Patent Privateering

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Abstract

We examine whether firms under competitive pressure are more likely to sell patents to non-practicing entities (NPEs), also known as patent trolls, and if so, whether those patents are subsequently used in litigation against competitors. We find that when firms face technological competition, they are more likely to sell their patent rights to a non-practicing entity. Furthermore, the likelihood that these patents are used in litigation in the next three years increases, especially litigation against the original owner's competitors. Patent sales to trolls are more pronounced among firms who are more likely to benefit from enforcing patent rights via a third party rather than directly. Specifically, firms that operate in technology areas with frequent litigation or high collaboration are more likely to sell to NPEs. The increase in patent sales to trolls is concentrated among well-resourced firms, contrary to the notion that small firms are using NPEs to enforce patent rights against larger industry players. The results are robust to an instrumental variable approach and behave intuitively around legislative reforms that curb patent trolls' litigation effectiveness. Our results highlight an overlooked player in the policy debate about patent trolls, namely the practicing entities that "feed" the trolls in the first place.

Key words: Technological competition, Patent market, Innovation

JEL codes: D23, M40, M41, O30, O31, O32, O34, O39

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In the late 16th century, Queen Elizabeth I of England commissioned Francis Drake to sail for America. The Queen asked him to plunder Spanish vessels on its way there. Francis Drake became a pirate commissioned by the crown. This type of "legal" pirate was called a "privateer." They allowed nations to attack one another without the risk to be counterattacked, because the identity and the nationality of these pirates' employer were kept secret.

Today, the spirit of those pirates is reborn. Called "patent troll," they now act for high-tech companies by "patent privateering" others.

- *Thibault Schrepel, LLM*

1. Introduction

The past two decades have seen a sharp rise in patent litigation in the United States brought about by non-practicing entities (NPEs). Practicing entities dominated patent litigation in the first half of the 2000s, representing about 70% of lawsuits. From 2009 to 2015, the proportion almost reversed - now NPEs assert patents in most lawsuits (55%-60%) (Miller et al. [2018]). NPEs acquire patents not to develop commercial products, but to seek licensing fees or pursue infringement litigation related to their patent portfolios. The rise of NPEs has sparked debate on NPEs' controversial impact on innovation. Proponents argue that NPEs play a valuable role in deterring patent infringement by acting as intermediaries to enforce intellectual property rights, especially for small inventors. They contend that without NPEs, well-funded firms could more easily infringe upon smaller inventors' intellectual property (Federal Trade Commission [2011]). Conversely, critics argue that NPEs hinder innovation and technological progress by inflicting significant financial losses on both large and small companies.

A growing body of literature has provided evidence consistent with the critics' view. It shows that NPEs, often labeled as "patent trolls," frequently file frivolous lawsuits against operating firms, irrespective of actual patent infringement, thereby hindering innovation.[1] For example, Cohen et al. [2016, 2019] show that patent trolls tend to target cash-rich firms, leading

[1] We use NPEs, patent assertion entities (PAEs), and patent trolls interchangeably in this paper.

to a negative impact on the research and development (R&D) activities of these defendants. Additionally, several studies highlight that unique characteristics of certain start-ups and small companies make them attractive targets for NPEs, even though they may lack deep pockets. These studies show that patent infringement claims by NPEs adversely impact these firms' ability to grow, create jobs, innovate, and raise capital (Chien [2012], Appel et al. [2019]). Chen et al. [2023] further show that the negative financial and real impact of NPE litigation spills over to the defendants' technology peer firms. While much of the existing literature focuses on the downstream impacts of NPEs, little is known about the entities *supplying* patents to patent trolls or their strategic objectives. We examine whether firms under competitive pressure are more likely to sell patents to NPEs, and if so, whether those patents are subsequently used in litigation against competitors.

One strategy a firm can undertake when facing competitive pressure is to sue rivals for infringing on the firm's patents, thereby enforcing its monopoly right and changing the competitive landscape. However, directly suing a competitor can increase the likelihood of receiving a countersuit or other form of retaliation, a strategy frequently advised by lawyers counselling defendants in an infringement suit (McDaniel and Matthews [2024]). Instead, a firm could employ patent privateering as an alternative strategy to assert its intellectual property rights without directly suing the infringing party. In a patent privateering strategy, the company sells its patents to a non-practicing entity, which then often uses that patent to pursue infringement claims against other firms. This approach allows the original owner to distance itself from direct litigation while still reaping competitive benefits.[2] As competitors become embroiled in legal disputes, they are

[2] As the introductory quote implies, there may be instances where there is an explicit agreement between the original patent owner and an NPE at the time of sale that the NPE will pursue litigation against the original owner's competitors. For example, Kesan, Laye-Farrar, and Schwartz (2019) find cases of NPEs that have explicit financial agreements to revenue sharing with the seller, though they acknowledge the underlying agreements are typically

often forced to redirect resources away from R&D and other strategic initiatives (Chien [2012], Appel et al. [2019]). This diversion can slow their innovation, allowing the original owner to advance its products or services without encountering the same level of competitive pressure.

Compared to directly enforcing a patent, privateering allows a company to distance itself from direct involvement in litigation, which offers distinct advantages. First, by using a third party (i.e., a patent troll) the original owner could reduce the likelihood of being the target of retaliatory actions. Information about patent sales is often opaque and lacks timeliness, allowing the seller to obscure its involvement. Even if a sued competitor identifies the original owner, the firm can credibly hide behind the argument that it only sold the patent to rebalance its innovation portfolio or for liquidity reasons. Second, by providing a means for the original owner to distance itself from the litigation, patent privateering minimizes the risk of receiving negative publicity and backlash from stakeholders, including customers and investors. Finally, privateering can help mitigate the costs of regulatory scrutiny (Cohen et al. [2016], Appel et al. [2019]). If a patent troll sues on the focal firm's behalf, the Federal Trade Commission (FTC) and Department of Justice (DOJ) could be less likely to scrutinize the lawsuit as a potential violation of antitrust regulations.

We conjecture that firms facing heightened technological competition are more likely to engage in patent privateering to change the competitive landscape. Specifically, our first hypothesis predicts that firms experiencing greater technological competition will sell more patents to trolls. While firms sell patents for various reasons, such as to rebalance an innovation portfolio, for liquidity, or to meet earnings targets (Kim and Valentine [2024]), we anticipate that

confidential and thus unobservable on a large scale. However, selling patents to a troll absent an explicit agreement that they sue competitors nonetheless increases the likelihood the original owner's competitor is sued for patent infringement given NPE's business model of enforcing patent rights via litigation. Our objective is to examine both types of patent privateering, be it explicit agreements with trolls or via increasing the likelihood a competitor is sued.

privateering motivated patent sales are more likely to lead to increases in patent litigation. Our second hypothesis posits that heightened technological competition is also associated with subsequent increases in patent infringement lawsuits targeting focal firms' technological peers, rather than non-peers, consistent with a deliberate attempt to influence the competitive environment.

Leveraging the USPTO patent assignment data and the Stanford NPE litigation database, we test our predictions with a sample of 146,851 firm years with at least one patent sale and one patent litigation from 2000 to 2021, including both private and public firms. Inspired by the method utilized in Cao et al. [2018], we proxy for competitive pressure using the sum of peer firms' cumulative patent stock, weighted by their technological proximity to the focal firm and scaled by the focal firm's own patent stock. The idea is that a firm's competitive threat comes from its peers' technological advancement (captured by their patent stock) with these successful efforts weighted by the degree of competition they pose to the focal firm. The scaler accounts for the focal firm's own level of technological progress. An advantage of using a patent-based measure of technological competition is that we can consider the activity of private as well as public competitors. We count the number of patents sold to patent trolls as our primary dependent variable.

We find that the number of patents sold to NPEs is significantly positively associated with the level of technological competition they experience. Specifically, a one inter-quartile increase in technological competition corresponds to a 4.63% increase in patents sold to NPEs. We next examine whether this increased sales prompt increased lawsuits targeting selling firms' peers. We find that the frequency of subsequent patent infringement litigation is increasing in the level of technological competition and that these lawsuits *disproportionally* target firms operating within the same technological domain as the focal firm. This result obtains after controlling for the

number of seller-initiated infringement lawsuits, suggesting that the privateering effect is incremental to the latent level of patent infringement.

To provide stronger evidence that the patents sold to trolls are then used in litigation against the sellers' peers, we perform a matched patent-sample analysis that compares patents sold to the same troll but differ on two dimensions (i.e., targeted peer group or pseudo-sale date). In this matched patent sample, we find that the frequency of subsequent patent infringement litigation increases in the three years following the sale among peers of the seller's patent, but not among peers of the counterfactual patent sale or around a pseudo sale date. We include in this specification a dense fixed effect structure, including matched pair by patent and matched pair by year fixed effects. Thus, the incremental increase in NPE litigation targeting peers of the selling firm is likely attributable to the sale of the focal patent and less likely due to trolls simply suing a focal firm's rivals more in general. Furthermore, NPEs' incremental propensity to sue the seller's peers using the recently purchased patent is stronger when greater technological competition is present. Taken together, the evidence is consistent with the practice of patent privateering, where firms strategically transfer patents to NPEs, increasing the likelihood their technological competitors are sued for infringement and tied up in costly litigation.

Next, we investigate cross-sectional variation in the effect of technological competition on privateering. We find that privateering is more pronounced among firms more likely to prefer suing competitors via a third party, namely firms that operate in technology sectors with frequent litigation and where collaboration is valued. In subsample analysis, we find that firms endowed with greater resources, and thus more concerned about attracting antitrust scrutiny, are more likely to engage in patent privateering. This finding challenges the idea that NPEs help level the playing

field between large and small firms, and instead suggests that more sophisticated actors strategically use patent sales to trolls.

We recognize that unobservable factors may influence both technological competition and patent sales to trolls. To address potential endogeneity, we perform two additional tests to strengthen our identification. First, the America Invents Act ("AIA"), enacted in 2013, included several reforms that limited the ability of NPEs to enforce patents (Bryant [2012]). We find that the positive relation between technological competition and patent transfers to NPEs has weakened post AIA. This suggests that when regulation reduces NPEs' ability to enforce patent infringement, firms sell fewer patents to trolls in anticipation of a privateering strategy being less effective.

