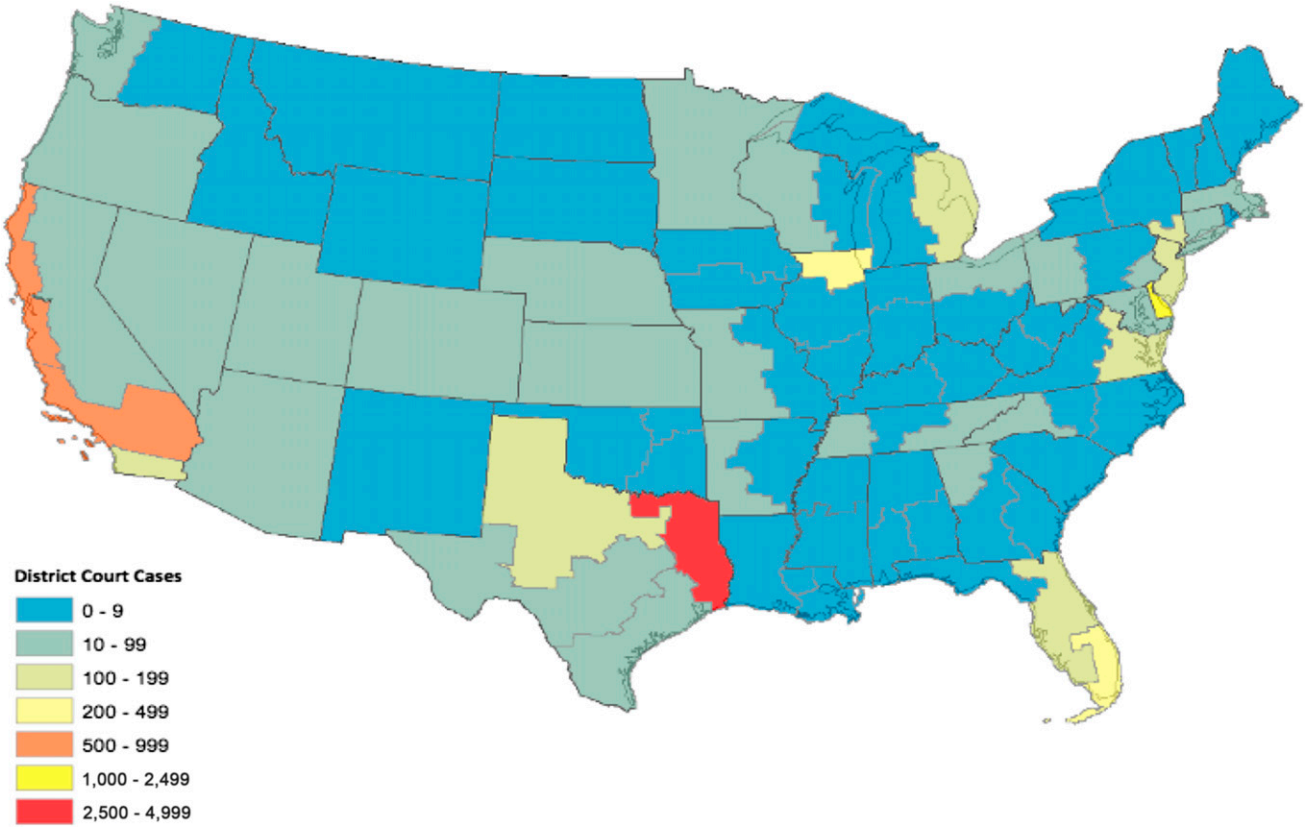
3.7. Probability of Paying

In this section, we test whether proxies for firm's readiness (and ability) to stave off NPE litigation impact firms' probabilities of being targeted. We create two measures: one measure counting the number of lawyers firms have at their disposal and the second counting how busy firms are with non-IP litigation actions.

The idea of the first measure—number of lawyers—is that large legal teams may deter NPEs because they could serve to prolong the court (or settlement) process. The second measure—how busy the firm is with outside litigation—is meant capture the within-firm resource constraint on time and costs spent battling litigation. We expect that, if NPEs opportunistically target firms that are unlikely to be able to defend themselves, then (1) having many lawyers should deter suits (so there should be a negative coefficient on the number of lawyers) and (2) being involved in extraneous, non-IP cases should draw more suits (so the associated coefficient should be positive).

To measure firms' legal teams, we extract data from the ALM Legal Intelligence database. We obtain a list of all law firms and their clients from ALM Legal Intelligence between 2005 and 2012. Then, we follow the procedure outlined in Table B2 to define a dummy variable *IPLegalTeamSize*, which takes a value of 1 if the firm employs more IP-focused law firms than a comparable

Figure 2. Geography of NPE Patent Litigation



Note. This map charts NPE Patent litigation intensity across court districts.

firm with similar characteristics. Our second measure, *OngoingCases*, measures the existence and number of reported, ongoing non-IP-related litigation actions. From Table 5, we see that controlling for all other characteristics, NPEs are less likely to sue a firm with more legal representation. The coefficient on *IPLegalTeamSize* in column (1) implies that a one standard deviation increase in IP legal team size decreases the likelihood of suit by 7.2% ($t = 2.13$). NPEs are also more likely to target firms that are busy with ongoing, non-IP litigation. The column (2) coefficient on *OngoingCases* (0.0171, $t = 2.38$) implies that firms that are occupied with large numbers of non-IP cases are 19% more likely to be targeted by NPEs.

The empirical specification considered in this section also provides evidence against a precautionary savings interpretation of the cash-targeting results shown in Table 2. If precautionary savings were driving the relationship seen in Table 2, then we would expect the coefficient on *LegalTeamSize* to be positive; firms saving cash to stave off infringement litigation should also be growing their legal teams(!). (At the very least, under the precautionary savings hypothesis, we would not expect the negative and significant relationship observed in the data.) To believe the precautionary savings hypothesis, we would need to believe that firms are raising cash to preempt litigation at the same time as they are actively *decreasing* their legal representation; this seems unlikely. Instead, the findings as a whole appear more consistent with NPEs acting opportunistically—targeting cash-rich firms that are more likely to settle either because they have recently reduced their legal teams or because they are embroiled in outside litigation.

3.8. Sum of Evidence

In summary, our empirical evidence shows that

1. NPEs specifically target litigation against firms that are flush with cash.

2. Cash targeting appears to be unique to NPE IP litigation.

- Cash is neither a significant positive predictor of PE IP lawsuit targeting nor of non-IP lawsuit targeting (rather, these other classes of lawsuits appear to have most of the R^2 driven by infractions themselves).
- More generally, NPE behavior is different from PE behavior even conditioning on the same type of infraction (alleged IP infringement).

3. NPEs target cash unrelated to alleged infringement with essentially the same frequency that they target cash related to alleged infringement.

4. The cash-targeting behavior we observe is driven by large aggregator NPEs and is not the behavior of small innovators.

Table 5. Impact of Legal Team Size and Outside (Non-IP) Litigation

	(1) *Sued by NPE*	(2) *Sued by NPE*
Cash level	0.0592***	0.0563***
	(0.0155)	(0.0132)
Total assets	0.0323***	0.0197**
	(0.0115)	(0.0083)
Market value	−0.0324***	−0.0122
	(0.0103)	(0.0083)
B/M	−0.0219***	−0.0151**
	(0.0072)	(0.0061)
Past return	0.0009	−0.0006
	(0.0029)	(0.0025)
R&D expense	0.1087*	0.1213**
	(0.0588)	(0.0485)
Number of patents	0.0009	0.0005
	(0.0040)	(0.0038)
Cash shock	0.0200*	0.0166**
	(0.0104)	(0.0081)
Legal team size	−0.0062**	
	(0.0029)	
Ongoing cases		0.0171**
		(0.0072)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
N	37,947	50,965
R^2	0.56	0.55

Notes. In this table, we use a linear probability model to estimate the probability of being sued by an NPE. The outcome variable, *Sued by NPE*, is a dummy equal to 1 if the firm was litigated by an NPE in a given year. We introduce two dummy variables to the main specification reported in Table 2. The first variable, *Legal team size*, is a dummy variable that takes a value of 1 if the firm employs more IP-focused law firms than a comparable firm with similar characteristics. Table B2 provides details of IP legal team size calculation. The second variable, *Ongoing cases*, takes value of 1 if the amount of ongoing litigation the firm is engaged in is more than 10% of the sum of ongoing litigation of its peer firms in the same industry-year. The sample contains firm-year observations between 2005 and 2012 in the first column because of data limitations. Standard errors, clustered by firm, are reported in parentheses.