Second, we use the introduction of state-level R&D tax credits to construct an instrumental variable for technological competition (Bloom et al. [2013], Cao et al. [2018]). The idea is that state-level R&D tax credits stimulate R&D activity and thereby patenting by peer firms headquartered in the affected states, leading to exogenous changes to a focal firm's perceived competition. The technological competition predicted by R&D tax credits is thus correlated with the competition faced by a focal firm but is not expected to directly influence the patent sales to NPEs. Our results remain robust under this instrument variable approach.

We perform three sets of additional analyses to validate the robustness of our results. First, we consider two alternative measures for our dependent variable. Our main proxy is the number of patent sales to trolls, which captures both the occurrence and volume of transfers. We employ two alternative metrics: 1) a binary indicator for patent sales to trolls, which focuses solely on the presence of a transfer; and 2) the number of sales to trolls as a percentage of the total number of patent sales for the year, which directly controls for a firm's overall propensity to sell patents. In both cases, our inferences remain the same.

Second, we assess the robustness of our results using two alternative definitions of technological competition. In the first approach, we remeasure technological competition using only peer firms with above-median patent portfolio similarity to the focal firm, excluding those with lower similarity to the focal firm's patent portfolio. In the second approach, we compute technological competition based exclusively on patent stock within the top ten CPC 3-digit classes given that that approximately 80% of the patents sold to trolls are concentrated in the top ten technological classes (many related to high tech as the introductory quote suggests). Our results are robust to both alternative definitions.

Third, to further address the possibility of unmodeled time-invariant factors driving our results, we conduct a falsification test by examining the association between four-year ahead technological competition and current year patent sales. We find an insignificant association between future technological competition and current patent sales, which alleviates concerns regarding the influence of omitted variables on our findings.

We contribute to the literature on technological competition and firms' strategic behavior. Prior work finds that firms can use disclosure to deter or even sabotage competitors (Glaeser and Landsman [2021], Valentine, Zhang, and Zheng [2024], Zhang [2024]). We complement this evidence by demonstrating that a real action, namely patent sales, can also be a means of changing the competitive environment. Prior literature has found that firms' creation of patent thickets can change innovation in the area (Galasso and Schankerman [2010]; Noel and Schankerman [2006]; Ziedonis [2004]) and that firms can use acquisitions to quash competitor technologies (Kepler, McClure, and Stewart [2024]). We add to this literature by documenting patent privateering as another strategy firms use to influence their relative position among technology peers.

We also contribute to the emerging literature that examines the implications of innovation-oriented firms' patent sales to non-practicing entities that own patents without producing commercial products or providing services. Existing research primarily focus on the behavior of patent trolls, particularly their litigation patterns against practicing companies and the negative consequences for the targeted firms. For example, prior studies find that patent trolls often target firms with substantial financial resources, such as large firms with good performance and significant cash holdings (Cohen et al. [2019]). Extant work also finds that patent trolls impair the ability of targeted firms to innovate and grow (Tucker [2014], Cohen et al. [2019], Appel et al. [2019], Mezzanotti [2021]). Our paper complements these studies by investigating the actors enabling these trolls and their strategic motives. We reveal that, in many cases, it is the competitors of the targeted firms who instigate these patent attacks.

2. Institutional Background and Hypothesis Development

2.1 Institutional Background

In 2019, industries relying on intellectual property accounted for 41% of U.S. economic output and 44% of employment (Toole, Miller, and Rada [2019]). Furthermore, intangible assets account for an increasing share of firm value over time (Corrado and Hulten [2010], Eisfeldt and Papanikolaou [2013], Srivastava [2014]). Given the importance of intellectual property to the broader economy and to individual firms, there are important incentives for firms to properly manage their intellectual property portfolio, including patents. Patent holders have exclusivity rights for a specified period of time but must be prepared to sue for patent infringement in order to enforce those rights.

In a regime with clearly defined and transparent intellectual property rights, innovators can avoid *ex post* infringement lawsuits by identifying the technologies required before making an

investment decision. If a patented technology exists that is necessary for the firm to develop its invention, it can enter into a licensing agreement with the patent holder *ex ante*. However, in practice it can be difficult to identify the legal boundaries for an invention due to the inherent subjectivity in defining intellectual property rights (relative to physical property, for example) and the sheer volume of granted patents (Bessen and Meurer [2013]). This uncertainty leaves open the possibility that firms will invest in a technology only to find *ex post* that it infringes on another's patent. In that case, a firm could "come clean" to the technology developer about its unwitting infringement and attempt to negotiate a licensing agreement ex post, risk willful infringement in the hope of going undetected, or attempt to invalidate the related patent in litigation (Bessen and Meurer [2006]).

Patent litigation is a lengthy and costly process that favors well-resourced firms with large patent portfolios (Bessen and Meurer [2013], Lanjouw and Schankerman [2004]). The median time to trial for patent litigation is over two-and-a-half years (PriceWaterhouseCoopers [2018]). Lanjouw and Schankerman [2004] find that firms with larger patent portfolios are less likely to be sued for infringement. They also argue that a large patent portfolio allows firms to settle disputes before going to court for two reasons. First, firms with large patent portfolios may be more able to enter into cross-licensing agreements. In practical terms, when firms with large patent portfolios are sued for infringement, they have a deeper bench of patents to draw from to threaten to countersue for infringement, thus bringing the other party to the negotiating table. If it is determined that both firms are infringing on each other's patents, they can negotiate cross-licensing agreements.

Second, larger firms can anticipate more repeated interactions with technology developers and are thus more incentivized to cooperate. Related firms can have repeated business interactions

with each other, including via licensing agreements, customer-supplier relationships, or joint ventures and co-patenting. The existence of repeated interactions can make firms reticent to sue each other (Lanjouw and Schankerman [2004]) and in some cases, licensing agreements may explicitly include a covenant not to sue.

Given that patent litigation favors larger, well-resourced firms, non-practicing entities can potentially play an important role in aiding small entities to enforce their patent rights. NPEs are arguably infringement litigation specialists and better equipped to take on large infringing firms than original patent owners. The PwC 2018 Patent Litigation Study found that NPEs have median damages awards more than three times that of practicing entities over the 2013 to 2017 time period, highlighting their expertise. However, it is also possible that large firms can use patent trolls to engage in patent privateering, a strategy that could allow well connected firms with larger patent portfolios to have their cake and eat it too – be able to maintain relationships with competitors with whom they have repeated interactions and be able to hide behind a third-party enforce patent infringement, thereby increasing their competitors' costs.

2.2 Hypothesis Development

In the presence of competition, a firm can seek to improve its relative position in the industry by increasing the profitability of its own operations and/or by taking actions to decrease competitors' profitability. Specifically, a firm can endeavor to increase its own revenues (decrease competitor revenue) and/or decrease its expenses (increase competitor expenses). Engaging a technology competitor in patent litigation can increase competitor expenses in the short run as the lawsuit progresses and potentially result in a settlement or damage awards. In the long run,

successful deterrence can also decrease competitors' revenues if they exit a profitable technology space, thereby increasing the focal firm's relative market share.[3]

However, companies may not always be in a position to openly pursue patent infringement lawsuits against their competitors. Several factors can deter firms from initiating such legal actions themselves, including strategic business relationships (for example, existing cross-licensing agreements), reputation management, and concerns about drawing antitrust scrutiny. Thus, selling a patent to a third-party who will likely sue a competitor can achieve the same competitive goal for the firm while mitigating the costs of direct legal action.

Thibault Schrepel, an Associate Professor of Law at the Vrije Universiteit Amsterdam University and a Faculty Affiliate at Stanford University, defines patent privateering as "strategy where a [non-practicing entity] acquires/buys patents [from] its original holder and then engage a lawsuit against companies, in most cases the rivals of the original holder. The troll and the original holder then share the booty. It could be either licensing royalties, litigation settlements or damage awards." We define patent privateering more broadly to also include the original owner selling a patent to an NPE to simply increase the likelihood a competitor is sued, rather than requiring an explicit agreement between an NPE and the original owner to share in the benefits.

The benefits of patent privateering via an NPE potentially include 1) preserving the firm's relationships with competitors, including shielding the firm from retaliatory actions, 2) minimizing negative publicity from stakeholders, and 3) protecting the firm from antitrust allegations. First, using an NPE to sue a competitor rather than suing directly provides the seller

[3] Of course, a firm trades off the expected litigation costs of bringing a patent infringement lawsuit against a competitor with the net benefits of harming the competitor's profitability. The direct costs of lengthy litigation proceedings can increase a firm's own expenses in the short run. Industry reports suggest that for the average patent lawsuit, costs are $1.6M through the discovery stage and $2.8M in total. As discussed further below, in addition to the direct costs of litigation, suing competitors for patent infringement could also potentially expose the firm to potential retaliation.

with a shield of anonymity (or at least increases competitor processing costs) and could prevent competitor retaliation. If the patent seller is intent on maintaining secrecy, they may structure the arrangement such that even the privateer is unaware of the original owner's identity (Ewing [2012]).[4] As a result, it becomes extremely challenging for a target firm to determine the identity of the original owner and who is really behind these lawsuits. Even if the competitor can ultimately identify the original patent owner and attempts to retaliate with an infringement lawsuit of its own, the competitor would still have to contend with the NPE's infringement suit. Thus, the typical strategy of mitigating an infringement lawsuit via a countersuit is rendered ineffective, making a separate retaliatory lawsuit more costly.

Second, firms can use patent privateering as a means to avoid public backlash from customers or investors. For instance, Ewing [2012] identifies a scenario where two large firms compete for a large supply contract with a prominent customer. In this case, either firm might choose to sponsor a privateer instead of engaging in direct litigation which could irritate the prospective customer and backfire. By sponsoring a privateer, the company can subtly undermine its competitor's reputation through litigation by highlighting the competitor's vulnerabilities to the potential customer.

Finally, suing competitors through a patent troll can allow a firm to avoid antitrust scrutiny from regulators. Antitrust concerns are particularly pronounced when the lawsuit is perceived as an attempt to stifle competition or create monopolistic advantages. The Antitrust Division of the US Department of Justice (DOJ) and the Federal Trade Commission (FTC) closely monitor large patent transactions and any subsequent patent infringement lawsuits, especially when firms with significant market share are the plaintiffs (Schrepel [2014]). The DOJ may challenge patent

[4] For example, shell companies are often used to camouflage these privateering arrangements. According to Ewing [2012], Intellectual Ventures, the largest NPE in the U.S., has more than 1,500 shell companies.

acquisitions that create or enhance monopoly power and create the potential for anticompetitive effects. For instance, in 2011 the DOJ prevented Microsoft from acquiring Novell's patents to which Microsoft already had a license (Gross [2011]).[5] Similarly, Section 5 of the Federal Trade Commission (FTC) Act prohibits "unfair methods of competition in or affecting commerce, and unfair or deceptive acts or practices in or affecting commerce", which could be used by the FTC to monitor large patent transactions.

Based on the preceding discussion, we make the following predictions stated in the alternative:

H1: Technological competition increases a firm's patent sales to patent trolls.

H2: Technological competition increases future patent troll lawsuits targeting rivals.

There are several reasons why we may not observe the predicted effects. First, once a firm sells its patent to a troll, it loses control over litigation-related decisions, such as whether to bring suit, settle, or pursue a trial. This loss of control could make the patent privateering strategy less attractive to firms facing competition. Second, in order for a patent transfer to be recognized in court, it must be recorded with the USPTO which eventually makes the transfer record public knowledge. Accordingly, it may be possible for competitors to identify when they are the target of a shadow lawsuit and still find a way to retaliate against the firm. If the firm anticipates competitors will retaliate despite increased processing costs about patent ownership, it may not pursue the patent privateering strategy.

[5] https://www.pcworld.com/article/490637/article-1284.html

3. Research Design

3.1 Data and Sample Selection

We obtain information on patent sales from the USPTO patent assignment data, patent characteristics from PatentsView, and NPE litigation data from the Stanford NPE Litigation Database. The USPTO patent assignment dataset includes information such as the buyer and seller names, the number of patents included in the sale, the sale execution date, and a brief description of the reason for the patent trade. PatentsView allows us to observe patent information for both public and private firms, such as technology class, the number of figures included in the patent filings, and forward citations received. Finally, the Stanford NPE Litigation Database provides comprehensive records of patent lawsuits filed in the U.S. district courts from 2000 to 2022, identifying each patent plaintiff as either a practicing entity or as one of eleven types of plaintiffs.

Table 1 illustrates our sample construction process. We combine the above three databases to create a sample with a firm-year unit of observation. We begin with all firm-years between 2000 and 2021 in PatentsView, totalling 6,741,658 observations. We select this sample period because 2000 marks the earliest year for which the Stanford NPE Litigation data is available, and we examine all litigation occurring in the three years following the year when technological competition is measured, making 2021 the final year of our sample period. To ensure the firms in our sample participate in the secondary patent market and are involved in intellectual property litigation, we require firms in our sample to have at least one patent sale and one patent that has been asserted (either directly or indirectly) for patent infringement within this period, resulting in 195,140 observations. Additionally, each firm-year must have been granted at least one patent in the past 20 years to ensure active engagement in patenting. This process yields a final sample of

146,851 firm-year observations, representing 8,625 unique firms. Among these, 7,018 are private firms and 1,607 are publicly traded firms.

3.2 Key Measures

3.2.1 Key Dependent Variable: Patent Sales to Troll

We define our key measure of patent trades, *No. Patent Sales to Trolls*, as the inverse hyperbolic sine (IHS) transformation of the total number of patents sold to patent assertion entities (PAEs) or trolls by a firm in year t, following Kim and Valentine [2024]. We apply the IHS transformation to this variable to address issues associated with skewed distribution and accommodate zero values and then multiply by 100 for ease of interpretation.

Given that the patent market, particularly patent sales to trolls, is relatively underexplored in the literature, we provide some descriptive context in this subsection. As illustrated in **Table 2, Panel A**, of the 146,851 firm-year observations, 24,154 (16.45%) have at least one patent sale. Of these, only 2,245 firm-years (1.53%) involve patent sales to trolls, suggesting such transactions are relatively rare. However, among the 8,625 unique firms in our sample, 1,301 (15.08%) have sold a patent to a troll at least once. Notably, more than half of those firms (666 out of 1,301, or 51.2%) have their sold patents subsequently involved in patent troll litigation. Taken together, these summary statistics suggest that while patent sales to trolls are not common, such transactions may be strategically motivated, given the high probability of subsequent litigation.

Table 2 Panel B lists the top ten patent technology classes with the highest number of patents sold to patent trolls, along with the percentage of patents in each technology class sold to these entities. Not surprisingly, the categories of Electric Communication, and Computing, are at

the top of the list. This trend can be attributed to the USPTO's practice of granting numerous overlapping and broadly defined patents in these technology areas (Boyfield [2013]).[6]

Table 2 Panel C compares the characteristics of patents sold to trolls with those sold to other parties, and those that were never sold. Compared to sales to other parties, transfers to trolls typically involve a larger number of patents per transaction. Overall, patents that are sold to trolls tend to be more valuable, as indicated by their scientific value (proxied by forward citations) and possess greater scope (measured by the number of independent claims). These patents are generally older and tend to exhibit less transparency in their disclosures (as indicated by fewer patent figures), and involve fewer inventors. These observations are consistent with the findings in the literature, which indicate that while patent trolls are generally known for using older and vaguer patents, those affiliated with established companies may be equipped with higher-quality patents, as these patents originate from operating firms. Consequently, such patents can have a more significant impact on the competitive landscape (Schrepel [2013]). Given these differences, we control for these characteristics in our subsequent multivariate analysis.

3.2.2 Key Independent Variable: TechComp

To construct the technological competition measure, *TechComp*, we follow Bloom et al. [2013] and Cao et al. [2018], adapting their R&D-based measure from product market competitors to the patent domain. Boom et al. [2013] create a measure using the sum of peer firms' cumulative R&D investments, weighted by their closeness to the focal firm, based on the idea that a firm's technological threat comes from its peers' technological advances as proxied by R&D investments. Cao et al. [2018] refine this measure by using the firm's own R&D investments as the scalar, thus accounting for the sample firm's own preparedness.

[6] The USPTO grant patents that essentially overlap with existing patents 30% of the time: https://www.thisamericanlife.org/441/transcript

Overall, the technological competition measure from Cao et al. [2018] reflects the aggregate technological investments of a firm's *product market* peers relative to the firm's own investments. We measure technological competition in the *patent* domain similarly. Specifically, for sample firm *i*, *TechComp* at the beginning of fiscal year *t* is calculated as follows:

$$TechComp(untransformed)_{i,t} = \sum_{j \neq i} (\omega_{i,j} \times Patent\ Stock_{j,t}) \,/\, Patent\ Stock_{i,t}$$

Our measure of *TechComp* has three components: (1) peer *j*'s patent stock at the beginning of year t; (2) the closeness of peer *j* to sample firm *i* in the technology space, which we proxy for using the distribution of firms' patent stock across CPC subclasses. $\omega_{i,j}$ serves as the weight to aggregate threats from multiple peers; and (3) firm *i*'s own patent stock at the beginning of year *t*. We measure a firm's patent stock as the number of patents granted over the past 20 years, with a decay rate of 15%: $Patent\ Stock_{j,t} = \sum_{n=1}^{20}[Patent\ Grant_{j,t-n} \times (1 - 15\%)^n]$.

$\omega_{i,j}$ is calculated as the cosine similarity of the peer firm's and the sample firm's patent distributions for fiscal year *t* across CPC 4-digit subclasses as follows:

$$\omega_{i,j} = \frac{\sum_{k=1}^{K} v_{i,k} v_{j,k}}{\sqrt{\sum_{k=1}^{K} v_{i,k}^2} \sqrt{\sum_{k=1}^{K} v_{j,k}^2}}$$

where the index of summation *k* goes over each CPC 4-digt subclasses and $v_{i,k}$ is firm *i*'s patent stock in technology subclass *k* divided by the firm's overall patent stock. The cosine similarity increases with the number of overlapping CPC subclasses between the patents of the two firms and also with the proportion of each firm's patents in the overlapping CPC subclasses. Intuitively, firms with a similar patent distribution across technology subclasses are considered closer

technological competitors and pose a greater threat to each other. **Online Appendix 1** provides more details about the calculation of $\omega_{i,j}$ with some examples.

Overall, our *TechComp* measure captures the technological advancement of peer firms in terms of successful innovation efforts, as indicated by their patent stock, and weighs these efforts by the degree of competition they pose to the focal firm. This measure also accounts for the focal firm's competitive position in the patent race, as measured by its own patent stock. A higher value of *TechComp* indicates greater technological competition in patenting that the focal firm faces. The median value of *TechComp* for our sample firm-years is 9.192, indicating that for every unit of patent stock held by the average sample firm, its peers hold a total of 4,913 in patent stock.

3.2.3 Reasons for the Modification

We modify the product market rivalry measure of Cao et al. [2018] by replacing the dollar amount of R&D stock, an input measure, with patent stock, an output measure of innovation. This adjustment is driven by two considerations. First, from a conceptual standpoint, patent stock more accurately reflects the technology threat posed by competitors, as it captures successful innovation efforts, whereas R&D expenditures do not always result in patents. Second, our sample comprises both public (19%) and private firms (81%), for which R&D investment data is unavailable. Excluding private firms, which constitute a significant portion of the sample, would likely introduce significant measurement error in assessing competition and lead to potentially erroneous conclusions and inferences (Ali et al. [2009], Ali et al. [2014]).[7] Consistent with this modification, we also identify *peer* firms based on their overlap in patenting with the focal firm rather than on product market competition.[8]

[7] Ali et al. [2009] suggest that proxies for product market competition using COMPUSTAT data, which covers only public firms in an industry, exhibit significant measurement error for the actual level of competition. Based on this argument, Ali et al. [2014] develop new proxies for product market concentration based on the U.S. Census data.
[8] Our results are robust to two alternative measurement choices for defining *TechComp* (see section 6.2).