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

5. The patents NPEs assert are seemingly different in quality from those asserted by PEs (in particular, on average, NPEs assert patents that are broader and closer to expiry). Moreover, NPEs assert patents more aggressively than PEs do.

6. NPEs appear to forum shop, trying the preponderance of their cases in a single district in Texas.

7. NPEs target firms that may have reduced ability to defend themselves against litigation.

Although none of our results alone proves opportunistic behavior (patent trolling) on the part of NPEs, the mass of the evidence to this point appears most consistent with NPEs behaving as patent trolls.

In line with our evidence, there have been increasingly frequent high-profile anecdotal accounts of trolling by NPEs (nearly always litigated in Marshall, Texas). For instance, Lumen View Technology LLC sued numerous online dating companies for alleged infringement on a patent on computerized matchmaking that U.S. District Judge Denise Cote later pronounced to be obviously invalid. "There is no inventive idea here," Judge Cote declared, pointing out that "matchmaking" is literally ancient (Mullin 2013). Meanwhile, MPHJ Technology Investments sued more than 16,000 small businesses (along with a number of branches of the U.S. government) alleging infringement on a patent covering "scan-to-email" functionality. Many of MPHJ's cases were not only dismissed but prompted countersuits for deceptive practices (Mullin 2014).

We conduct several robustness checks on our analysis in Section 3.9 and then assess the impact of NPEs on real outcomes in Section 4. We tie back to theory and discuss welfare implications in Section 5.

3.9. Robustness Tests

Now, we provide a number of robustness tests, including an out-of-sample test and a number of additional specifications.

3.9.1. Out-of-Sample Test. As mentioned in Section 2, the analyses discussed in the text use data from RPX Corporation, a company that tabulates information on NPE behavior. Although the data are all sourced from public documents (namely the USPTO and public court records), RPX retains the data set itself as proprietary. Cotropia et al. (2014) recently hand-coded and classified NPE IP litigation events for a two-year sample (2010 and 2012) and made this data publicly available at http://www.npedata.com.

We have rerun all of our analyses on the Cotropia et al. (2014) data; the results of this out-of-sample test are shown in Table B4. We find the same results using the Cotropia et al. (2014) data as with the RPX data: cash is a large and significant predictor of NPE targeting, and this behavior is driven by PAEs.[47]

3.9.2. Thicket Industries and Additional Specifications. Patent thickets are dense, overlapping webs of patents that make it difficult to commercialize because products may overlap with large numbers of patented technologies. Certain industries are known to be more prone to patent thickets, and those industries themselves have been linked to strategic patenting behavior (Bessen and Meurer 2013). We test whether the cash-targeting behavior of NPEs differs between thicket- and nonthicket industries.[48] Columns (1) and (2) of Table 6, panel A, show the results.

Column (3) runs the same analysis excluding IT firms (SIC code 35, e.g., Apple and IBM, and SIC code 73, e.g., Yahoo! and eBay); again, cash is a strong determinant of targeting, nearly identical in magnitude and significance. Column (4) uses a cash measure that

Table 6. Robustness Tests

Panel A: Thicket industries vs. nonthicket industries

	(1) *Sued by NPE*	(2) *Sued by NPE*	(3) *Sued by NPE*	(4) *Sued by NPE*	(5) *Sued by NPE*	(6) *Sued by NPE*
	Thicket industry	Nonthicket industry	Exclude SIC = 35, 73	Alternative cash measure	All industries	Unlogged variables
Cash level	0.0891**	0.0515***	0.0543***	0.0324***	0.0613**	0.0074**
	(0.0353)	(0.0143)	(0.0137)	(0.0124)	(0.0291)	(0.0029)
Total assets	0.0343	0.0192**	0.0187**	0.0217**	0.0209**	0.0205**
	(0.0311)	(0.0085)	(0.0085)	(0.0084)	(0.0092)	(0.0092)
Market value	0.0014	−0.0178*	−0.0178**	−0.0126	−0.0124	0.0098
	(0.0180)	(0.0095)	(0.0089)	(0.0083)	(0.0083)	(0.0292)
B/M	−0.018	−0.0147**	−0.0156**	−0.0145**	−0.0149**	−0.0015
	(0.0152)	(0.0067)	(0.0064)	(0.0061)	(0.0061)	(0.0014)
Past return	−0.0017	−0.0006	−0.0008	−0.0002	−0.0006	0.0017
	(0.0052)	(0.0029)	(0.0027)	(0.0025)	(0.0025)	(0.0017)
R&D expense	0.0578	0.1098*	0.1094**	0.1362***	0.1230**	2.2316*
	(0.0867)	(0.0573)	(0.0508)	(0.0488)	(0.0482)	(1.1895)
Number of patents	0.0054	−0.0058	−0.0037	0.0007	0.0006	−0.0029*
	(0.0057)	(0.0049)	(0.0041)	(0.0038)	(0.0038)	(0.0015)
Cash shock	0.0339**	0.0107	0.0211**	0.0202**	0.0167**	0.0219***
	(0.0171)	(0.0092)	(0.0088)	(0.0081)	(0.0081)	(0.0080)
Financial constraints					0.0012	−0.0054*
					(0.0035)	(0.0032)
Cash level squared					−0.0044	−0.0001**
					(0.0218)	(0.0000)
Cash level cubed					0.0008	0.0000*
					(0.0040)	(0.0000)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	13,791	37,174	43,430	50,965	50,965	50,965
R^2	0.56	0.54	0.54	0.55	0.55	0.55

Panel B: Alternative estimation methods

	(1) *Sued by NPE*	(2) *Sued by NPE*	(3) *Sued by NPE*	(4) *Sued by NPE*	(5) *Sued by NPE*
	OLS	Tobit	Probit	Logit	Negative binomial
Cash level	0.4439***	1.9722***	0.2896***	0.4731***	0.5780***
	(0.1638)	(0.1645)	(0.0466)	(0.0863)	(0.1097)
Total assets	0.2309**	−0.1947*	−0.0113	0.0091	−0.0254
	(0.0939)	(0.1018)	(0.0315)	(0.0623)	(0.0600)
Market value	−0.2695**	2.3869***	0.3408***	0.6016***	0.7859***
	(0.1065)	(0.1151)	(0.0364)	(0.0711)	(0.0667)
B/M	−0.1620***	−0.0943	−0.0385	−0.0807	0.0148
	(0.0392)	(0.1394)	(0.0393)	(0.0825)	(0.0874)
Past return	−0.0147	−0.1791	−0.0087	0.0067	−0.1069**
	(0.0146)	(0.1322)	(0.0193)	(0.0398)	(0.0462)
R&D expense	5.9518***	2.6446***	0.1843	0.3067	0.4096**
	(1.8900)	(0.2524)	(0.1274)	(0.2367)	(0.2038)
Number of patents	0.1408**	0.5181***	0.0918***	0.1706***	0.1530***
	(0.0664)	(0.0350)	(0.0120)	(0.0229)	(0.0245)
Cash shock	0.0086	0.1677	0.0564	0.1138	−0.0409
	(0.0580)	(0.2272)	(0.0420)	(0.0764)	(0.0809)

Table 6. (Continued)

	Panel B: Alternative estimation methods				
	(1) *Sued by NPE*	(2) *Sued by NPE*	(3) *Sued by NPE*	(4) *Sued by NPE*	(5) *Sued by NPE*
	OLS	Tobit	Probit	Logit	Negative binomial
Firm fixed effects	Yes	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes
N	50,965	50,965	50,965	50,965	50,965
R^2	0.75	0.14	0.20	0.20	0.14

Notes. In panel A of this table, we report the results for several robustness tests. In the first two columns, we reports results for thicket industries (i.e., industries that are characterized with dense overlapping intellectual property rights and strategic patenting behavior) and nonthicket industries. In column (3), we exclude the IT industry from the sample. We use SIC codes 35, 36, 38, and 73 to identify thicket industries. We use SIC codes 35 and 73 to identify IT firms (see Bessen and Meurer 2014). In column (4), we use an alternative cash measure (sum of cash and marketable securities) as our main variable of interest. In column (5), we add three new variables to the baseline specification: cash level squared, cash level cubed, and the Hadlock and Pierce (2010) financial constraints index, which measures how constrained the firm is in terms of accessing external funds, combining information on firm asset size, firm asset size squared, and firm age. We use mean firm age for firms whose ages are missing to keep the sample size constant across specifications (the coefficient on cash is 50% larger when we use the subsample that does not have information on firm age). In the last specification, we use unlogged variables. In panel B, we report several specifications based on different estimation methods. In the first two columns and the last column, we change the left-hand side variable to the number of times sued in a given year and use OLS, Tobit, and negative binomial models, respectively. In the third and fourth columns, we use Probit and Logit models, respectively.