Table 3 provides summary statistics on patent sales, subsequent litigation, *TechComp*, and control variables, for our sample firms. The top panel of this table shows the distribution of the two sets of dependent variables. Consistent with our previous observations, the mean values for *No. Patent Sales to Trolls* (untransformed) is 0.497 and for *Patent Sales to Trolls (dummy)* is 0.015. This indicates that patent sales to trolls are relatively infrequent, with only 1.5% of the firm-year observations involving such transactions. Regarding subsequent litigation, on average, our sample firms experience 0.195 cases where patents sold to trolls lead to infringement lawsuits initiated by these trolls against other parties in future three years. Turning to control variables, firms in our sample, on average, sell 5.437 patents to other parties (untabulated) and initiate 0.482 patent lawsuits in the 3-year window (untabulated). Each firm-year observation has an average patent stock of 94.241(untabulated). The average age of these patents is 8.39 years, with a diversification score of -0.562, and a scientific value of 0.072 (untabulated). Additionally, these patents average 3.173 independent claims, 11.854 figures, and 2.268 inventors (untabulated).

4. Regression Model and Results

4.1 Technological competition and Patent Sales to Trolls

To test our main hypothesis on whether technological competition drives firms' decision to sell patents to trolls, we estimate the following regression at the firm-year level:

Eq. (*1*):

$$No.\,Patent\ Sales\ to\ Trolls_{i,t} = \beta_1 TechComp_{i,t} + Controls + Firm\ FE + Year\ FE + \epsilon_{i,t}$$

For firm *i*, year *t*, the dependent variable in Eq. 1 is the number of patents sold to trolls and $TechComp_{i,t}$ is our measure of technological competition, as previously defined. A positive coefficient on $TechComp_{i,t}$ suggests that technological competition has a positive effect on the

focal firm's decision to sell their patents to patent trolls, with a high likelihood the NPE will deploy them to pursue litigation against their competitors.

We include a vector of time-varying control variables for firm-year-level characteristics that may impact the decision to sell patents to trolls. Specifically, we first control for firm-level factors related to the supply and tendency to sell patents. These factors include the number of patents the firm sold to parties other than trolls, the focal firm's patent stock, and the average age of patents in its patent portfolio.

Following Kim and Valentine [2024], we also include control variables that capture the quality of the patents, such as patent scientific value, and the transparency of patent disclosure, measured by the number of patent figures and the number of inventors listed on the patents. Additionally, we include two litigation-related characteristics of patent portfolio: the number of independent claims and the level of patent portfolio diversification. Patents with more independent claims are broader and, therefore, easier to defend, which may increase the likelihood of patent sales to trolls. The influence of patent diversification on patent sales to trolls is less clear. While a firm with a diverse patent portfolio might be more likely to sell its non-core patents to trolls, the firm's overall complexity may make active privateering less feasible. Such firms might prefer to use non-core patents defensively rather than selling to trolls. Ultimately, patent portfolio diversification could either increase or decrease the propensity to sell patents to trolls. In all our main analyses, we include firm and year fixed effects and cluster standard errors at the firm level.

4.2 Technological Competition and Litigation Through Troll

If patent sales to trolls are intended to deter competition by equipping PAEs with patents to increase the likelihood competitors are plagued with litigation, we would expect to observe an increase in the number of infringement lawsuit, filed against focal firms' competitors in the years

following a patent sale to a troll. We examine whether technological competition leads to an increase in patent infringement litigations initiated by trolls against peer firms in subsequent years. Specifically, we estimate the following regression model:

Eq. *(2):*

$$Troll\ Litigation_{t+1,t+3} = \beta_1 TechComp_{i,t} + Controls + Firm\ FE + Year\ FE + \epsilon_{i,t}$$

where the dependent variable can be one of two variables: 1) the number of patent lawsuits initiated by patent trolls in the future three years (from t+1 to t+3) using patents acquired from an operating firm ($Patent\ Litigation\ through\ Trolls_{t+1,t+3}$).[9] We apply the inverse hyperbolic sine (IHS) transformation to this variable to address issues associated with zero values and then multiply it by 100 for ease of interpretation; or 2) the number of patent lawsuits that target the focal firm's technological peer firms, where peer firms are those competing in the same patent class as the focal firm ($Litigation_target\ peers_{t+1,t+3}$).

The control variables are largely consistent with those used in Eq. 1, with one exception. In the determinants model of patent sales to trolls, we control for the number of patents the firm sold to parties other than trolls. For Eq. 2, we replace that variable with the number of patent lawsuits initiated by the focal firm during the same time period (year t+1 to year t+3), to control for the latent level of patent infringement.

If technological competition (*TechComp*) indeed motivates our sample firms to sell patents to trolls to increase the likelihood their competitors are deterred via patent infringement lawsuits,

[9] Note that we include any patents a troll has acquired from operating companies when determining the number of patent lawsuits. An ideal approach would be to identify which patents sold to trolls were motivated by a patent privateering strategy and examine whether those specific patents were used by a troll to sue a competitor for infringement. However, we are not able to take this approach given the difficulty in positively identifying the motivation for patents sold and instead rely on the notion that patents sold with a privateering strategy will differentially target the original owner's peers.

we expect β_1 to be positive. Again, we control for firm- and year-fixed effects and cluster standard errors at the firm level.

4.3 Empirical Results

Table 4 presents the results of estimating Eq. 1 (H1). Columns (1) to (3) present results with fixed effects and with progressively adding different combinations of control variables. Across all three columns, the coefficients on *TechComp* are positive and significant at the 1% level. Specifically, **Panel A,** Column (1) of **Table 4** shows a significant positive association between *TechComp* and *No. Patent Sales to Troll*, after controlling for the overall tendency to sell patents, the stock of granted patents, patent age, and firm and year fixed effects (coefficient = 0.536; t-stat= 3.13). Columns (2) and (3) indicate that this effect persists when additional controls are included: Column (2) considers patent characteristics such as patent scientific value, number of patent figures, and number of patent investors while Column (3) includes litigation-related characteristics of patent portfolios. In terms of economic significance, the coefficient of 0.649 in Column (3) suggests that, increasing *TechComp* from the 25th percentile to the 75th percentile is associated with a 4.63% increase in patent sales to patent trolls per firm-year, indicating that the effect is economically meaningful.[10]

Table 5 presents the results of estimating Eq. 2, where the dependent variable is the number of litigations through troll (*Patent Litigations through Troll*$_{t+1,\ t+3}$) in Column (1), and the percentage of such litigations targeting the focal firm's technology peer firms *(Litigation_target peers*$_{t+1,\ t+3}$) in Column (2). We find the coefficient on *TechComp* is significantly positive when

[10] To compute the economic effects, we first multiply the regression coefficient (e.g., 0.649 in Column (3) of Table 3) to the change in our independent variable going from the 25th to the 75th percentile: 0.649×(10.713-7.733) = 1.93402. We use this value to derive the implied change in our dependent variable relative to its (untransformed) mean value (i.e., 0.497) in the following way: 100×(IHS(0.497×(1+r)) – IHS(0.497)) = 1.93402 and solve for r to assess the economic effect of the coefficient relative to the mean value of our dependent variable. In this example, r = 4.63%. Unless otherwise noted, the economic magnitudes of other analyses are computed analogously throughout.

Patent Litigations through Troll$_{t+1, t+3}$ (coefficient = 1.034; t-stat = 3.78) and %*Litigation_target peers*$_{t+1, t+3}$ (coefficient = 0.133; t-stat = 2.68) are the dependent variables.

Collectively, these results suggest that after our sample firms sell their patents to trolls in response to increased technology threats from their peers, these trolls tend to leverage patents to sue practicing firms in subsequent years. Such litigation tends to disproportionally target the focal firms' technology peers. The coefficients on *TechComp* are 1.034 and 0.133 in Columns (1) and (2), respectively. In economic terms, moving from the 25th percentile to the 75th percentile in *TechComp* is linked to a 15.38% increase in the number of patent lawsuits targeting any firm (Column 1) and a 38.86% increase in the proportion of such litigations specifically targeting the focal firm's technology competitors (Column 2). These effects are economically meaningful.

Our main dependent variable captures infringement litigations within *three years* following the year when *TechComp* is assessed. In un-tabulated results, we also estimate Eq. 2 for litigations in years t+1, t+2, and t+3 separately. The coefficient on *TechComp* is positive and statistically significant at the 1% level for each of the three years, although it exhibits decreasing economic and statistical significance over time.

While our firm-level evidence on litigation, as presented in **Table 5**, provides evidence that trolls are likely to sue focal firms' competitors after a patent sale, it does not answer the question on whether the trolls precisely use acquired patents to sue the competitors, as a privateering strategy would imply. To examine this implied relation, we use a more granular approach by examining litigation behavior at the *patent* level. Specifically, we employ a nearest-neighbor matching approach to pair each patent (patent A) sold by a focal firm to a troll with another, characteristically similar patent (patent B) sold by another firm to the *same* troll. We expect that a

troll will be more likely to *specifically* use patent A to target firm A's technological competitors relative to that of patent B, and consider two benchmarks for this analysis.

First, for Patent A that was sold to a troll, we examine the number of litigations targeting peers of seller A in the three years around the actual sale to the number of litigations targeting peers of seller A in the three years around the sale of Patent B that was sold to the same troll in a different period. This comparison holds constant the peer group (all peers of seller A) and exploits variation in whether the period of the patent sale was the true selling date or a counterfactual selling date to the same troll (i.e., Patent B's actual sales date). Second, for Patent A that was sold to a troll, we examine the number of litigations targeting peers of seller A in the three years around the actual sale to the number of litigations targeting peers of seller B for the same period (where Patent B was sold to the same troll in a period different from Patent A). This comparison holds constant the time period and exploits variation in the peer group.

Table 6 presents the results of the patent-level litigation analysis. Consistent with our expectation, **Panel A** Column (1) shows that trolls are more likely to target peer firms specifically using patents acquired by a focal firm, relative to patents acquired by another firm. As falsification, Column (2), however, shows that trolls are not more likely to target non-peer firms of the selling focal firm. **Panel B** presents a subsample analysis based on the technological competition. Consistent with a patent privateering mechanism, we find that the increased frequency of litigation targeting the seller's peer firms specifically using the seller's patents is stronger when the seller faces a higher level of technological competition (i.e., the estimate in Column (2) is statistically greater than that of Column (1)). Taken together, our results support the idea that technological

competition motivates our sample firms to sell patents to trolls, who then in turn use those patents to sue the seller's competitors.

4.4 Mechanism Tests

We next exploit cross-sectional variation in the degree to which firms prefer to use a proxy to sue their competitors. One significant advantage of using patent trolls for litigation – rather than asserting the patents directly – is that it decreases the likelihood of retaliation by obfuscating the identity of the firm behind the transaction. We examine two sources of such variation. First, if a firm operates in technology spaces with frequent litigation, the ex-ante likelihood of a retaliatory lawsuit increases. Second, for firms innovating in highly collaborative technological spaces, maintaining good relationships with peers is crucial. As a result, these firms are more likely to shadow sue their peers through patent trolls, rather than initiating litigation.

Given that the majority of our sample firms are private firms, for which we do not have financial statement data, we use patent portfolio characteristics to capture the aforementioned cross-sectional variables. Specifically, we capture litigation frequency and innovation collaboration intensity based on patent stock. **Appendix A** provides detailed variable definitions. We partition observations based on the sample median of each cross-sectional variable and estimate Eq. 1 for each sub-sample. We expect the effect of *TechComp* on *No. Patent Sale to Trolls* to be more pronounced among firms operating in technology spaces with frequent litigation and in highly collaborative technological areas, as they are more likely to benefit from privateering by obfuscating their identity.

Table 7 presents the results of this analysis: **Panel A** presents the results based on the litigation frequency and **Panel B** presents the results based on the innovation collaboration intensity. Consistent with our predictions, the effect of *TechComp* on sales to trolls is more pronounced

among firms innovating in litigious technology areas and firms innovating in technology fields with high collaboration intensity. F-tests indicate that these differences are significant between each pair of sub-samples.

4.5 Subsample Analysis

We next examine the characteristics of firms for whom patent trolls appear to be enforcing patent rights. We first examine firm size. On the one hand, small players in the technology area could turn to NPEs to enforce patent rights due to resource constraints, and thus patent trolls have the potential to level the competitive playing field. On the other hand, larger firms could be more concerned about antitrust scrutiny (Watts and Zimmerman [1986]). Large firms with significant market share are often more visible and have many competitors, making them more likely to attract antitrust scrutiny. Thus, larger firms could have greater incentives to use trolls as a means to sue competitors rather than suing directly and be accused of anticompetitive behavior.

Second, we explore whether firms with strong financial positions are more likely to sell patents to trolls in anticipation that they may otherwise be targeted for retaliatory infringement lawsuits because competitors know these firms can potentially pay substantial settlements or damages (Cohen et al. [2019]). Alternatively, financially constrained firms could be more likely to sell to NPEs for liquidity reasons and benefit from resource-rich trolls pursuing any infringement lawsuit. We measure firm size based on patent stock as it is applicable for both public and private firms in our sample. For the subsample of public firms, we assess financial positions using cash holdings and the leverage ratio.

Table 8 presents the results of this analysis: **Panel A** reports sub-sample results based on size and **Panel B** details results for leverage ratio and cash holdings. We find that the effect of *TechComp* on privateering is more pronounced among large firms, firms with low leverage ratios

and high cash holdings. F-tests indicate that these differences are significant between each pair of sub-samples, except for firm size. Importantly, the F-test for firm size becomes significant when comparing firms in the top quintile with others, suggesting that only the largest firms are more likely to sell to trolls, perhaps due to concerns about antitrust scrutiny. These results are inconsistent with smaller, more resource constrained firms turning to patent trolls as a means to enforce their patent rights in the face of competition.

5. Identification

5.1 The America Invents Act

If the increase in technological competition (*TechComp*) is related to unobserved factors that also determine the number of patent sale to trolls (*No. Patent Sales to Trolls*), the estimated relation between *TechComp* and *No. Patent Sales to Trolls* may be biased. To address endogeneity, we exploit the implementation of AIA as an exogenous shock to the effectiveness of privateering.

Congress passed the America Invents Act ("AIA") to curb the frequency of patent troll infringement suits, based on the prevailing view that patent trolls deter innovation and harm the economy. Enacted in 2011, the AIA introduced several significant reforms to the U.S. patent system, which had a notable impact on the effectiveness of using patent trolls to enforce patents. Following the implementation of the AIA, patent troll litigation began to decline (Baucus [2022]). Among the various changes brought about by the AIA, the Joinder Provision is arguably the most crucial in limiting the effectiveness of patent trolls (Bryant [2012]).

Patent trolls commonly rely on the litigation strategy of joining multiple, unrelated defendants in the same patent infringement suit. This practice offers two advantages. First, it helps patent trolls reduce their litigation costs by litigating common issues, such as the validity and scope of the patent, only once instead of repeating the same evidence in multiple cases. Second, it helps

them choose a favorable venue, such as the Eastern District of Texas, by making it less likely that a motion to transfer the case will succeed.

The Joinder Provision makes clear that defendants cannot be grouped together simply because they are accused of infringing the same patent. Defendants can only be joined if (1) they are alleged to be jointly or individually liable, or their alleged infringements are related to the same transaction or event, and (2) there are common questions of fact.

As a result, the Joinder Provision significantly increases legal costs for patent trolls and makes targeting multiple defendants less economically viable. It also limits their ability to consolidate cases in favorable venues, such as the Eastern District of Texas. Overall, it has substantially reduced the prevalence and effectiveness of patent troll litigation by complicating their legal strategies and raising costs.[11]

We examine the moderating effect of AIA implementation on our sample firms' patent sales to trolls when facing technological competition. Specifically, we add an interaction term *TechComp*×*POST_AIA* in Eq.1, where *POST_AIA* is an indicator variable equal to one for post-AIA years and zero otherwise.[12] Following Valentine et al. [2024], we exclude the years 2011 and 2012 —between the AIA announcement date and its effective date — to remove any anticipatory effects from our analysis. We estimate Eq. 1 using both the full sample and a smaller sample that includes only three years before and after the AIA.

[11] The AIA includes several other reforms that have made it more challenging for patent trolls to enforce patents. Patent trolls face more robust mechanisms for invalidating patents, increased transparency, and potential penalties for abusive litigation practices. For instance, the AIA established new procedures for challenging patents after they have been granted, such as Inter Partes Review (IPR), Post-Grant Review (PGR), and Covered Business Method (CBM) reviews. These processes allow parties to contest the validity of patents before the Patent Trial and Appeal Board (PTAB). The introduction of these review mechanisms made it easier for defendants to challenge the validity of patents asserted by patent trolls, thus reducing their effectiveness.

[12] Note that we cannot include *POST_AIA* in the regression due to the inclusion of year fixed effects.

Table 9 reports the results for this analysis. In both regressions, the coefficient on *TechComp* continues to be significantly positive, while the coefficient on the interaction term *TechComp×POST_AIA* is negative and significant. These findings support the notion that the AIA reduced the effectiveness of using patent trolls to enforce patents and therefore firms are less likely to resort to privateering when faced with technological threats post AIA. Comparing Column (2) with Column (1), we observe a larger coefficient on *TechComp×POST_AIA* and a noticeably higher adjusted R-squared, suggesting that the impact of the AIA is more pronounced in the years immediately after its implementation.

Overall, this section addresses endogeneity concerns by raising the hurdle of omitted correlated variables driving our results, as any omitted variable would have to be contemporaneous to the AIA.

5.2 R&D Credits

This section provides instrumental variable estimations to further alleviate the endogeneity concern. Specifically, we use a regulatory event – the introduction of state-level R&D tax credits – to construct our instrumental variable. The idea is that state-level R&D tax credits promote R&D activity and patenting by peer firms headquartered in the affected states and results in exogenous changes to a focal firm's technological competition (*TechComp*).

The existing literature suggests a large degree of randomness in the introduction and level of R&D tax credits, and use these regulatory events as instruments for R&D activities (Bloom et al. 2013; Cao et al. 2018). Building on this, we posit that these exogenous increases in R&D investments also lead to corresponding increases in patenting, a measure of innovation output.

We follow Bloom et al. [2013] and construct the instrumented *TechComp* measure in two steps. As a first step, we obtain firm-year-level R&D tax incentive measures from Bloom et al.

[2013] and use the R&D tax incentives to predict each firm's number of patents. Bloom et al. [2013] construct two tax policy instruments: first, they use Wilson's [2009] estimates of state-specific R&D tax prices, combined with the patent inventors' locations across states of each firm; second, they construct a firm-specific user cost using the federal rules with the firm-specific R&D base.[13] Second, we use the predicted values of each peer firm's patents, weighted by their patent portfolio cosine similarity to the focal firm, as instruments for our *TechComp* measures in the second stage equations (Eq. 1). Ultimately, the technological competition term is instrumented by the values of peer firms' tax prices, weighted by their overlap in the tech space with the focal firm.

The predicted *TechComp* (*TechComp_IV*) captures the increases in the patent stock of the sample firm's peers due to the exogenous regulatory changes. This variable is correlated with *TechComp* but should not affect the sample firm's patent sales to trolls. Therefore, it can serve as an instrument for estimating the relation between *TechComp* and patent sales to trolls.