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

incorporates marketable securities of the firm. The economic magnitude implied by the coefficient of *CashLevel* in this specification is similar to our baseline specification. Column (5) allows additional nonlinearities in cash (cash level squared and cubed); neither loads significantly, and allowing nonlinearity does not appear to have an impact on the estimated magnitude or significance of the *CashLevel* and *CashShock* coefficients. In this specification, we also include a new variable (*FinancialConstraints*) that measures how financially constrained firms are; we find that financial constraints are not a statistically significant predictor of NPE targeting.[49] Finally, in Column (6) we repeat the same specification used in Column (5) using unlogged values of *Cash* and all control variables. This specification affirms *CashLevel* and *CashShock* as large and significant determinants of targeting, showing their robust relation across functional form assumptions.

Panel B of Table 6 shows a number of additional specifications. First, throughout the paper, we have used whether a firm is sued by an NPE in a given year (*SuedByNPE*). However, a number of firms are sued multiple times by different (or even the same) NPEs within a single year. In Table 6, panel B, we replace the dependent variable with the number of times a firm is sued by an NPE in a given year. We find similar results to those presented in Table 2: *CashLevel* and *CashShock* are large and significant predictors of the number of times a firm is sued in a given year (in OLS, Tobit, and negative binomial specifications). For instance, column (1) of Table 6, panel B, shows a coefficient on *CashLevel* of 0.4439 ($t = 2.71$), implying that a one standard deviation increase in cash doubles the number of times a firm is targeted by NPEs. Additionally, columns (3) and (4) of Table 6, panel B, show the base categorical variable specification of the dependent variable (*SuedByNPE*) but in Probit and Logit regressions. Again cash remains a large and significant predictor of NPE targeting behavior.

4. Impact of NPE Litigation on Real Outcomes

Up to this point, we have examined which firms NPEs target and when. We now examine the real impacts of NPE litigation on the firms being targeted. Of course, a difficulty in obtaining any causal estimates here is that we have a clear selection problem (that is, it might be the case that the firms that NPEs target experience some outcome not because of NPE litigation, but because they share some common unobservable characteristic). We attempt to alleviate selection concerns somewhat by conditioning on being targeted; we compare two groups of firms, both selected to be sued by NPEs. Specifically, we compare all firms targeted by NPEs, separating targeted firms specifically according to whether (1) they were forced to pay out to NPEs (they either lost in court or settled) or (2) the cases against them were dismissed (including when the court ruled against the NPE).[50,51,52]

We test whether losing to an NPE and having an NPE lawsuit dismissed lead in different directions in terms of future R&D productivity. Specifically, we focus on how R&D expenditures on projects differ (prelitigation and postlitigation) among the two classes of targeted firms.

Table 7 reports the difference-in-differences results. From panel A of Table 7, we see that losing to an NPE has a large and negative impact on future R&D activities, again, even conditioning on being selected for litigation. We compare average annual R&D expense

Table 7. Impact of IP Litigation on Real Outcomes

Panel A: Real effect analysis

Sued by	(1) Treated	(2) Untreated	(3) *N*(Treated)	(4) *N*(Untreated)	(5) Change in R&D around litigation
NPE	Settled + Won by NPE	Dismissed + Lost by NPE	1,929	533	−163.97 (7.18)
PAE	Settled + Won by PAE	Dismissed + Lost by PAE	1,868	502	−155.02 (6.60)
PE	Settled + Won by PE	Dismissed + Lost by PE	175	38	167.657 (1.28)

Panel B: Parallel trend analysis

Sued by	(1) Treated	(2) Untreated	(3) Change in R&D ($t-3$ to $t-2$)
NPE	Settled + won by NPE	Dismissed + lost by NPE	18.951 (1.18)
PAE	Settled + won by PAE	Dismissed + lost by PAE	−1.95 (0.06)
PE	Settled + won by PE	Dismissed + lost by PE	50.79 (0.31)

Panel C: Real effects OLS analysis: Settled + won by NPE vs. dismissed + lost by NPE

Sued by	(1) NPE	(2) PAE	(3) PE
	Future R&D/A	*Future R&D/A*	*Future R&D/A*
Dummy (Settled + won by NPE)	−0.0173** (0.0081)	−0.0179** (0.0082)	0.0058 (0.0306)
Market value	−0.0238*** (0.0048)	−0.0230*** (0.0047)	−0.0275** (0.0127)
B/M	−0.0468*** (0.0070)	−0.0447*** (0.0068)	−0.1266*** (0.0361)
Past return	−0.0061 (0.0068)	−0.005 (0.0069)	−0.0527 (0.0410)
Cash level	0.0174*** (0.0056)	0.0160*** (0.0055)	0.0138 (0.0222)
Cash shock	0.0137* (0.0071)	0.0135* (0.0071)	0.0162 (0.0277)
Citation commonality	0.0046*** (0.0008)	0.0048*** (0.0009)	−0.0005 (0.0011)
Ongoing cases	−0.0513*** (0.0097)	−0.0508*** (0.0096)	−0.0832** (0.0333)
Year fixed effects	Yes	Yes	Yes
N	2,462	2,370	209
R^2	0.13	0.13	0.15

Notes. In panel A of this table, we present the impact of being sued by an NPE, PAE, or PE on research and development expenditures in the two years following litigation filing in comparison with the two years before litigation filing. We use the timing of the case filing as the expectations regarding the case outcome start impacting firm operations after the litigation event becomes common knowledge. Following Allison et al. (2010), we exclude case outcomes such as "stayed," "transfers," and "procedural dispositions." We only use case outcome RPX codes as "dismissed," "settled," "won by NPE," and "lost by NPE." In our sample, settlements and won by NPE result in 88% of the outcomes, and dismissals and lost by NPE arise in 12% of the cases. We compare two groups of firms based on case outcomes of "settled or won by NPE" to "dismissed or lost by NPE." In the first row of panel A, we consider the change in R&D expense, before and after litigation filing, comparing defendant firms whose cases were "settled or won by NPE" with those whose cases were "dismissed or lost by NPE." We compare average R&D expense spending two years following the litigation filing to average R&D expense spending two years before the litigation filing. Using this difference-in-differences design, we report mean of change in R&D (treated) − change in R&D (untreated). We note that some settlements do not necessarily involve conditions that could be significantly different from dismissals. Furthermore, a given firm may be sued multiple times in a given year, and these cases may end with different outcomes. To define the treatment sample cleanly, we assume that a firm can only be grouped into the treated sample if *all* the cases against that firm in a given year conclude with "settled or won by NPE" outcomes. These assumptions assure that the effects we document are conservative. In panel B, column (3), we test whether the research outputs of the treated and untreated sets were similar prior to litigation. In the first column of panel C, we report the results of the OLS regression in which future R&D expense (scaled by total assets) is regressed on a dummy variable that takes a value of 1 if all the cases filed by NPEs against the firm in a particular year are settled or won by the NPE. The unit of observation is firm-year. To measure future R&D expense, we use average of R&D spending two years following the litigation. To calculate citation commonality, we do the following: We count the number patents citing a given patent of a firm and the asserted patent of NPE; we then add up these figures for all patents of the firm. Standard errors, clustered by firm, are reported in parentheses.

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

two years following the litigation to average annual R&D expense two years before the litigation. To get an idea of the effect magnitude, the results shown in panel A imply that firms that lose to a large aggregator NPE (*Settled + Won By NPE*) invest significantly less in R&D in the years following the loss ($163 million less, $t = 7.18$) relative to firms that were also targeted by NPEs but won (*Dismissed + Lost By NPE*).

Panel A also shows that we see no such patterns for PE versus PE cases: unlike firms that lose to NPEs, firms that lose to PEs show no reduction in R&D investment.[53] Panel B of Table 7 runs parallel trends analysis, showing that the firms in our comparison groups had similarly moving R&D expenditures prior to the NPE lawsuits.