Table 10 reports the results of estimating Eq. 1 using the predicted value of tech competition (*TechComp_IV*) with a reduced sample because information for calculating *TechComp_IV* is only available among public firms up to 2015. Across all three columns, the fitted values of *TechComp* demonstrate a positive link to *No. Patent Sales to Trolls*, suggesting robustness of our main results.

6. Additional analysis and robustness tests

6.1 Alternative measures for No. Patent Sales to Troll

We first evaluate the robustness of our results to the use of alternative definitions of the dependent variable (*No. Patent Sales to Troll*). We consider two alternative measures: (1) *Indicator Variable for Patent Sales to Trolls*: Our main proxy is based on patent transaction counts, which

[13] We thank Bloom et al. [2013] for sharing their data on R&D tax credit. The data is available for U.S. public firms from 1980 to 2015 at https://nbloom.people.stanford.edu/research.

reflects both the occurrence and frequency of patent sales to trolls. This approach makes the proxy more sensitive to firm-years with multiple sales, effectively giving greater weight to those firm-years compared to firm-years with no such transactions. In contrast, the first alternative approach involves creating an indicator variable which equals one for firm-years with at least one patent sale to a troll. This approach focuses solely on the presence of such sales; (2) *Percentage of Patent Sales to Trolls*: In our main analyses, we account for a firm's overall tendency to sell patents by including the number of patent sales to other parties as a control variable. The 2nd alternative approach controls for this tendency directly by measuring the percentage of patent sales to trolls relative to the total number of patent sales during the year.

Columns (1) and (2) of **Table 11 Panel A** report the results of this exercise. The results employing these alternative definitions of *No. Patent Sales to Trolls* are consistent with our main findings.

6.2 Alternative measures for TechComp

We also assess the robustness of our results to the use of alternative definitions of technological competition (*TechComp*). We explore two alternative measures: (1) *TechComp_High Similarity Peers*: Our main proxy includes patent competition threats from any firm that overlaps in any USPTO (CPC) patent classes as its technology peers. For firms with diversified patent portfolios, this measure may overstate the pressure from firms that do not directly compete with the focal firm. In this alternative approach, we restrict peer firms to those with above-median cosine similarity of patent stock with the focal firm; (2) *TechComp_Top10 Classes*: **Panel A** of **Table 2** shows that the top ten technological classes account for approximately 80% of the total number of patents sold to trolls. Accordingly, we calculate *TechComp* focusing solely on patents in these 10 CPC 3-digit classes.

Table 3 reports the summary statistics for these alternative measures of *TechComp*. As expected, the *TechComp_High Similarity Peers* measure has lower value compared to the original *TechComp,* due to the exclusion of firms that may not directly compete with the focal firm when aggregating peer threats. In contrast, the *TechComp_Top10 Classes* measure shows greater values than *TechComp,* as it focuses exclusively on technological classes with the most intense patent competition. Specifically, the sample mean for *TechComp, TechComp_High Similarity Peers,* and *TechComp_Top10 Classes* are 9.241, 8.414, and 9.940, respectively, which corresponds to aggregated patent stock from peers of 5,176, 2,252, and 10,340. Columns (3) and (4) of **Table 11, Panel A** report the results of estimating Eq. (1) using these alternative *TechComp* measures. The results using these alternative definitions of *TechComp* yield qualitatively similar results.

6.3 Placebo Test

To provide further evidence that the extent of privateering is attributable to technological competition, but not unobservable firm characteristics, we perform a falsification test. Specifically, we replace $TechComp_t$ with $TechComp_{t+4}$ when estimating Eq. 1 and Eq. 2. If unmodeled time-invariant firm characteristics drive our results, we would expect to find similar results with $TechComp_{t+4}$. **Table 11 Panel B** reports the results of this falsification test. The coefficients on $TechComp_{t+4}$ for both regressions become negative but not significantly different from zero. Overall, these results help mitigate the endogeneity concern by raising the hurdle that alternative explanations drive our results.

7. Conclusion

We examine whether firms are more likely to sell patents to NPEs in the presence of technological competition, and if so, whether NPEs use those patents to sue the original owner's competitors, a practice known as patent privateering. We find that technological competition is

positively associated with the number of patent sales to trolls and that these patents are more likely to be asserted in infringement lawsuits in subsequent years, especially in lawsuits targeting the rivals of the original patent owner. The increased sales to patent trolls are more pronounced for large firms, contrary to the potentially beneficial role of NPEs in enforcing under-resourced firms' patent rights. The increased likelihood of selling to a troll is also greater when firms operate in a litigious environment or in a highly collaborative technological space.

We provide important insights about the motivations and characteristics of practicing entities that supply patents to patent trolls, who are frequently accused of hampering innovation and targeted by policymakers. Many practicing companies and industry groups have lobbied in favor of anti-patent troll legislation. As Google states, "We need to take action against abusive patent practices that hinder innovation and stifle competition". However, our study reveals that practicing companies are often the very entities feeding patents to patent trolls in the first place. When confronted, these firms often blame the patent system, claiming they are forced to sell patents to trolls due to the high costs associated with maintaining large patent portfolios.[14] Our evidence, however, suggests a different narrative: these firms sell patents to trolls and obtain a strategic benefit. We contribute to the debate on patent trolls by providing insights into patent privateering, which can be a first step in addressing these issues (Schrepel 2014).

[14] https://ipwatchdog.com/2013/05/01/is-patent-litigation-really-a-problem-for-big-tech/id=39325/.

Appendix A. Variable Definition

Variable	Definition
Dependent variables	
No. Patent Sales to Troll	The inverse hyperbolic sine (IHS) transformation of the number of patents sold to patent trolls by a firm in year t, multiplied by 100.
No. Patent Sales to Troll (dummy)	An indicator variable that equals 1 if a firm sells patents to patent trolls in year t.
% Patent Sales to Troll	The percentage of patents sold to patent trolls, relative to patents sold to any buyers by a firm in year t, multiplied by 100.
No. Patent Litigation_{t+1,t+3}	The inverse hyperbolic sine (IHS) transformation of the number of patent litigations initiated based on a firm's patent, either by the firm itself or by other institutions who bought the patent from the firm, in years t+1 to t+3, multiplied by 100.
Patent Litigation through Troll_{t+1,t+3}	The inverse hyperbolic sine (IHS) transformation of the the number of patent litigations initiated by patent trolls in years t+1 to t+3, using patents acquired from an operating firm, multiplied by 100.
Litigation _target peers_{t+1,t+3}	The number of patent litigations initiated by patent trolls, targeting focal firms' technological peers, in years t+1 to t+3, using patents acquired from an operating firm, scaled by the total number of patent lawsuits.
Litigation _target nonpeers_{t+1,t+3}	The number of patent litigations initiated by patent trolls, against non-peer firms of the focal firms during the years t+1 to t+3, using patents acquired from an operating firm, scaled by the total number of patent lawsuits.
Independent variables	
TechComp	The inverse hyperbolic sine (IHS) transformation of the technological competition of a firm in year t. Technological competition = $[(\sum_{j \neq i} \omega_{i,j} \times Patent\ Stock_{j,t}) / Patent\ Stock_{i,t}]$, where j represents firm i's peer firm (any firm that overlaps with firm i in any CPC subclasses in their patent stock), t represents year t, $\omega_{i,j}$ is the cosine similarity between firm i's patent stock and firm j's patent stock, based on their percentage of patent stock in each CPC subclass.
TechComp (high similarity peers)	The inverse hyperbolic sine (IHS) transformation of the technological competition of a firm in year t, with technological competition being calculated based on peers with above-median cosine similarity of patent stock with the focal firm.
TechComp (top 10 classes)	The inverse hyperbolic sine (IHS) transformation of the technological competition of a firm in year t, with technological competition being calculated based on patents in the top 10 CPC 3-digit classes with the most patents sold to patent trolls.

Control variables	
No. of Indep. Claims	The inverse hyperbolic sine (IHS) transformation of the weighted average number of independent claims of patents granted to a firm in the past 20 years.
No. of Patent Figures	The inverse hyperbolic sine (IHS) transformation of the weighted average number of figures of patents granted to a firm in the past 20 years.
No. of Patent Inventors	The inverse hyperbolic sine (IHS) transformation of the weighted average number of inventors of patents granted to a firm in the past 20 years.
Patent Sale to Others	The inverse hyperbolic sine (IHS) transformation of the number of patents sold non-troll buyers by a firm in year t.
Patent Litigation by Self_{t+1,t+3}	The inverse hyperbolic sine (IHS) transformation of the number of patent litigations initiated by a firm itself in the future 3 years from t+1 to year t+3.
Patent Stock	The weighted average number of patents granted to a firm in the past 20 years, with a 15% annual depreciation rate.
Patent Age	The average number of years between the patent grant year and the current year for patents granted to a firm in the past 20 years.
Patent Diversification	The Herfindahl-Hirschman Index (HHI) of a firms' patent stock among CPC subclasses, multiplied by -1.
Patent Scientific Value	The inverse hyperbolic sine (IHS) transformation of the average number of forward citations of patents granted to a firm in the past 20 years.
Cross-sectional variables	
Patent Portfolio Size	The weighted average number of patents granted to a firm in the past 20 years, with a 15% annual depreciation rate.
Litigation Frequency	The average litigation frequency among all CPC subclasses within a firm's patent stock. The CPC subclass-level litigation frequency is measured by counting the litigation cases initiated based on patents in the corresponding subclass from 2000 to 2021.
Innovation Collaboration	The average innovation collaboration intensity among all CPC subclasses within a firm's patent stock. The CPC subclass-level innovation collaboration intensity is measured based on the percentage of patents that have multiple firms as co-applicants granted in the corresponding subclass over the past 20 years, with a 15% annual depreciation rate.
Leverage	Total debt scaled by total asset (Compustat items (DLTT+DLC)/AT).
Cash	Cash and cash equivalent scaled by total asset (Compustat items CHE/AT).

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Table 1. Sample Selection

	#Firm-Year	#Firms
Universe of Public and Private Firms in PatentsView (2000-2021)	6,741,658	306,439
Require at least one patent sale and one patent litigation (2000-2021)	195,140	8,870
Require at least one patent granted in the past 20 years	146,851	8,625

This table presents the sample selection procedures.

Table 2. Descriptive Statistics of Patent Sales

Panel A. Patent Sales and Litigation

	Obs	% of Total
Total firm-year observations from 2000-2021	146,851	100%
Patent sales	24,154	16.45%
Patent sales to trolls	2,245	1.53%
Patent litigation	13,570	12.23%
Patent litigation through trolls	1,462	1.00%
Patent litigation through trolls in the future three years	2,868	1.95%
Unique firms from 2000-2021	8,625	100%
Firms that sell at least one patent to trolls	1,301	15.08%
Firms with patent litigation through trolls	666	7.72%

Panel B. Top 10 Technology Classes with Patents Sold to Troll

CPC_Class	#Patents sold to troll	%Patents sold to troll
H04 (Electric communication technique)	29,356	12.29%
G06 (Computing; calculating or counting)	20,251	10.40%
H01 (Electric elements)	13,570	8.30%
G11 (Information storage)	4,544	8.56%
A61 (Medical or veterinary science; hygiene)	4,045	3.16%
G01 (Measuring; testing)	3,756	5.51%
H03 (Electronic circuitry)	2,680	7.41%
B60 (Vehicles in general)	2,600	9.56%
G02 (Optics)	2,141	4.86%
F16 (Engineering elements and units; general measures for producing and maintaining effective functioning of machines or installations; thermal insulation)	1,972	8.44%
Total of Top 10	84,915	78.39%

Panel C. Descriptive Statistics of Patent Sales Transactions

	Sales to Troll		Sales to Others		Difference	Not Sold		Difference (Troll - NoSale)
	N	Mean	N	Mean	(Troll - Other)	N	Mean	
No. of Patents per Transaction	30,812	4.391	641,208	3.010	1.381***	-	-	-
Patent Scientific Value	135,283	28.166	1,929,786	21.208	6.959***	5,706,635	12.885	15.281***
Patent Age	135,283	6.026	1,929,786	3.860	2.166***	-	-	-
No. of Indep. Claims	135,283	3.227	1,929,786	2.891	0.336***	5,706,635	2.570	0.658***
No. of Patent Figures	135,283	13.860	1,929,786	14.173	-0.313***	5,706,635	11.661	2.200***
No. of Patent Inventors	135,283	2.610	1,929,786	2.833	-0.223***	5,706,635	2.502	0.107***

This table presents the descriptive statistics of patent sales. Panel A provides descriptive statistics for patent sales and patent litigations. Panel B lists the top 10 CPC 3-digit technological classes with the highest number of patents sold to patent trolls. Panel C provides descriptive statistics for patent characteristics and transaction sizes related to patent sales to patent trolls and other buyers, respectively. ***, ***, * indicates statistical significance at 1%, 5%, and 10%, respectively.

Table 3. Descriptive Statistics of Key Variables in Regression Sample

	(1) N	(2) mean	(3) sd	(4) p25	(5) p50	(6) p75
Dependent Variable						
No. Patent Sales to Troll (untransformed)	146,851	0.497	24.824	0.000	0.000	0.000
No. Patent Sales to Troll	146,851	3.563	34.016	0.000	0.000	0.000
No. Patent Sales to Troll (dummy)	146,851	0.015	0.123	0.000	0.000	0.000
No. Patent Sales to Troll (percentage)	146,851	1.040	9.626	0.000	0.000	0.000
Patent Litigation through Troll t+1,t+3(untransformed)	146,851	0.195	3.444	0.000	0.000	0.000
Patent Litigation through Troll t+1,t+3	146,851	4.212	33.975	0.000	0.000	0.000
Litigation_target peers_t+1, t+3	146,851	1.020	9.104	0.000	0.000	0.000
Litigation_target nonpeers_t+1, t+3	146,851	0.933	8.628	0.000	0.000	0.000
Independent Variable						
TechComp	146,851	9.241	2.173	7.733	9.192	10.713
TechComp (high similarity peers)	146,851	8.414	1.990	7.028	8.317	9.713
TechComp (top 10 classes)	109,789	9.940	2.133	8.527	9.981	11.393
Control Variables						
Patent Sale to Others	146,851	0.378	1.064	0.000	0.000	0.000
Patent Litigation by Self_t+1,t+3	146,851	23.084	58.652	0.000	0.000	0.000
Patent Stock	146,851	2.318	1.931	0.771	1.824	3.346
Patent Age	146,851	8.390	4.865	4.364	7.889	11.752
Patent Diversification	146,851	-0.562	0.328	-0.280	-0.503	-1.000
Patent Scientific Value	146,851	0.044	0.226	0.000	0.000	0.000
No. of Indep. Claims	146,851	1.785	0.417	1.522	1.812	2.023
No. of Patent Figures	146,851	2.875	0.829	2.512	2.958	3.349
No. of Patent Inventors	146,851	1.482	0.401	1.195	1.458	1.754

This table presents descriptive statistics for the variables used in our analyses, including the mean, standard deviation, and percentile values for our sample of 146,851 firm-year observations. Detailed definitions of all variables are provided in Appendix A.

Table 4. Technological Competition and Patent Sales to Troll

	No. Patent Sales to Troll_t		
	(1)	(2)	(3)
TechComp_t	**0.536*** **	**0.549*** **	**0.649*** **
	(3.13)	**(3.19)**	**(3.67)**
Patent Sales to Others_t	1.790***	1.789***	1.785***
	(8.11)	(8.11)	(8.10)
Patent Stock_t	2.023***	1.998***	2.272***
	(7.72)	(7.55)	(7.62)
Patent Age_t	-0.060	-0.042	-0.030
	(-1.23)	(-0.83)	(-0.57)
Patent Scientific Value_t		-0.434	-0.371
		(-1.62)	(-1.39)
No. of Patent Figures_t		-0.219	-0.142
		(-0.66)	(-0.42)
No. of Patent Inventors_t		0.235	0.279
		(0.37)	(0.43)
No. of Indep. Claims_t			-0.239
			(-0.43)
Patent Diversification_t			-2.017**
			(-2.48)
Observations	146,851	146,851	146,851
R-squared	0.186	0.186	0.186
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

This table presents regression results from the regression of the number of patents sold to patent trolls on technological competition. Column (1) includes the baseline regression with a vector of control variables and firm- and year-fixed effects. Columns (2) and (3) gradually expand the vector of control variables. T-statistics, based on standard errors clustered at the firm level, are reported below the coefficient estimates in parenthesis. ***, ***, * indicates statistical significance at 1%, 5%, and 10%, respectively (two-tailed). Detailed definitions of all variables are provided in Appendix A.

Table 5. Technological Competition and Litigation Through Troll

	*Patent Litigations through Troll_*{t+1, t+3}	
	(1)	(2)
	All	*%Target peers*
TechComp_t	**1.034*** **	**0.133*** **
	(3.78)	**(2.68)**
Patent Litigations by Self_{t+1,t+3}	0.004	
	(1.38)	
Patent Litigations by Self_%Target peers_{t+1,t+3}		0.001
		(0.95)
Patent Stock_t	2.194***	0.375***
	(5.17)	(4.66)
Patent Age_t	-0.167*	-0.042***
	(-1.88)	(-3.24)
Patent Scientific Value_t	-0.040	-0.022
	(-0.09)	(-0.31)
No. of Indep. Claims_t	1.046	0.126
	(1.28)	(0.89)
No. of Figures_t	0.244	-0.028
	(0.45)	(-0.38)
No. of Patent Inventors_t	0.664	0.310*
	(0.56)	(1.70)
Patent Diversification_t	-2.701**	-0.517**
	(-1.97)	(-2.55)
Observations	146,851	146,851
R-squared	0.366	0.281
Firm FE	Yes	Yes
Year FE	Yes	Yes

This table presents regression results from the regression of the litigations initiated through patent trolls using the focal firm's patents in the future 3 years on technological competition. Column (1) presents the results on the total number of litigations initiated through patent trolls in the future 3 years. Columns (2) report the results on the percentage of litigations initiated through patent trolls targeting peer firms. T-statistics, based on standard errors clustered at the firm level, are reported below the coefficient estimates in parenthesis. ***, ***, * indicates statistical significance at 1%, 5%, and 10%, respectively (two-tailed). Detailed definitions of all variables are provided in Appendix A.

Table 6. Do Trolls Specifically Use the Acquired Patents to Sue Seller's Competitors?

Panel A. Main analysis

	(1) *Patent Litigations_Target peers*	(2) *Patent Litigations _Target non-peers*
Treat*Post	**0.024****	**-0.014**
	(2.13)	**(-1.41)**
Patent Litigations	0.560***	0.694***
	(21.42)	(24.52)
Observations	622,836	622,836
R-squared	0.916	0.942
Matching Pair*Patent FE	Yes	Yes
Matching Pair*Year FE	Yes	Yes

Panel B. Moderating Effects by Technological Competition

	(1)		(2)
	Patent Litigations_Target peers		
	LowTechComp		HighTechComp
Treat*Post	**-0.002**		**0.052****
	(-0.82)		**(2.28)**
Patent Litigations	0.725***		0.518***
	(12.47)		(18.37)
High - Low		0.053**	
		(2.35)	
Observations	308,620		308,448
R-squared	0.949		0.910
Matching Pair*Patent FE	Yes		Yes
Matching Pair*Year FE	Yes		Yes

This table presents regression results from the regression of the litigations initiated through patent trolls using the focal firm's patents. Specifically, our sample includes 6 years of observations for both treated and matched control patents, from 3 years prior to 3 years after when a treated patent is sold to a troll, excluding the sales year itself. A treated patent is defined as a patent sold by focal firm to a troll, whereas a control patent is defined as a patent sold by a different, but characteristically similar firm to the same troll. Panel A Column (1) presents the results using the number of litigations targeting the focal firm peers, whereas Column (2) reports the results using the number of litigations targeting non-peer firms, respectively. Panel B compares the effect of litigation a focal firm's peer across high vs. low technological competition. T-statistics, based on standard errors clustered at the firm level, are reported below the coefficient estimates in parenthesis. ***, ***, * indicates statistical significance at 1%, 5%, and 10%, respectively (two-tailed). Detailed definitions of all variables are provided in Appendix A.