Finally, panel C of Table 7 shows an analysis of the same firms pre– and post–difference-in-differences analysis but in a regression framework in which more firm-level determinants of R&D can be included. From panel C, we see that losing to a large aggregator NPE (again, selecting on being targeted) leads to a 1.73% reduction in future R&D expense (scaled by assets).[54] Considering the mean of the dependent variable is 8.7%, this magnitude is economically large and statistically significant, representing a roughly 20% reduction ($t = 2.43$) in R&D investment. Again, from column (3) of Table 7, panel C, we see that there is no resultant reduction in R&D expenditure following losses in PE versus PE cases.

More broadly, we find additional evidence suggesting that the differential motivations of NPEs and PEs have an impact on real outcomes as well. In particular, losing firms that survive PE lawsuits increase R&D by more than those that survive NPE lawsuits, potentially to stave off increased competitive threats (and also possibly because NPEs drain targets' cash). Moreover, we find that PE-targeted firms are unconditionally more likely to have their credit downgraded following being targeted, potentially tied to the increased motivation of PE targeting to eliminate competition. Both results are shown in Table B7 in the online appendix.

In all, the evidence in this section supports the idea that NPEs have a real and negative impact on innovation of U.S. firms and that within the IP space—like the cash-targeting behavior we have observed—the negative impact on R&D is unique to NPE lawsuits. However, we must be cautious in interpreting this finding because it is possible that some correlated (unobservable) omitted variables drive both litigation outcomes and future R&D—even conditional on being targeted (e.g., lack of real innovative efforts at the firm).

5. Discussion

Our results show that NPEs, on average, sue firms that have substantial cash holdings. Although we cannot observe directly whether infringement has occurred in a given case, our results suggest that cash—rather than policing infringement—drives NPE targeting. Cash is a first-order determinant of NPE IP litigation even when that cash is unrelated to the alleged infringement and even though cash is neither a key driver of PE patent lawsuits nor of non-IP litigation. Meanwhile, NPEs appear to bring lower-quality lawsuits than PEs, and there is evidence that NPEs are actively forum shopping.

NPE litigation has a real negative impact on innovation at targeted firms: PEs substantively reduce their innovative activity after settling with NPEs (or losing to them in court). Measuring NPEs' *net* impact on innovation, however, requires accounting for the potential of NPE litigation to positively incentivize innovation by individual inventors. Unfortunately, because most settlement values are not disclosed, we cannot measure the full size of the transfer from PEs to NPEs (much less the transfer from NPEs to end inventors). Furthermore, we cannot measure the increase in innovation incentives that might come from PEs being less likely to infringe (given NPE behavior). Thus, we cannot explicitly measure the potential welfare gains from NPE litigation.[55]

That said, there are three pieces of empirical evidence that speak to the impact of NPEs on inventors' innovation incentives. First, Bessen et al. (2011) directly estimate the pass-through parameter that our theory highlights as the key mediator of NPEs' benefits for end inventors. Bessen et al. (2011) find very low pass-through, estimating that only five cents of every dollar in damages paid by PEs to NPEs makes it back to end innovators. Thus, one would need to believe in a large multiplier (summing both direct and indirect spillover effects) to justify, from a social-welfare perspective, NPE litigation practices as an efficient mechanism to transfer the marginal dollar of innovative capital *even if all NPE lawsuits were well founded*. Second, Feldman and Lemley (2015) find evidence that patent licensing does little or nothing to increase innovation irrespective of whether NPEs or PEs are the licensors. Finally, we conduct a simple empirical analysis, presented in Table 8, in which we measure changes in innovation outcomes in the *exact* technology areas in which NPE litigation is most frequent. In NPE-heavy areas, both the direct and indirect (incentive) benefits of NPE litigation should be largest, but Table 8 shows that there has been no observable increase in innovation by small innovators.[56]

6. Conclusion

We provide the first large-sample evidence on the behavior and impact of NPEs. Although NPE litigation can reduce infringement and support small inventors, as NPEs become effective at bringing opportunistic lawsuits, they can inefficiently crowd out firms that would otherwise produce welfare-enhancing innovations

Table 8. NPE Litigation and Individual Inventor Patenting Activity, 1995–2010

	Individual innovator share	*Individual innovator share*	*Individual innovator share*
Litigation5	−2.0158		
	(2.5914)		
Litigation4		−2.0362	
		(2.3644)	
Litigation3			−2.0699
			(2.1816)
Tech group fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
N	8,975	8,975	8,975
R^2	0.80	0.80	0.80

Notes. In this table, we estimate an OLS model using past NPE litigation activity to predict the share of all future patents produced by individual innovators (*Individual Innovator Share*). The unit of observation is year-IPC subclass code. We exclude patents if a technology class (IPC code) is not reported in the Thompson Innovation database. Individual innovator patents are those that name the same individual as the "innovator" and "assignee." If a patent belongs to multiple IPC subclasses, it is counted toward each. We define past litigation activity by calculating the average number of NPE litigation events in the past three, four, and five years (*Litigation3, Litigation4,* and *Litigation5*). Standard errors are clustered by year and reported in parenthesis.

***, **, and * refer to statistical significance at 1%, 5%, and 10% levels, respectively.

without engaging in infringement. Our empirical analysis shows that, on average, NPEs appear to behave as opportunistic patent trolls. They sue cash-rich firms; a one standard deviation increase in cash holdings doubles a firm's chance of being targeted by NPE litigation. By contrast, cash is neither a key driver of IP lawsuits by PEs, nor of any other type of litigation against firms. The cash-targeting behavior we observe is driven by large aggregator NPEs and is not the behavior of small innovators. NPEs even target conglomerate firms that earn their cash from segments unrelated to alleged infringement (profitability in unrelated businesses is nearly as predictive of NPE lawsuits as is profitability in business segments related to NPE-alleged patent infringement). We find further suggestive evidence of NPE opportunism, such as forum shopping and litigation of lower-quality patents as well as targeting of firms that may have reduced ability to defend themselves against litigation. We find moreover that NPE litigation has a real negative impact on innovation at targeted firms: firms substantively reduce their innovative activity after settling with NPEs (or losing to them in court). Meanwhile, we neither find any markers of significant NPE pass-through to end innovators, nor of a positive impact of NPEs on innovation in the industries in which they are most prevalent.

Setting intellectual property policy regarding patent assertion is first-order. If widespread opportunistic patent litigation makes the United States a less desirable place to innovate, then innovation and human capital—and the returns to that innovation and human capital—will respond accordingly. That said, innovators will also leave if they feel they are not protected from large, well-funded interests that might infringe on innovative capital without recompense. Our results provide evidence that NPEs—in particular, large patent aggregators—on average do not appear to protect innovation. Rather, our results are consistent with NPEs, on average, behaving as patent trolls that target cash and negatively impact innovative activities at targeted firms. Given our findings, policy should seek to more carefully limit the power of NPEs or introduce cost-shifting or screening measures that reduce the incentive to bring nuisance suits.[57]

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Appendix A. Formal Model

Here, we introduce a model of innovation and NPE litigation that illustrates how the real benefits that NPEs can provide small inventors balance with the possibilities of NPE opportunism. We focus on a simple scenario in which a firm is aware of a small inventor's patent and must choose whether to infringe. The NPE serves as a specialized litigation intermediary that can help the small inventor respond to patent infringement, but the NPE is so effective at litigation (or, equivalently, the courts are sufficiently imperfect) that the NPE can sometimes win lawsuits when no infringement has occurred. Thus, the central welfare trade-off is whether (and when) the positive value of NPEs to small inventors outweighs the costs of frivolous litigation. The trade-off we observe is nontrivial because widespread frivolous litigation causes an endogenous, inefficient increase in infringement (firms that know they will get sued anyway might as well infringe) and can also crowd out innovating firms completely. Note that in our model we focus only on NPE litigation given the possibility of intentional infringement on a real invention. We do *not* address NPE activities that are purely rent seeking, such as asserting weak patents or "holding up" firms by making them aware of patented technologies only after innovation and production have occurred; such activities would only reduce the case in support of NPEs (in our model and in general).

A firm decides whether to invest in *innovation*, which has payoff v and cost $k < v$ for net return

$$u \equiv v - k > 0.$$

If the firm does not innovate, then it produces a "safe" product, which has net return normalized to 0. If the firm does innovate, then it may simplify its innovation process by *infringing* upon intellectual property that has been developed and patented by an outside *inventor*. (For now, we assume that there is no possibility that the firm can license the inventor's intellectual property; we later add licensing to the model and investigate the impact of NPEs on licensing rates.) Infringement reduces the costs of innovation by $\pi > 0$ so that innovation with infringement yields net return

$$v - (k - \pi) = u + \pi$$

for the firm; π represents the cost of "designing around" the invention, which is not spent if the firm infringes.[58]

Once the firm has made its production decisions, the inventor may choose to litigate either on his or her own or through an NPE.[59] For plaintiff e, bringing a lawsuit has fixed-cost c_e and per-unit effort cost w_e. We assume that lawsuits against firms producing the safe product are never profitable—for instance, because that product is clearly unrelated to the invention in question—so litigation will only occur if the firm chooses to innovate. However, we do *not* assume that litigation is only profitable in the presence of infringement; that is, we allow for the possibility of *nuisance lawsuits* that occur even in the absence of infringement (or when the asserted patents are invalid). When the inventor and NPE are ineffective at bringing nuisance suits, litigation will occur only in the presence of infringement, but as the inventor and/or NPE become better at bringing nuisance suits, lawsuits will occur whenever the firm innovates (so long as they are ever profitable), irrespective of whether the firm infringes.

When bringing a lawsuit, the plaintiff chooses the optimal litigation effort L. Courts are assumed to be imperfect; both the probability of winning and the damages from suit depend on (1) the level of litigation effort, (2) whether infringement has occurred, and (3) whether the inventor or an NPE is the plaintiff.

The probability of winning a suit is given by

probability of winning	if(infringement)	if(no infringement)
inventor plaintiff	$\overline{p}_i(L)$	$\underline{p}_i(L)$
NPE plaintiff	$\overline{p}_n(L)$	$\underline{p}_n(L)$

(A.1)

We assume that the probability of winning is always weakly increasing in effort (i.e., we have $\overline{p}_i', \overline{p}_n', \underline{p}_i', \underline{p}_n' \geq 0$). Moreover, as NPEs have a comparative advantage in litigation (see, e.g., Khan 2013, 2014; Lamoreaux and Sokoloff 1996, 2001), we assume that NPEs are always weakly more effective at bringing lawsuits than the inventor is (i.e., $\overline{p}_n(L) \geq \overline{p}_i(L)$ and $\underline{p}_n(L) \geq \underline{p}_i(L)$). We also assume that lawsuits are more likely to be successful when infringement occurs (i.e., that $\overline{p}_i(L) \geq \underline{p}_i(L)$ and $\overline{p}_n(L) \geq \underline{p}_n(L)$).

Analogously, we assume that the damages received upon winning a suit are given by

damages	if(infringement)	if(no infringement)
inventor plaintiff	$\overline{\delta}_i(L)$	$\underline{\delta}_i(L)$
NPE plaintiff	$\overline{\delta}_n(L)$	$\underline{\delta}_n(L)$

(A.2)

We assume that damages are weakly increasing in effort (i.e., we have $\overline{\delta}_i', \overline{\delta}_n', \underline{\delta}_i', \underline{\delta}_n' \geq 0$) and that damage awards won by NPEs are weakly higher than those won by individual inventors (i.e., $\overline{\delta}_n(L) \geq \overline{\delta}_i(L)$ and $\underline{\delta}_n(L) \geq \underline{\delta}_i(L)$, again, because of NPEs' comparative advantage). We also assume that damages are higher in the presence of infringement (i.e., that $\overline{\delta}_i(L) \geq \underline{\delta}_i(L)$ and $\overline{\delta}_n(L) \geq \underline{\delta}_n(L)$).[60]

When bringing a lawsuit, the plaintiff $e \in \{i, n\}$ chooses litigation effort L to solve

$$\max_L \{p_e(L)\delta_e(L) - w_e L - c_e\} \equiv V_e, \tag{A.3}$$

where p_e and δ_e are the appropriate functions in Equations (A.1) and (A.2), respectively.[61,62] The first-order condition

$$p_e'(L)\delta_e(L) + p_e(L)\delta_e'(L) = w_e \tag{A.4}$$

determines e's optimal level of effort, L^*; this, in turn, determines the payoffs from a suit, which we denote V_e^*. Each of the four possible litigation scenarios (inventor or NPE plaintiff and presence or lack of infringement) has a different payoff from optimal effort, which we notate as follows:

returns to litigation	if(infringement)	if(no infringement)
inventor plaintiff	$\overline{V}_i^*$	$\underline{V}_i^*$
NPE plaintiff	$\overline{V}_n^*$	$\underline{V}_n^*$

(A.5)

Some features of the returns to litigation are apparent immediately from the first-order condition (A.4). First, shifting either the probability of winning or the damages function upward increases the optimal effort as well as the returns to litigation. Moreover, we observe a direct substitution between damages and probability of winning (holding the plaintiff type and firm production decisions constant); this is natural as the expected returns to suit are exactly the product of the probability of winning and the size of the damage award.

We assume that the NPE shares a fraction λ of its litigation surplus with the inventor. That is, if the inventor sues via an NPE, then the inventor receives (expected) payoffs

$$\lambda(\overline{V}_n^* - \overline{V}_i^*) + \overline{V}_i^* \quad \text{and} \quad \lambda(\underline{V}_n^* - \underline{V}_i^*) + \underline{V}_i^*$$

in the cases of infringement and no infringement, respectively. Thus, in the case of infringement, the inventor sues if and only if

$$\max\{\overline{V}_i^*, \lambda(\overline{V}_n^* - \overline{V}_i^*) + \overline{V}_i^*\} \geq 0; \tag{A.6}$$

in the case of no infringement, the inventor sues if and only if[63]

$$\max\{\underline{V}_i^*, \lambda(\underline{V}_n^* - \underline{V}_i^*) + \underline{V}_i^*\} \geq 0. \tag{A.7}$$

We recall that NPEs are more effective at litigation than inventors are per unit effort (both in terms of success probability and damages). Thus, examining Equation (A.4), we see that $\overline{V}_n^* \leq \overline{V}_i^*$ and $\underline{V}_n^* \leq \underline{V}_i^*$ only when the inventor faces far lower costs of litigation effort than the NPE does (i.e., unless the unit litigation effort cost of the inventor, w_i, is much lower than that for the NPE, w_n). If anything, the opposite appears to be true in real markets (see, e.g., Ball and Kesan 2009 and Haber and Werfel 2016): NPEs are sophisticated and specialized in litigation, whereas individual inventors are under-resourced and rarely skilled at litigation. Thus, Equations (A.6) and (A.7) suggest that $\overline{V}_n^* \geq \overline{V}_i^*$ and $\underline{V}_n^* \geq \underline{V}_i^*$, and when inventors choose to sue, they will typically work through NPEs. Moreover, as inventors are often unable to bring lawsuits on their own (because of capability or resource constraints; again, see Ball and Kesan 2009 and Haber and Werfel 2016), their bargaining power with individual NPEs (embodied in λ) may be low.[64]

Now, we turn to the firm's incentives. We suppose that defending against litigation costs the firm c_f; this includes purely monetary costs as well as costs from disruption and loss of reputation.[65] Then, if the firm chooses to innovate, it receives the following payoffs:[66]

firm payoff	if(sued)	if(not sued)
if(infringement)	$u + \pi - c_f - \max\{\overline{V}_i^*, \overline{V}_n^* \mathbb{1}_{\overline{V}_n^* \geq \overline{V}_i^*}\}$	$u + \pi$
if(no infringement)	$u - c_f - \max\{\underline{V}_i^*, \underline{V}_n^* \mathbb{1}_{\underline{V}_n^* \geq \underline{V}_i^*}\}$	u

(A.8)

(Note that the firm must pay the full NPE damage award even though the inventor only receives fraction λ of the surplus.) The firm infringes whenever the benefits of doing so exceed the costs. The full extensive form is pictured in Figure A.1.

A.1. Impact of NPEs on Innovation and Infringement

To simplify the analysis, we focus on the case in which the inventor never sues on the inventor's own; that is, when $\overline{V}_n^* \geq \overline{V}_i^*$ and $\underline{V}_n^* \geq \underline{V}_i^*$. In this case, Equation (A.8) simplifies to

firm payoff	if(sued)	if(not sued)
if(infringement)	$u + \pi - c_f - \max\{\overline{V}_n^*, 0\}$	$u + \pi$
if(no infringement)	$u - c_f - \max\{\underline{V}_n^*, 0\}$	u

(A.9)

All the qualitative results we state here carry over to the full model. We see that:

- When $\underline{V}_n^* \to 0$ so that the NPE is ineffective at bringing nuisance suits, the availability of the NPE reduces total infringement. A lawsuit occurs only following infringement, and the firm infringes if and only if

$$u + \pi > c_f + \overline{V}_n^*. \tag{A.10}$$

Importantly, as $\underline{V}_n^* \to 0$, infringement is strictly lower than if the NPE were absent, as Equation (A.10) is tighter than $u + \pi > c_f + \overline{V}_i^*$, which is the condition that would determine infringement absent the NPE.