Table 7. Mechanism Tests

Panel A. Technology Field Litigation Frequency

	No. Patent Sales to Troll_t	
	(1)	(2)
	Low Litigation Freq.	High Litigation Freq.
TechComp_t	0.395*	1.409***
	(1.95)	(3.77)
Difference (High - Low)	**1.014****	
	(2.38)	
Observations	73,441	73,410
R-squared	0.257	0.174
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes

Panel B. Technology Field Innovation Collaboration

	No. Patent Sales to Troll_t	
	(1)	(2)
	Low Collaboration	High Collaboration
TechComp_t	0.481**	1.159***
	(2.35)	(3.60)
Difference (High - Low)	**0.678***	
	(1.78)	
Observations	73,427	73,424
R-squared	0.183	0.264
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes

This table presents regression results from the regression of the number of patents sold to patent trolls on technological competition within the corresponding subsample. Panel A presents the results for subsamples of firm-years based on the litigation frequency of technological subclasses within the firm's patent stock. Panel B presents the results for subsamples of firm-years based on the patent collaboration of technological subclasses within the firm's patent stock. T-statistics, based on standard errors clustered at the firm level, are reported below the coefficient estimates in parenthesis. ***, ***, * indicates statistical significance at 1%, 5%, and 10%, respectively (two-tailed). Detailed definitions of all variables are provided in Appendix A.

Table 8. Subsample Analysis

Panel A. Size

	No. Patent Sales to Troll_t			
	(1)	(2)	(3)	(4)
	Small	Large	Small (Q1-Q4)	Large (Q5)
TechComp_t	0.314*	1.068*	0.292**	5.194**
	(1.74)	(1.95)	(2.09)	(2.09)
Difference (Large - Small)	**0.754**		**4.901****	
	(1.31)		**(1.97)**	
Observations	73,427	73,424	117,481	29,370
R-squared	0.198	0.215	0.151	0.236
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Panel B. Financial Position

	No. Patent Sales to Troll_t			
	(1)	(2)	(3)	(4)
	Low Leverage	High Leverage	Low Cash	High Cash
TechComp_t	6.337***	-0.226	0.571	6.829**
	(2.71)	(-0.14)	(0.44)	(2.49)
Difference (High - Low)	**-6.563****		**6.258****	
	(-2.31)		**(2.06)**	
Observations	8,316	8,316	8,312	8,311
R-squared	0.359	0.285	0.350	0.256
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

This table presents regression results from the regression of the number of patents sold to patent trolls on technological competition within the corresponding subsample. Panel A presents the results for subsamples of firm-years based on patent portfolio size. Column (1) and (2) of Panel A split the sample based on sample median. Column (3) and (4) of Panel A split the sample based on sample quintiles. Panel B presents the results for subsamples of firm-years with financial constraints being above and below the sample median. T-statistics, based on standard errors clustered at the firm level, are reported below the coefficient estimates in parenthesis. ***, ***, * indicates statistical significance at 1%, 5%, and 10%, respectively (two-tailed). Detailed definitions of all variables are provided in Appendix A.

Table 9. Patent Sales to Troll Around the America Inventor Act

	No. Patent Sales to Troll_t	
	(1)	(2)
	Full Sample	6-Year Window
TechComp_t	0.972***	1.360**
	(4.39)	(2.57)
TechComp_t*×*Post_AIA	**-0.400****	**-0.494***
	(-2.24)	**(-1.95)**
Observations	146,851	42,950
R-squared	0.186	0.372
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes

This table presents regression results from the regression of the number of patents sold to patent trolls on the interaction between technological competition and an indicator variable for the post-America Inventor Act period, to examine the moderating effect of the America Inventor Act implementation on firms' sales to patent trolls when facing technological competition. Column (1) reports the results based on the full sample. Column (2) reports the results based on a 6-year short window, with 2008 to 2010 being the pre-AIA period and 2013 to 2015 being the post-AIA period. T-statistics, based on standard errors clustered at the firm level, are reported below the coefficient estimates in parenthesis. ***, ***, * indicates statistical significance at 1%, 5%, and 10%, respectively (two-tailed). Detailed definitions of all variables are provided in Appendix A.

Table 10. R&D Credit as Instrument Variable

	No. Patent Sales to Troll_t		
	(1)	(2)	(3)
TechComp_IV_t	**2.223***	**2.294***	**2.995****
	(1.80)	**(1.86)**	**(2.15)**
Patent Sales to Others_t	1.870***	1.865***	1.857***
	(4.79)	(4.77)	(4.77)
Patent Stock_t	4.179***	4.141***	5.407***
	(3.26)	(3.21)	(3.30)
Patent Age_t	-0.082	-0.089	0.015
	(-0.30)	(-0.32)	(0.05)
Patent Scientific Value_t		-0.699	-0.490
		(-0.63)	(-0.45)
No. of Patent Figures_t		-1.509	-1.160
		(-1.23)	(-0.92)
No. of Patent Inventors_t		1.162	1.548
		(0.49)	(0.65)
No. of Indep. Claims_t			-0.181
			(-0.08)
Patent Diversification_t			-8.947***
			(-2.59)
Observations	23,839	23,839	23,839
R-squared	0.240	0.240	0.241
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

This table presents regression results from the regression of the number of patents sold to patent trolls on technological competition, where technological competition is calculated based on the predicted value of peer firms' number of patents, using peer firms' R&D tax credit as the instrument variable. T-statistics, based on standard errors clustered at the firm level, are reported below the coefficient estimates in parenthesis. ***, ***, * indicates statistical significance at 1%, 5%, and 10%, respectively (two-tailed). Detailed definitions of all variables are provided in Appendix A.

Table 11. Robustness Tests

Panel A. Alternative Measures

	No. Patent Sales to Troll_t			
	(1)	(2)	(3)	(4)
	Alternative Dep. Variables		Alternative Ind. Variables	
	Dummy	Percentage	High Similarity Peers	Top 10 Classes
TechComp_t	0.002***	0.117**	0.396**	0.876***
	(2.71)	(2.30)	(2.32)	(3.59)
Observations	146,851	146,851	146,851	109,789
R-squared	0.180	0.121	0.186	0.191
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Panel B. Pseudo Test

	(1)	(2)
	Patent Sales to Troll_t	Patent Litigation through Troll_{t+1, t+3}
TechComp_{t+4}	-0.089	-0.101
	(-1.54)	(-1.39)
Observations	123,242	123,242
R-squared	0.201	0.385
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes

This table presents the results of robustness tests. Panel A reports the regression results of Eq. 1 using alternative measures of the dependent variables and independent variables, respectively. Column (1) uses an indicator variable that equals 1 if a firm sells patents to patent trolls in a year as the dependent variable. Column (2) uses patents sold to patent trolls as a percentage of total patents sold to any buyers as the dependent variable. Column (3) measures technological competition using patents from peer firms with above-median patent portfolio cosine similarity with the focal firm. Column (4) measures the technological competition using patents from the top 10 CPC 3-digit technological classes with most patents sold to patent trolls. Panel B reports the pseudo-test results on the regression of the patent sales to patent trolls at year t (Column (1)) and patent litigations initiated through patent trolls during years t+1 to t+3 (Column (2)) on technological competition at year t+4. T-statistics, based on standard errors clustered at the firm level, are reported below the coefficient estimates in parenthesis. ***, ***, * indicates statistical significance at 1%, 5%, and 10%, respectively (two-tailed). Detailed definitions of all variables are provided in Appendix A.

Online Appendix 1: *TechComp* and the closeness measure

The closeness, $\omega_{i,j}$, is calculated in the *technological space* spanned by CPC 4-digit subclasses. The more overlapping CPC subclasses between the patents of the two firms, the higher the closeness. Additionally, the higher the proportion of each firm's patents in the overlapping CPC subclasses, the greater the closeness. To illustrate, consider two firms, *i* and *j*, and three CPC subclasses: A, B, and C. In the first case, both firms have two-thirds of their patents in subclass B, one-third in subclass C, and none in subclass A. In the second case, firm *i* has two-thirds of its patents in subclass B and one-third in subclass C, while firm *j* has one-third of its patents in subclass B and two-thirds in subclass C. In the third case, firm *i* has one-third of its patents in subclass B and two-thirds in subclass C, whereas firm *j* has one-third of its patents in subclass B and two-thirds in subclass A. The two firms are closest in Case 1 and least close in Case 3. If the two firms do not overlap in any CPC subclass, then firm *j* is not a peer of firm *i* at all.

	Case 1			Case 2			Case 3		
CPC Subclass	A	B	C	A	B	C	A	B	C
Firm i	0	2/3	1/3	0	2/3	1/3	0	1/3	2/3
Firm j	0	2/3	1/3	0	1/3	2/3	2/3	1/3	0

We formally calculate $\omega_{i,j}$ by taking the cosine of the two firms' vectors (V_i and V_j) with the k^{th} element of each vector equal to the firm's proportion of its patent stock in the past 20 years with a 15% decay rate in CPC subclass k, where K is the total patent count for a given CPC subclass. The cosine of the vectors ($\emptyset_{i,j}$) has a geometrical interpretation as the similarity of the two vectors:

$$\omega_{i,j} = \cos(\emptyset_{i,j}) = < \frac{v_i}{\|v_i\|} \cdot \frac{v_j}{\|v_j\|} > = \frac{\sum_{k=1}^{K} v_{ik} v_{jk}}{\sqrt{\sum_{k=1}^{K} v_{ik}^2} \sqrt{\sum_{k=1}^{K} v_{jk}^2}}$$

In our example, Case 1 has a cosine similarity of 1, Case 2 has a cosine similarity of 0.8, and Case 3 has a cosine similarity of 0.2.