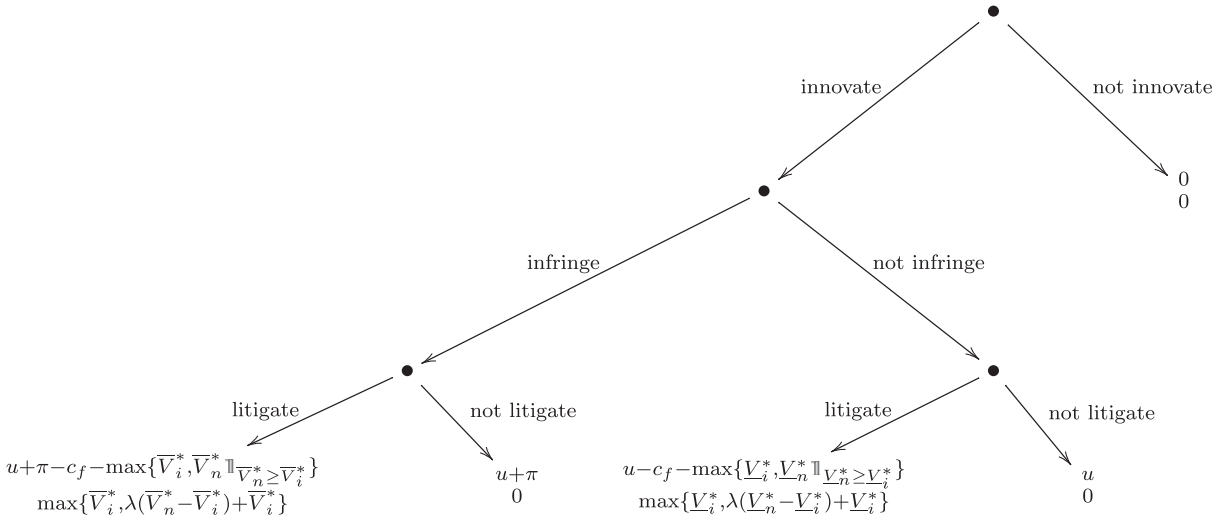
- However, as the NPE becomes better at bringing nuisance suits, that is, as $\underline{V}_n^* \to \overline{V}_n^*$, lawsuits occur whenever the firm innovates (so long as suits are ever profitable) irrespective of whether the firm infringes. In that case, all innovating firms will infringe even if the benefits of infringement are small.
- Moreover, as $\underline{V}_n^* \to \overline{V}_n^*$, if either the defense costs c_f or the payoff $\overline{V}_n^*$ are sufficiently large, then we have

$$u + \pi - c_f - \overline{V}_n^* < 0,$$

so that the firm will choose not to innovate. Consequently, when $\overline{V}_n^*$ is high enough and $\underline{V}_n^* \to \overline{V}_n^*$, the firm *always* chooses not to innovate even if, absent the NPE, the firm would choose to innovate without infringing.

Specifically, the firm chooses not to innovate when $u + \pi - c_f - \overline{V}_n^* < 0$. If $u + \pi - c_f - \overline{V}_i^* < u$, then the firm would innovate without infringing if there were no chance of nuisance suit. Thus, if $\underline{V}_n^*$ is sufficiently high and the benefits of infringement are low ($\pi < c_f + \overline{V}_i^*$), the presence of the NPE results in mid-value range innovations (those having values $u < c_f + \overline{V}_i^* - \pi$) being crowded out of the market.

Figure A.1. The Innovation and Litigation Game



Notes. First, the firm decides whether to innovate. If the firm chooses to innovate, then it must decide whether to infringe. Then, the inventor litigates (either on the inventor's own or through the NPE) if doing so is profitable. For each end node, the top term denotes the firm's payoff and the bottom term denotes the inventor's payoff.

- Overall, when the litigation costs w_e and c_e increase, we obtain more innovation from firms (both with and without infringement) because small inventors are less likely to bring lawsuits; extrapolating slightly beyond the model, this means that when the costs of litigation increase, we expect to see more innovation from firms relative to small inventors.[67]

A.2. Impact of NPEs on IP Licensing

Next, we suppose that the firm uses the inventor's invention (for return π) if it innovates, but the inventor and firm can agree to license terms ex ante in exchange for committing not to litigate.

If the firm innovates and infringes, then the inventor stands to earn

$$\max\{\overline{V}_i^*, \lambda(\overline{V}_n^* - \overline{V}_i^*) + \overline{V}_i^*, 0\}$$

through litigation (recall Equation (A.6)). Thus, if the firm has all the bargaining power, then it can license the invention for

$$\max\{\overline{V}_i^*, \lambda(\overline{V}_n^* - \overline{V}_i^*) + \overline{V}_i^*, 0\}.^{68} \tag{A.11}$$

Examining Equation (A.11), we see that the NPE only improves the terms of licensing for the inventor when $\overline{V}_n^* > \overline{V}_i^*$, that is, when the inventor would prefer to sue through the NPE instead of litigating on the inventor's own. But then the value of the license to the inventor is mediated by the rate at which the NPE passes surplus through to the inventor. No inventor gains more through licensing than the inventor would earn through bringing suit (although licensing is more efficient because it saves court costs). In particular, if λ is small—as it would be, say, if there were significant competition among inventors for the NPE's time—then the availability of the NPE has little impact on the inventor's licensing revenues. By contrast, if λ is large—as in the case of significant competition among NPEs for inventors' patents—then the NPE's presence can lead to significantly higher license fees.

A.3. Welfare Impact of NPEs

Our model illustrates that the welfare impact of NPEs is ambiguous. When NPEs are more effective at bringing lawsuits than individual inventors are, the threat of NPE litigation can reduce infringement and promote a transfer to inventors when infringement occurs. However, the value of NPEs to inventors is mediated by the fraction λ of the surplus that NPEs pass through. NPE-backed lawsuits may help inventors extract licensing fees from firms, but again, this effect is mediated by λ; if λ is small, then the inventor cannot extract a significantly higher licensing fee than the inventor would obtain absent the NPE.[69]

Meanwhile, if NPEs become effective at bringing nuisance lawsuits, then, in equilibrium, NPEs bring lawsuits even absent infringement. Somewhat paradoxically, this leads innovating firms to infringe *more* as they know that avoiding infringement will not deter suit.[70] Additionally, the cost of nuisance lawsuits inefficiently crowds out welfare-increasing innovation by some firms that, absent NPEs, would prefer to innovate without infringing.

Our results here shed new light on the impacts of "patent reform" legislation targeted at reducing low-quality NPE lawsuits. Reigning in frivolous lawsuits could both reduce crowd-out of innovative firms and (again, almost paradoxically) reduce infringement.[71] Meanwhile, reducing NPE litigation would only significantly affect the licensing revenues and innovation incentives of those inventors who are receiving a very large share of NPE revenues.[72]

Endnotes

[1] Bessen and Meurer (2014) estimate that, from 2007 to 2010, litigation (and settlement) losses because of NPEs averaged more than $83 billion per year in 2010 dollars (just summing over the losses to publicly traded firms). In magnitude, this corresponds to more than 25% of annual U.S. industrial R&D investment.

[2] Congress has considered the Innovation Act (H.R. 9 and H.R. 3309), the Targeting Rogue and Opaque Letters Act (H.R. 2045), the Patent

Transparency and Improvements Act (S. 1720), the Patent Quality Improvement Act (S. 866), the Patent Abuse Reduction Act (S. 1013), the Patent Litigation Integrity Act (S. 1612), the Innovation Protection Act (H.R. 3309), the Patent Litigation and Innovation Act (H.R. 2639), the Saving High-tech Innovators from Egregious Legal Disputes Act (H.R. 845), the Stopping the Offensive Use of Patents Act (H.R. 2766), and the End Anonymous Patents Act (H.R. 2024). Meanwhile, the U.S. Patent and Trademark Office (2015) has undertaken an initiative on Enhancing Patent Quality.

[3] Based on the body of evidence we document here, in related policy and law pieces, we propose a framework for advance screening aimed at abating patent trolling—particularly nuisance suits—while encouraging well-grounded lawsuits (Cohen et al. 2016, 2017).

[4] Our theoretical model, which we present in Appendix A, supports both sides of the NPE debate: NPE litigation can both reduce infringement and promote a transfer to inventors when infringement occurs, although the value of NPEs to inventors—both in terms of license fees and awards through litigation—is only as large as the fraction of the damage award that NPEs pass through. As NPEs become effective at bringing nuisance lawsuits, however, the resulting defense costs inefficiently crowd out some firms that, absent NPEs, would prefer to engage in innovation without infringing. Somewhat paradoxically, we also find that the possibility of nuisance lawsuits can lead some innovating firms to infringe *more* because avoiding infringement may not deter suit.

[5] All of the other key determinants of NPE targeting have (statistically and economically) no impact on PE litigation behavior with the exception of ongoing, non-IP-related cases, which has a positive impact on targeting for NPEs but a negative impact for PEs.

[6] *Prior art* refers to other patents, publications, and publicly disclosed but unpatented inventions that predate the patent application's filing date.

[7] In 2015, the average time between application and initial examiner report was 17.3 months, and on average, it took 26.6 months for the USPTO to issue a patent. The USPTO granted 325,979 patents in 2015. For other USPTO-related statistics, see http://www.uspto.gov/about/stats/.

[8] Following the *eBay Inc. v. MercExchange, L.L.C., 547 U.S. 388* Supreme Court ruling in 2006, injunctions became much harder to acquire, and thus, monetary damages became the far more prevalent remedy.

[9] In 2012, the America Invents Act forced the "disjoining" of lawsuits based on unrelated infringement claims. Thus, the increase in NPE litigation around 2012 is not quite as sharp as Figure 1 suggests, especially because many NPEs file suits against multiple parties. Even adjusting for this issue, the rise in NPE litigation is still striking.

[10] Surveys, clinical, and anecdotal work—finding evidence both in favor of and against NPEs—include the work of Lemley and Shapiro (2005), Bessen and Meurer (2006), Leychkis (2007), Ball and Kesan (2009), Galasso and Schankerman (2010), Bessen et al. (2011), Chien (2013a, 2014), Galasso et al. (2013), Bessen and Meurer (2014), Choi and Gerlach (2014), Cotropia et al. (2014), Feldman (2014), Schwartz (2014), Schwartz and Kesan (2014), Scott Morton and Shapiro (2014), Smeets (2015), Kiebzak et al. (2016), Tucker (2014), Feldman and Lemley (2015), Feng and Jaravel (2015), Haber and Werfel (2016), and Allison et al. (2017). Sokol (2017) presents recent analysis of the economic impact of NPEs.

[11] A related economic history literature has looked at modern NPEs' predecessors in prior ages of invention, illustrating how NPEs arose as specialized litigation intermediaries (see, e.g., Lamoreaux and Sokoloff 1996, 2001; Khan 2013, 2014; and Beauchamp 2016).

[12] Using data obtained from an NPE (but not studying NPEs, per se), Abrams et al. (2013) found an inverted-U relationship between patent citations and patent value (as measured in terms of associated revenue).

[13] Previous surveys include those of Cooter and Rubinfeld (1989), Hay and Spier (1998), and Daughety and Reinganum (2000).

[14] Prior research has investigated the impact of litigation risk on several characteristics, including cash holdings (Arena and Julio 2011), equity-based compensation (Jayaraman and Milbourn 2009), stock prices (Bhagat et al. 1994), IPO underpricing (Lowry and Shu 2002, Hanley and Hoberg 2012), institutional monitoring and board discipline (Cheng et al. 2010), conservatism in debt contracting (Beatty et al. 2008), audit fees (Seetharaman et al. 2002), and auditors' resignation decisions (Shu 2000). Papers have also investigated the relationship between managers' financial reporting and disclosure decisions and firms' litigation risk (see, e.g., Francis et al. 1994; Skinner 1994, 1997; Johnson et al. 2000; and Rogers and Van Buskirk 2009).

[15] RPX Corporation defines an NPE as "a firm that derives the majority of its revenue from licensing and enforcement of patents" (https://www.rpxcorp.com/wp-content/uploads/sites/2/2016/01/RPX-2015-NPE-Activity-Highlights-FinalZ.pdf, p. 11). Under this definition, traditional legal entities established to license and enforce patents comprise the majority of NPEs. Additionally, individual inventors may be counted although universities will not be counted (unless they have patent enforcement subsidiaries).

[16] Chien (2013b) compared a subsample of about 1,000 of RPX's codings to her own hand-codings, finding no more than 7% disagreement.

[17] RPX Corporation cleans its raw filing data (for instance, removing some administrative duplicates representing the same case but transferred across districts).

[18] One company executive relayed to us his reply to NPEs that send demand letters: "If you have a truly viable case you will sue; otherwise, don't waste my time with this letter(!)."

[19] See, for example, the Executive Office of the President (2013) report "Patent Assertion and U.S. Innovation."

[20] Of course, there is also a strategic element inherent in the timing of litigation disclosure. As Bessen and Meurer (2012) have shown, strategic disclosure of patent litigation operates on time frames (weeks to months) narrower than the frequency of our data (years); hence, we cannot directly address strategic disclosure here. That being said, there is new evidence (Bereskin et al. 2017) that finds positive returns around litigation disclosure in patent litigation.

[21] Table B1 presents detailed descriptions of the specific data fields used in our study.

[22] The remaining 12% are a blend of originally assigned and acquired patents.

[23] Consistent with this, Love et al. (2017) found that NPEs purchase a large majority of their patents in the secondary market—oftentimes from other NPEs.

[24] We thank Leonid Kogan, Amit Seru, Noah Stoffman, and Dimitris Papanikolaou for providing both patent and citation data.

[25] The USPTO defines utility patents as patents issued for the invention of new and useful processes, machines, manufactures, or compositions of matter or new and useful improvements thereof. A utility patent generally permits its owner to exclude others from making, using, or selling the patented invention for a period of up to 20 years from the date of patent application filing. Approximately 90% of the patent documents issued by the USPTO in recent years have been utility patents.

[26] Note that we do not measure firms' cash holdings in overseas subsidiaries not recorded on the balance sheet (see, e.g., Faulkender and Petersen 2012 and Cohn and Wardlaw 2016); however, as this artificially reduces our estimates of some firms' cash holdings, it should bias against the results we find.

[27] We use Tobin's Q to proxy for investment opportunities.

[28] Neither the magnitudes nor the significance levels of our coefficients change appreciably when we do not use the log transformation.

[29] A survey by the American Intellectual Property Law Association (2015) found the median cost of seeing a patent lawsuit all the way through discovery to be $400,000 for suits with less than $1 million at stake and just under $1 million for $1 million–$10 million suits (see also Bessen and Meurer 2012, 2014). Lawsuits that end at the demand letter or filing stage are less expensive, but precise cost estimates are not available.

[30] *SuedByPE* is a dummy variable equal to 1 if a firm faces IP lawsuits from PEs in a given year.

[31] Note that the number of observations of columns (2)–(5) of Table 3 is smaller than that in column (1); this is because columns (2)–(5) are based on Russell 1000 firms reported by Audit Analytics instead of all Compustat firms.

[32] The *eBay Inc. v. MercExchange, L.L.C.* Supreme Court case made it more difficult for NPEs to seek injunctive relief in patent lawsuits while leaving PEs' injunctive relief options effectively unchanged. At least in theory, this could somehow contribute to the difference between PEs' and NPEs' targeting behaviors. (That said, given that NPEs do not produce commercial products—and, thus, are not in product-market competition with their targets—it is unclear why NPEs would value injunctive relief other than for its ability to pressure cash settlement.) We have redone our analysis for the pre- and post-eBay samples and find similar results in both, so it seems unlikely that the eBay-induced changes in injunctive relief opportunities are driving our findings.

[33] Audit Analytics collects details related to specific litigation, including the original dates of filing and locations of litigation; information on plaintiffs, defendants, and judges; and, if available, the original claim and final settlement amounts.

[34] The concordance file we use was developed by Silverman (2003) and later improved by Kerr (2008). This concordance has been used in several other studies, including those of McGahan and Silverman (2001) and Mowery and Ziedonis (2001).

[35] Although we would ideally prefer to measure cash at the segment level to make our segment-level analysis completely analogous to the tests in Tables 2 and 3, segment-level cash variables are not reported. Thus, we use profitability (revenues net of costs) at the segment level to proxy for profitability of suit.

[36] The remaining 2.38% of cases are not included in the analysis presented in this section as those cases could not be clearly assigned to either group.

[37] We might worry about selection here; in principle, those lawsuits brought by small inventors could be precisely the lawsuits that NPEs are unwilling to take because they are unlikely to yield large cash payoffs. However, if anything, given the significant costs and difficulties small inventors face when bringing lawsuits on their own (Ball and Kesan 2009, Haber and Werfel 2016), it seems more likely that selection effects (if any) would go in the opposite direction. All else equal, the lawsuits small inventors bring directly would be the ones of higher direct return to the inventors; this matches up with what our model suggests (see Appendix A). In any event, we have confirmed empirically that the characteristics of firms targeted by PAEs are similar to those of firms targeted by small inventors.

[38] More generally, NPEs lose in court significantly more often than PEs do; however, all these results vary significantly by technology, industry, court, and NPE entity type (see Allison et al. 2017).

[39] Risch (2015) followed the 10 most litigious NPEs over time, finding that many of their patents were never tested on merits.

[40] A number of other scholars have attempted to assess the quality of NPEs' patents. An early literature (e.g., Shrestha 2010, Fischer and Henkel 2012, and Risch 2012) based on small and selected samples suggested that NPEs' patents are equal in quality to PEs' (or of even higher quality). More recent, large-sample evidence suggests, by contrast, that NPEs, in fact, hold and assert seemingly low-quality patents (see, e.g., Miller 2013, Love 2014, and Feng and Jaravel 2015).

[41] Plaintiffs might choose to litigate older patents rather than newer ones as damages may be higher (or more targets may be available) once there has been more time for ongoing infringement or for technology to build upon the patented invention. However, if this were the only driving effect, then we would not see any difference between the ages of patent asserted by NPEs and PEs.

[42] We thank the associate editor for suggesting we consider this alternate hypothesis.

[43] Patents asserted by NPEs (PEs), on average, have 5.86 (4.83) associated technology classes ($t = 21.50$).

[44] Feng and Jaravel (2015) found concordant evidence, suggesting that NPEs assert patents that were granted by more overburdened patent examiners and contain more "vague" claims.

[45] Our findings here are corroborated by empirical evidence assembled by Allison et al. (2017).

[46] Given the perceived plaintiff-friendliness of Marshall, Texas, for patent lawsuits, we might conversely wonder why PEs would choose not to bring as many suits there as NPEs do. On this point, we can only conjecture, but we might think that as PEs' motivations for bringing suits are varied (e.g., preemption, defensive motives, and competitive docket stuffing), they may also include aspects to which a home court (or court with more technical expertise) may be of increased value relative to the courts in Marshall.

[47] The estimated magnitudes on cash are actually a bit larger in the Cotropia et al. (2014) subsample (given the larger standard deviation of cash in the later 2010–2012 period) with the coefficient on large aggregators being roughly triple the size of small innovators and statistically significantly larger. We also calculate the overlap rate between the RPX and Cotropia et al. (2014) samples for the two years available (2010 and 2012) and find a roughly 90% overlap.

[48] We define thicket industries as those having two-digit SIC codes of 35, 36, 38, and 73, following Bessen and Meurer (2014). These industries encompass software, semiconductors, and electronics and include firms such as Apple, Google, and Intel.

[49] Here, we use the Hadlock and Pierce (2010) financial constraints index of firms' constraints on accessing the external funds.

[50] We find analogous results if we exclude settlements from the analysis.

[51] Following Allison et al. (2010), we exclude case outcomes such as "stay," "transfer," and "procedural disposition."

[52] Some firms settle for de minimus amounts (e.g., for tax purposes), so our settled + won by NPE category may include some targeted firms that did not really lose much money to NPEs in practice. However, including too many firms in the *Settled + Won By NPE* category would bias against our result, leading us to underestimate the costs of losing to NPEs. Similarly, our *Dismissed + Lost By NPE* category may include some firms that make confidential settlements, but this would again bias against our findings.

[53] We are unsure why PE litigation does not appear to cause a reduction in R&D investment; it has been suggested to us that this effect has something to do with the presence of PE versus PE product market competition, but we are not certain what the mechanism would be. (Indeed, we might have supposed that the relatively higher availability of injunctive relief in PE versus PE lawsuits would lead to more significant R&D reduction than in NPE versus PE lawsuits.)

[54] In these tests, we control for *CitationCommonality*, a pairwise patent similarity measure provided to us by Ambercite (see Table B1).

[55] Nevertheless, we note that, as our theoretical model suggests (see Section A.2), the benefits of NPEs in terms of increased innovation incentives for end inventors (both the direct benefits through lawsuits and the indirect benefits in terms of enhanced licensing

potential) depend on the fraction of NPE profits passed through to end inventors.

[56] Even if small inventors primarily benefit from NPEs via improved licensing opportunities, we would expect this to improve inventors' innovation incentives and, thus, lead to an increase in small inventor innovation. As we see no impact of NPE litigation on small inventor innovation, we infer that the licensing pathway is not providing significant new innovation incentives to small inventors.

[57] To this end, we propose an advance screening solution that would mitigate patent trolling while encouraging high-quality lawsuits (Cohen et al. 2016, 2017).

[58] Note that, with this setup, the inventor's IP has real social/technical value (even if it has no outside commercial value), as using the IP reduces the firm's cost of innovation.

[59] In practice, litigating through an NPE means that the inventor would transfer ownership of the inventor's patent to the NPE (in exchange for the inventor payoffs described in the sequel). The inventor typically would not prefer to license the patent to the NPE in exchange for a constant fraction of future returns, as that would act like a tax on the NPE's returns to litigation and distort the NPE away from optimal litigation effort (this matches up with historical accounts; see, e.g., Khan 2013, 2014).

[60] Our results are unchanged if we also allow damages to be a function of the firm's commercial profits (see the extensive-form game diagram pictured in Figure A.1).

[61] For this maximization, we need to assume $\delta_e''(L) \leq 0$, $p_e''(L) \leq 0$, and $c_e \geq 0$—with at least one strict inequality—so that the relevant second-order conditions hold.

[62] Small inventors may be ex ante budget-constrained so that their litigation efforts L are bounded above; this would amplify the value of NPEs by increasing the surplus from NPE-led litigation.

[63] Note that, in principle, both $\underline{V}_i^*$ and $\lambda(\underline{V}_n^* - \underline{V}_i^*) + \underline{V}_i^*$ can be negative if the costs of litigation c_e are too large in Equation (A.3).

[64] Even though there are many NPEs (on the order of 850 parent companies in our data), there are far, far more small inventors, so the impact of competition on bargaining power, if anything, is likely to favor NPEs.

[65] The analysis extends straightforwardly if the firm's cost of defense depends on the plaintiff's effort or on whether infringement has occurred.

[66] Here, $\mathbb{1}$ denotes the indicator function.

[67] We thank a referee for pointing out this observation.

[68] If the firm splits fraction α of the surplus with the inventor, then Equation (A.11) is increased by an additional term $\alpha(c_f + \pi)$, but this term is independent of whether the NPE is available, so our qualitative results are unchanged. (The presence of the NPE would not affect α as the full effect of the NPE on the firm's payoff is already internalized in the maximization term of Equation (A.6).)

[69] A secondary effect of NPEs, which we do not explicitly model here, is that NPE litigation (or the threat thereof) could reduce infringement in ways that mitigate competition by large players, thus freeing small inventors to practice their own inventions. This effect could provide a benefit to inventors over and above the transfer value as firms' infringement reduction is independent of whether transfers from litigation go to inventors or NPEs; however, such benefits only arise in the case that NPE litigation actually reduces infringement, that is, when most NPE lawsuits are high quality.

[70] This finding echoes the classical insight of Polinsky and Shavell (1989) that when court error is possible, if plaintiffs' costs are low (or if the gains from suit are sufficiently high), then potential defendants will choose to disobey the law, as they will be sued irrespective of whether they obey the law.

[71] Although concerns about crowd-out are frequently cited as a reason for reducing NPE litigation, to our knowledge, the observation that patent reform could, in principle, reduce infringement is novel to the present work.

[72] There is not much evidence on the degree to which NPE proceeds are passed back to end inventors, but all available estimates suggest that the pass-through is small (see Bessen et al. 2011 and Bessen and Meurer 2014).

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